Index of Idiolectal Similitude for the phonological module of English applied to forensic speech comparison

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Als meus pares i al Jaume

A la Maite, *in memoriam*

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Abstract

The framework of the present PhD dissertation is the area that results from the overlap between the field of variationist sociolinguistics and forensic linguistics, which mainly concerns the study of variation between different individuals –inter-speaker variation– and variation within a single individual –intra-speaker variation– for forensic purposes. The primary objective of the present dissertation is twofold. On the one hand, it proposes a protocol for the creation of an Index of Idiolectal Similitude (IIS) for the phonological module of English that can effectively determine whether two oral samples show inter-speaker variation –which would indicate that the samples have been produced by two different individuals– or intra-speaker variation –which would allow to conclude that the samples have been produced by the same individual. On the other hand, the analysis of the fourteen variables proposed in a corpus that contains data on sixteen speakers and that is stratified according to measurement time –as a result of a real time study–, language contact and gender, provides an important contribution to the Base Rate knowledge, which constitutes one of the main challenges of current forensic linguistics.

Results show that inter-speaker variation is generally higher than intra-speaker variation, and that a speaker's idiolectal style remains relatively stable over time. Therefore, the IIS is presented as an innovative quantitative tool which, together with other quantitative and qualitative techniques that the linguist acting as expert witness may have at their disposition, can help reach a conclusion regarding the probability of two samples having been produced or not by the same speaker.

Keywords: applied linguistics, forensic linguistics, idiolectal style, intra-speaker variation, inter-speaker variation, Index of Idiolectal Similitude, Base Rate Knowledge, real-time study.

Resum

Aquesta tesi doctoral s'emmarca dins l'àrea comú on es troben els camps de la sociolingüística de la variació i la lingüística forense, en la qual es troba l'estudi de la variació entre diferents individus –variació inter-parlant– i la variació en del mateix individu –variació intra-parlant– amb finalitats forenses. La investigació té dos objectius principals. D'una banda, es proposa el protocol per a la creació d'un Índex de Similitud Idiolectal (ISI) per al mòdul fonològic de l'anglès que pot determinar de manera efectiva si dues mostres orals mostren variació inter-parlant –que indicaria que les mostres haurien estat produïdes per dos individus diferents– o variació intra-parlant –la qual cosa portaria a concloure que les mostres haurien estat produïdes pel mateix individu. D'altra banda, l'anàlisi de les catorze variables proposades en un corpus que conté setze parlants i que està estratificat per temps de mesura –com a resultat d'un estudi en temps real–, contacte de llengües i gènere biològic, comporta una contribució important a la referència de distribució poblacional (Base Rate Knowledge) que constitueix un dels grans reptes de la lingüística forense actual.

Els resultats mostren que la variació inter-parlant és generalment més alta que la intra-parlant, i que l'estil idiolectal d'un individu es manté relativament estable malgrat el pas del temps. Per tant, l'ISI es presenta com una eina quantitativa innovadora que, juntament amb altres tècniques quantitatives i qualitatives que el lingüista forense pot tenir a la seva disposició, pot ajudar a prendre una decisió sobre la probabilitat que dues mostres hagin estat produïdes o no pel mateix parlant.

Paraules clau: lingüística aplicada, lingüística forense, estil idiolectal, variació intra-parlant, variació inter-parlant, Índex de Similitud Idiolectal, Base Rate Knowledge, referència de distribució poblacional, estudi en temps real.

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Introduction

The field of forensic linguistics is a relatively young field and it is constantly looking for new discriminatory parameters and quantitative methods that combine with qualitative analyses in order to infer reliable and robust conclusions. In contrast with other forensic sciences, linguistic evidence, as language in general, has the beauty and the challenge of being intrinsically variable. In light of this variability, the forensic linguist conducting research and acting as expert witness is forced to measure as many linguistic parameters as possible in search of a conclusion regarding the probability of two linguistic samples –oral or written– having been produced or not by the same speaker.

The framework of the present study is divided into two major linguistic fields which are very much related to each other. On the one hand, variationist sociolinguistics has its main focus on the study of variation and its relation to linguistic, social and stylistic factors. The present study follows the sociolinguistic premises and methods proposed by variationist sociolinguistics as regards the analysis of the sociolinguistic variable and its study in its social context. On the other hand, forensic linguistics, and in particular, forensic phonetics, which is the area that considers speech productions, constitutes the field of motivation and the purpose of application of the present investigation. These two major linguistic fields overlap into a common area that is yet to be explored in more detail, which is the analysis of variation and its relation to the individual, i.e. variation between different speakers –inter-speaker variation– and variation within the same speaker –intra-speaker variation. In the centre of this common area lies the premise that each speaker has an individual and unique use of language, which separates them from the rest of members of their community: idiolect, or following Turell (2010a) idiolectal style, which is comprised of a set of linguistic selections that depend on the individual's particular linguistic history. In this sense, linguistic variation is a fundamental constituent of idiolectal style. Whenever individuals encounter variation, i.e. different ways of saying the same thing, they are presented with a choice, and the examination of a group of particular choices that an individual makes can provide information about that individual, information that is particularly valuable in a forensic context.

Despite its major relevance, linguistic variation and its role in a speaker's idiolectal style has only been the focus of very few studies. The innovation of the present PhD dissertation is its contribution to this lack of research and its main objective is to provide a deeper insight into the nature of inter- and intra-speaker variation and its relation to idiolectal style. On the one hand, the present study proposes a set of fourteen phonological variables belonging to the accent of Southern Standard British English (SSBE), which deal with processes affecting both vowels and consonants, and examines their discriminatory potential. The discriminatory potential of the processes considered in these variables have never been tested in SSBE, and the majority of them have not even been analysed in relation to English. The main aim of this examination is to contribute to the Base Rate Knowledge with new information about new variables that can be used in forensic contexts involving SSBE. On the other hand, an

Index of Idiolectal Similitude[1] (IIS) which considers these fourteen variables is proposed as a quantitative tool that can help forensic linguists determine the idiolectal distance between two linguistic samples in order to reliably say whether they have been produced or not by the same individual. This IIS is conceived as a complementary quantitative tool that can be used together with other quantitative and qualitative methods.

The protocol of creation of this IIS involves, firstly, a collection of corpus of study. This corpus contains data on sixteen speakers of SSBE, and is stratified according to three main factors: 1) measurement time, by means of a sociolinguistic real time study; 2) language contact, by the creation of one subcorpus containing data on speakers who have been in a long-term situation of language contact (*LanCon*) and another subcorpus with speakers who have not (*InSit*); and 3) gender, since the corpus contains data on both male and female subjects. The type of speech that is analysed is spontaneous speech, which is particularly relevant in forensic contexts. Secondly, the variables of analysis were formulated regarding, on the one hand, the definition, coding and analysis proposed by variationist sociolinguistics, and on the other, the definition and analysis of a variable considering its special requirements for its application to forensic contexts. The variables under analysis are concerned with processes that show current variation in SSBE, such as t-glottalling, frication of plosives and yod

[1] The word "similitude" is used in the present dissertation as the mass noun meaning "the quality or state of being similar to something" (as defined by the Oxford Dictionary http://oxforddictionaries.com/definition/english/similitude?q=similitude). This use should not be confused with the use of the same word in phonetics to mean the adaptation of segments to each other in context (e.g. Jones 1962; Abercrombie 1967).

coalescence. Finally, a statistical method for the calculation of the IIS is proposed, which is based on the statistical Chi-square test.

The present dissertation can be placed in the context of the work carried out at the Forensic Linguistics Laboratory (ForensicLab), a laboratory specialised in forensic linguistics research, teaching and expert witness work at Institut Universitari de Lingüística Aplicada (IULA), Universitat Pompeu Fabra. ForensicLab was created in 2003 by Professor Maria Teresa Turell, pioneer in Forensic Linguistics at a national and international level, and is part of the major research group *Unitat de Variació Lingüística* (UVAL). Since its creation, ForensicLab has set up the only MA in Forensic Linguistics in Spain and Latin America, has carried out research work through several research projects and PhD dissertations, and has been involved in numerous forensic cases involving forensic speech and text comparison, plagiarism detection, trademark and patent disputes and analysis of legal texts.

The present PhD dissertation is divided into ten chapters, which in turn are divided into two main parts. Part I is related to the theoretical background to the study and Part II is concerned with the investigation carried out.

Chapter 1 addresses the field of variationist sociolinguistics. Section 1.1 examines the variationist proposals for the observation of change in progress, in particular the apparent time construct and the studies in apparent and real time. Section 1.2 reviews the main sociolinguistic methodological proposals for the investigation of variation, and section 1.3 provides an account of the sociolinguistic variable as regards its definition, coding and analysis.

Chapter 2 provides a brief overview of the field of forensic linguistics, with particular attention to its origins and the different fields of research. Section 2.1 focuses on the area of research which is of particular concern to the present dissertation: forensic phonetics, and examines the main tasks involved in this area, as well as the current debates around terminology and framework for the presentation of conclusions. Section 2.2 provides an insight into the definition of what is an ideal parameter to consider in forensic contexts involving spoken evidence.

Chapter 3 builds on the previous two chapters and explains the common area that arises from the overlap between sociolinguistics and forensic linguistics, which is related to the study of variation between different speakers and within the same individual for forensic purposes. Section 3.1 focuses on inter-speaker variation and centers on its main sources, which relate to the physical and the linguistic properties, as well as the phonetic implementation of the acoustic and linguistic features into a speaker’s physiology. Section 3.1.2 is dedicated to idiolectal style as has been defined in the field of forensic linguistics, a concept that is crucial in the present investigation. Section 3.2 centers on intra-speaker variation, with particular emphasis to three factors that can influence variation within the same individual that are relevant to the present study: changes over time, style-shifting and language contact. Finally, section 3.3 provides a brief account of one of the main challenges of present-day forensic linguistics, which is the construction of a Base Rate Knowledge. This Base Rate Knowledge would allow samples examined in forensic cases to be compared with relevant population data in order to infer conclusions as regards the saliency of the features analysed.

Finally, Chapter 4 is concerned with the analytical proposal, which reviews the main theoretical and methodological proposals dealt with in the previous chapters that are most relevant to the study at hand. The main research project carried out at ForensicLab that serves as framework for the present dissertation will also be reviewed.

The first chapter in Part II is Chapter 5, which presents the IIS as the main objective of the study, as well as the research questions and hypotheses proposed. Chapter 6 is concerned with the experimental design. Section 6.1 tackles the collection of the corpus of study and its division into two main subcorpora and section 6.2 provides a detailed overview of the fourteen variables under analysis and the main research in which its selection and analysis have been based. This second section also contains a brief account of the perception test and the subsequent inter-rater reliability test that were carried out in order to justify the analysis of the variables that are most difficult to categorise (section 6.2.3). The last section in this chapter, section 6.3 explains the main technique of analysis used in the present investigation for the calculation of the IIS.

Chapter 7 reports the results obtained for the experiments carried out within the IIS protocol. Particular attention is paid to the analysis of intra-speaker variation over time and as a result of language contact, and to inter-speaker variation in relation to language contact and gender. This chapter includes a section, 7.2.3, dedicated to an analysis of speaking tempo in order to examine the relationship between this feature and the variables analysed.

Chapter 8 provides an account of the results obtained for the analysis of the discriminatory potential of the variables that was carried outside the IIS protocol. Results are reported in relation to the six main allophonic processes with which the fourteen variables are concerned: 8.1 deals with allophonic realisations of /t/ (glottalling, tapping and frication); 8.2 examines vowel alternation between [ə]-[ɪ]; 8.3 explains the process of yod coalescence; 8.4 deals with the process of insertion of epenthetic [t] between [n] and [s]; 8.5 regards the process of linking /r/; and 8.6 tackles the process of frication of /k/, which is also examined in relation to the process of frication of /t/.

Chapter 9 is dedicated to the discussion of the results obtained in chapters 7 and 8 in relation to the research questions posed by the present dissertation. Finally, Chapter 10 summarises the conclusions, the limitations and the main contributions of the present study, and it proposes new lines of future research.

PART I
Theoretical Background

Chapter 1
Variationist Sociolinguistics

Nowadays, every linguist is aware of the fact that language, at all its levels, is variable and in constant change. Moreover, the systematic nature of language variation has been established within the framework of the Labovian Theory of Language Change and Variation. However, only 60 years ago linguists were convinced that the variation observed in languages was the result of mistakes and language misuses, and therefore that this variation had to be ignored in a description of any level of a language. It was in the 1960s that the work of linguists such as Weinreich, Herzog and especially Labov showed that variation was inherent to languages and that, for an accurate description of a language, variation not only should not be ignored, but it also had to be analysed.

Before sociolinguists started acknowledging linguistic variation, major linguistic theories explained variation as the result of two main phenomena. On the one hand, there was the notion of **coexisting systems**, which affirmed that speakers acquired different phonologies (different dialects) and that variation might be the consequence of switching from one to another in certain contexts. On the other hand, the notion of **free variation** held that variation was the result of arbitrary fluctuations which were impossible to predict. In this sense, previous linguistic theories adopted what Chambers (2009) calls the **axiom of categoricity**, i.e., a dichotomy between a perfect and homogeneous linguistic system and the actual use that the speaker makes of it, which may include variation and/or errors. This dichotomy was supported by the main theorists of language at the time, i.e. Neogrammarians, Structuralists and Generativists.

According to Weinreich, Labov and Herzog (1968), Neogrammarians came up with the concept of **idiolect** at the end of the 19th century as an attempt to justify the legitimacy of focusing on the speech of a single individual in order to carry out linguistic analysis, because every language user was thought to share a linguistic system which was equal for every member of their community. In this light, a speaker's idiolect –normally that of the linguist himself– reflected the structured nature of their language and the regularity of linguistic change. According to this theory, dialects would be "groups of (phonologically) identical idiolects", dialect change would simply be "idiolects changing in parallel", and dialect splitting would be "no more than idiolects changing diversely" (Weinreich *et al.* 1968: 104).

Later on, Structuralists, especially Bloomfield (1933) and also Bloch (1948) –who coins the term 'idiolect'– acknowledged that every speaker, and therefore every idiolect, is different, but all of them reflect the speech of a homogeneous linguistic community, and any trace of variation needs to be ignored. Following this idea, Saussure introduces this dichotomy, or categoricity, by which this homogenous language is found in all the community members as *langue*, i.e., a perfectly structured grammatical system that does not show variation. The second element of the dichotomy is *parole*, the real use of language in social contexts, which is heterogeneous and imperfect because it is on this level that speakers make mistakes and variants appear. Following this view, any study of a language should be carried out by focusing solely on *langue*, by means of an idiolect, and never on *parole*. According to Labov, this *langue/parole* dichotomy constitutes a paradox, what he calls the **'Saussurean Paradox'** (1975: 186) in the sense that the social aspect of the language must supposedly be studied through a single individual's *langue*, whereas the study of the individual aspect, or *parole*, is carried out by observing language used within its speech community, i.e. its social context.

A similar axiom of categoricity is found in the Generativist tradition, primarily developed by Chomsky in the mid-20th century. According to generativists, the dichotomy is between *competence*, or the knowledge that every person has of their own language, and *performance*, the real use that people make of language in specific contexts. As Chomsky puts it himself, linguistic theory cannot be based on performance, since it is not perfect enough:

> Linguistic theory is concerned primarily with an ideal speaker-listener, in a completely homogeneous speech-community, who knows its language perfectly and is unaffected by such grammatically irrelevant conditions as memory limitations, distractions, shifts of attention and interest, and errors (random or characteristic) in applying his knowledge of the language in actual performance. (1965: 4)

It was not until the late 1960s that linguists such as Weinreich, Labov and Herzog (1968), Hymes (1972) and Labov (1975) realised and demonstrated with empirical findings that variation was inherent to all languages and all linguistic levels, even the idiolectal level, and that it was not random, but systematic and patterned. The fact that a certain social group produces one specific variable systematically shows that there is stylistic and social stratification. Contrary to previous linguistic theories, who only considered internal factors as possible motivators of linguistic change, sociolinguists focus on the social forces that shape linguistic use, as well as internal factors. In this sense, Weinreich *et al.* state that:

> Linguistic and social factors are closely interrelated in the development of language change. Explanations which are confined to one or the other aspect, no matter how well constructed, will fail to account for the rich body of regularities that can be observed in empirical studies of language behaviour. (1968: 188)

Therefore, linguistic variation was proved to be patterned and determined both by internal –linguistic– factors such as sentence stress or word order, and also by external –social– factors, such as gender, social class, educational level etc, and it is indispensable to consider both types of factors in order to carry out an accurate description of language. As Labov explains:

> One cannot understand the development of a language change apart from the social life of the community in which it occurs. Or to put it another way, social pressures are continually operating upon language, not from some remote point in the past, but as an immanent social force acting in the living present. (1972a: 3)

Labov (1982) argues that internal and external factors are independent from each other, in the sense that if an internal factor is changed, other internal factors may be affected but external factors do not change; and vice versa, if an external factor is changed, other external factors may change, but other internal factors will stay unaffected. At the same time, internal factors are independent from each other whereas external factors are interactive. As Labov states, “interaction is exceptional with internal factors, but it is the rule rather than the exception for external constraints” (1982: 52).

Since its origins, one of the major goals of variationist sociolinguistics has been the study of speech communities characterized by **language contact** (e.g. Weinreich 1951; Ferguson & Gumperz 1960; Gumperz 1964 among others) and to understand the linguistic outcomes derived from language contact (Sankoff 2002: 640). However, mainstream sociolinguistic research has focused on monolingual speakers and communities, and only few sociolinguists have continued to focus their research on language contact. The reason for this may be, as Sankoff explains, the fact that bilingual and multilingual communities present more variation than monolingual communities. Speakers have different levels of proficiency of the languages involved, which is translated into a higher inter-individual variation, which in turn makes it much more difficult to account for the social factors that explain the language contact situation (Sankoff 2002: 640). However, studies in language contact can shed light on the relationship between social factors and linguistic change, as Turell and Corcoll assert:

> The study of language contact (…) constitutes an essential element in the understanding of linguistic activity, and can also contribute to a better understanding of the externally-motivated dimension of language variation and change, because it allows for inquiring into not only the pragmatic contexts that determine the great variety of meanings expressed by each LC [language

> contact] feature, but also the psychological conditions and the social situations favouring the occurrence of this contact". (2006: 58)

Language contact can be considered as an external factor that can influence linguistic variation. However, language contact itself is also triggered by both internal and external factors that can be the source of both inter- and also intra-individual variation, which is of fundamental interest to the present PhD dissertation. These internal and external factors and the relationship to variation within the group and the individual will be further exposed in section 3.2.3, which is dedicated to the variation that arises as the result of language contact.

Another fundamental contribution of the variationist framework was the close relationship that was established between the synchronic and diachronic dimensions of the study of language, which had previously been considered separately. Up until that moment, the mainstream view of the study of language was the Saussurean dichotomy between diachrony and synchrony and his well-known analogy of to cuts made through the trunk of a tree. In this light, the study of language could be carried out either by making a horizontal cut and observing language at a single point in time, i.e. a synchronic study, or by making a vertical cut and examining the development of a particular feature over time –diachronic perspective– (Aitchison 2012: 11). Apart from the opposition between these two viewpoints, which in Saussure's terms were "absolute and allowe[d] no compromise" (Saussure 1915/1974: 83), previous linguistic theories maintained that language change was unobservable, and only its results could be detected. In this sense, Bloomfield states that "the process of linguistic change has never been directly observed; […] such observation, with our present facilities is inconceivable” (1933: 347). Thus, up until that point, historical linguistics, which was the field most concerned with linguistic change, centred the examination of change on the study of data from different points in history and the description of the comparison between those stages. However, this approach provided little insight into the reasons for the changes and how they had taken place (Bailey 2002). In other words, the diachronic perspective did not account for fundamental questions such as the social significance of the variants that coexisted in the community during the time the change was in progress, or how the minor variant took over the major one (Chambers 2009: 200).

According to Chambers, Labov’s synchronic approach to the study of language change is “the most striking single accomplishment of contemporary linguistics” (2009: 160). Variationist sociolinguistics could finally bridge the gap between the so far irreconcilable synchronic and diachronic perspectives by demonstrating that the study of synchronic variation was the best way to study a diachronic linguistic change. Through the study on Martha’s Vineyard and New York City[2], Labov demonstrated that linguistic variation was the main indicator of a linguistic change in progress, and that the study of variation allowed tracking changes as they were taking place. Apart from this groundbreaking change in the linguistic paradigm, another major contributions of variationist sociolinguistics to the study of language variation and language change also concerns innovative methods for the analysis of variation and the observation of linguistic change, in particular, the

[2] See Labov 1966 and 1972a for a detailed account of these studies.

proposal of two different ways to observe change in progress: studies in apparent time and studies in real time, which are explained in the following section.

1.1. Observing change in progress: apparent and real time

The ideal way to observe linguistic change in progress is to compile data in **real time**, which implies collecting data from the same community in two considerably different points in time. This way, the changes can be tracked objectively, especially if the same individuals are studied in both points in time. Real time studies can take two different forms: **trend studies** and **panel studies** (Labov 1994: 76). Trend studies are the simplest way to go back to the community, in that they involve selecting the same social group that was studied in the first place in terms of their social characteristics, but not the same individuals. The main objective of this methodology is to observe linguistic change undergone by the same social group, since the individuals may change from one measurement time to another, while the speech community remains constant. On the other hand, panel studies involve locating the same individuals who were involved in the first study and studying the changes that they have undergone, as representatives of the changes occurring in their community. However, studies in real time, and especially panel studies pose major methodological problems for the researcher. Firstly, if the data needs to be collected from scratch, it may not always be possible to wait for a considerable amount of time (normally ten or fifteen years) to be able to report observations. If the researcher does not wish to wait for so long, access to previously collected data is required, in which case, two major difficulties arise. On the one hand, data collected in both points in time should be equivalent in aspects such as the collection method, the length, the quality of sound, the recording device and other characteristics that may influence the subjects' linguistic production. On the other hand, even when suitable material is already available for the first measurement time, it is usually very difficult for the researcher to locate the same individuals after so many years to be recorded a second time (in the case of panel studies).

In order to overcome these major methodological problems posed by studies in real time, the variationist framework proposed one of the "most important innovations" in linguistic studies, which work as a "surrogate for the real-time examination of data at different points in history" (Bailey 2002: 312): the **apparent-time construct**. The apparent time hypothesis (Labov 1966, 1972a) maintains that individuals retain their childhood linguistic patterns, and thus remain stable, and changes in the community occur over different generations. In this light, a study in apparent time involves sampling and comparing different age groups at only one measurement time, and comparing the differences that arise in different generational groups.

Despite the fact that the apparent-time construct has proved to be a reliable tool to study linguistic processes from a synchronic point of view, patterns of linguistic features that correlate with age can also indicate other types of change in the speech community (Tagliamonte 2012: 43). Labov (1994) described four possible patterns of how individuals in particular and communities in general may change or not change over time, and how all the possible combinations can be interpreted. Sankoff and Blondeau (2007:

561-562) group these four possible interpretations into two observable synchronic patterns. A “flat” pattern would show no age differentiation, which would have two possible interpretations: a) the community, as well as the individual speakers, remain stable, i.e. no change occurs (Interpretation #1); or b) all the speakers in the community change at the same time, which would imply that both younger and older generations are changing at the same time and in the same direction (Interpretation #4). On the other hand, the pattern may be a regular slope with age, which can be interpreted as: a) the community remains stable over time, but individuals change as they get older, and all the generations change in the same way (Interpretation #2, **age-grading**), or b) individuals retain their childhood patterns and change occurs over generations (Interpretation #3, apparent time). Sankoff (2005) suggests that there can be a further interpretation if we observe speaker instability correlated with speaker age: on the one hand, age grading should make reference only to “a generational pattern that is cyclic or repeats as a function of cultural dictates of what is appropriate to speakers of a given age” (Sankoff & Blondeau 2007: 562), in other words, generation after generation, speakers will change in the same direction as they grow older, because certain patterns will be considered more appropriate for certain ages. The age grading interpretation implies that individuals remain unstable whereas the community remains stable. On the other hand, **lifespan change** would imply that “individual speakers change over their lifespans in the direction of a change in progress in the rest of the community” (Sankoff 2005: 1011), which does not imply that the next generation will suffer the same change. According to this interpretation, both the individual speakers and the community should be regarded as unstable. These five possible patterns and interpretations can be seen in Table 1.

Table 1: Patterns of change in the individual and the community (adapted from Labov 1994:83) showing Sankoff's (2005) addition of a pattern reflecting lifespan change. Source: Sankoff & Blondeau (2007: 563).

Synchronic Pattern	Interpretation	Individual	Community
Flat	1. Stability	Stable	Stable
Regular slope with age	2a. Age-grading	Change	Stable
Regular slope with age	2b. Lifespan change	Change	Change
Regular slope with age	3. Generational change [="apparent time" interpretation]	Stable	Change
Flat	4. Communal change	Change	Change

Patterns of change that involve changes undergone by the individual, i.e. age-grading and lifespan change, are of utmost importance for the present PhD dissertation. Due to the forensic application of the present study, which requires a focus on the individual rather than the community, an apparent time study would not have been suitable to test the hypotheses under consideration. One of the research questions raised by the present dissertation concerns what types of changes, if any, the phonological patterns under study undergo in the specific subjects in the present corpus of study. To answer this question, a panel study, by which the same speakers are compared at two different points in time, was the only suitable type of study to be carried out.

Apart from the different methods to observe change in progress, the variationist framework also provided other methodological innovations regarding data collection and analysis. The following section comprises an account of such main innovations which are particularly relevant for the present PhD dissertation, namely, the importance of analysing spontaneous speech and the sociolinguistic interview as the main tool for data collection.

1.2. Sociolinguistic methods

The major interest for sociolinguistics is the **vernacular**, which is defined by Labov as “the style in which the minimum attention is given to the monitoring of speech” (Labov 1972a: 208). In this light, more formal styles may not show regularity in linguistic patterns, and may imply some hypercorrection, but the vernacular is more systematic and clearly shows “the fundamental relations which determine the course of linguistic evolution” (Labov 1972a: 208). However, the Vernacular Principle poses one of the major paradoxes of the study of language in its social contexts: the **Observer’s Paradox**, or the fact that “to obtain the data most important for linguistic theory, we have to observe how people speak when they are not being observed” (1972b: 113). In this sense, the major innovation of the variationist approach to the study of language was the study of the subjects’ most spontaneous style, in contrast to the idealised versions of language that previous linguistic theories studied, as well as the tool that they developed for data collection in order to overcome the observer’s paradox: the sociolinguistic interview.

The **sociolinguistic interview** was designed with the purpose of eliciting as much speech and as varied as possible, in order to monitor the correlations that may exist between the variables under analysis and style, which may cause style-shifting, i.e. the change of linguistic patterns by the same individual depending on the contextual style. Labov conceived the sociolinguistic interview as comprising five different speech styles that corresponded to five different contexts (Labov 1966, 1972a). Context A corresponds to the most **casual speech**, which is defined as “the everyday speech used in informal situations, where no attention is directed to language" (Labov 1972a: 86). Since casual speech is not normally found in the body of the interview due to its formal setting (as explained below), casual speech is to be found only in very specific moments of the interview. Such moments are when the speaker addresses a relative or friend or answers a phone call, or when they answer questions regarding past traumatic experiences such as whether they ever thought their lives were in danger or whether they ever got blamed at school for something they did not do. It is in these situations when the informant is thought to forget about the microphone and the formal situation and focus on their experiences explaining them in their most natural and unmonitored style. Context B is the body of the interview, in which the speaker produces **careful speech**, which is "the type of speech that normally occurs when the subject is answering questions which are formally recognized as "part of the interview" (Labov 1972a: 79). In other words, due to the formal setting of an interview, normally with an unknown interviewer and a recording device, the subject adopts a more careful speech than the type of speech they would use with friends or relatives (casual speech), but in turn, careful speech is less formal than the speech used in a job interview or a public speech. After the interview, the interviewer may ask the subject to read a text or a set of texts which have previously been prepared so that they concentrate as many variables under analysis as possible. This situation corresponds to Context C, **reading style**. After reading the texts, the subject may be asked to read a **word list** (context D), which is a more formal context as the previous one, which is translated into more attention paid to speech, and finally, even more attention to speech is paid in Context D', where the subject is asked to read a list of **minimal pairs**, the most formal context.

Distinguishing casual speech from contexts C, D and D' is very easy, since the last three occur in a formal setting where the subject is asked to read a previously prepared text or list of words. However, the difference between casual speech and careful speech (context B) is much trickier. Certainly, Labov's identification of the contexts in which casual speech is most likely to appear (e.g. the danger of death question) is of great help to the researcher. However, the difference between careful and casual speech is defined as a rather categorical one, which does not acknowledge that the most unmonitored version of our language may come in the form of a continuum, with different ranges of unselfconscious styles which subjects may use in different occasions (Shilling-Estes 2007). For example, the type of casual speech that we may use with our parents may be somehow different from the casual speech we use with our friends. Moreover, the type of speech found in the interview (categorised by Labov as careful) may be more casual or more careful depending on the speaker and their level of self-consciousness present in the interview setting. Such is the complexity in trying to draw the line between casual and careful speech that many sociolinguists, including Labov himself, have decided at some point to ignore this difference and consider these two styles together. In his 1966 study on New York City, Labov makes the distinction between casual speech, as defined above, and **spontaneous speech**, which he defines as "a pattern used in excited, emotionally charged speech when the constraints of a formal situation are overridden" (Labov 1972a: 86). According to his initial definition of spontaneous speech, it would be equivalent to careful speech, since it is the type of speech that appears in the course of the interview. Thus, spontaneous speech is “the counterpart of casual speech which does occur in formal contexts, not in response to the formal situation, but in spite of it” (Labov 1972a: 86). Yet, Labov goes on by stating that “while there is no *a priori* reason to assume that the values of the variables will be the same in spontaneous as in casual speech, the results of this investigation show that they can be studied together” and that “they will both be measured under the heading *Style A*, or casual speech in general” (1972a: 86-87). Later on, in a study on the Philadelphia neighbourhood, Labov considers “both ‘casual’ and ‘careful’ speech as defined in Labov 1966” as being included within the category of spontaneous speech (1989: 11). Thus, as Rickford and McNair-Knox argue:

> What came to define the sociolinguistic/variationist approach to language was its use of recorded corpora of *spontaneous* (real, natural, conversational) speech in the new (Labov 1989) sense. There was an unspoken consensus that while it was valuable to try to get as much *casual* speech (in the old sense) as possible, the operational difficulties of separating casual from *careful* speech made further attachment to the theoretical distinction unrealistic. (1994: 238-239)

Apart from the difficulty of distinguishing between casual and careful speech, the sociolinguistic interview may also pose some methodological problems. On the one hand, it has been criticised as being less natural than other types of interviews (Wolfson 1976), since subjects may avoid talking extensively about their views and opinions and try to provide a ‘correct’ or ‘polite’ answer without talking too much. On the other hand, the interview is not a typical everyday situation of a casual conversation, and subjects may react in different ways. Subjects may be shocked to be asked certain questions, which they may consider as impolite or inappropriate. Also, despite Labov's successful use of the 'danger of death' question, the same question has proved to be quite unsuccessful in other investigations. In a context characterised by much violence, the subjects may narrate these sorts of experiences without much excitement or emotional involvement (see Milroy & Gordon's (2003: 66) account on Milroy and Milroy's studies in Belfast). On the other hand, subjects may not want to talk about a near-death experience due to precisely the terrifying contexts they entail (e.g. Butters 2000), or their answer may just be "no" if they have never had such experience (Shilling-Estes 2007).

Other data collection techniques have been used in sociolinguistics with the aim to overcome the limitations that the sociolinguistic interview may pose. Some of these data collection techniques may involve modifications of the sociolinguistic interview itself, such as interviewing groups of friends, instead of a single individual, in order to record the dynamics between friends that may prompt the use of casual speech (e.g. Labov *et al.* 1968), or recording spontaneous conversations (e.g. Milroy & Milroy 1977, 1978). In addition, an ethnographic approach, based on anthropological linguistic studies, has also been used in sociolinguistics, which involves analysts integrating themselves in the community and collecting linguistic data from a close relationship developed with the informants (e.g. Eckert 2000; Wolfram & Shilling-Estes 1995, among others).

In any case, despite the few drawbacks that the sociolinguistic interview presents, and the fact that it may work very differently depending on the subject and the social context, it still remains a fundamental tool for collecting valuable linguistic data. One of its major advantages is the wide range of styles that are concentrated in a relatively short period of time in comparison with other more casual types of conversations, where the researcher may need many hours of recorded conversation to get the same amount of speech and in such different styles.

The design of the corpus of the present PhD dissertation is based on the methodological proposals by variationist research as regards the study of spontaneous speech and the data collection techniques. As will be explained in section 6.1, the corpus of study is divided into two subcorpora. On the one hand, the subjects under the *LanCon* subcorpus, who have been in a long-term situation of language contact, were recorded in sociolinguistic interviews, and on the other, the *InSit* subcorpus, which contains data from speakers who have remained in their community (*in situ*), consists of public interviews available on the Internet. As regards the use of data collected for other purposes (rather than linguistic/sociolinguistic) or public speech, Milroy and Gordon argue that "data from public speech can be fruitfully applied to sociolinguistic research" (2003: 51) as in the case of Hay *et al.* (1999), who studied phonetic variation in the speech of Oprah Winfrey using broadcasts of her show. Thus, the present PhD dissertation shares its data collection techniques with other variationist sociolinguistic studies, and also its focus on spontaneous speech, as defined by Labov (1989), which is the kind of speech elicited in the sociolinguistic interviews and broadcast interviews contained in the corpus of study. The analysis of spontaneous speech in the present study relates to its main purpose of application to forensic contexts, since spontaneous speech is the style most present in forensic cases.

After defining the synchronic approach to diachronic change, and the main methods and techniques proposed by variationist sociolinguistics to study language variation and change, it is of utmost importance to define the main object of study with which variationist research is most concerned: the sociolinguistic variable. The following section is dedicated to the sociolinguistic variable, with particular attention to its identification, codification and analysis.

1.3. The sociolinguistic variable

The theory of language variation considers linguistic behaviour from the point of view of variable rules, in opposition to categorical rules. The basis of variable rules are factors, which can be linguistic, stylistic and social, which restrict the application of the rule or the occurrence of a determined variant in a particular context (Turell 1995: 23-24). Variable rules can be represented as follows:

$$X \rightarrow Y \,/\, \_\_\, Z$$

where, for example, linguistic phenomenon X becomes linguistic phenomenon Y under the condition that X occurs, in this case, before Z. An example of such variable rule would be the production of /s/ as [ʃ] when a palatal approximant [j] follows, as in the words *miss you* [mɪʃ ju]. As we have seen, the factor that restricts the application of –or that **correlates** with– a specific variant can also be social, in the sense that a certain social condition regarding, for example, gender, class, level of income, language contact, etc. needs to be given in order for the variable to apply. Also, factors may be stylistic, since formal contexts may prompt certain variants that might not occur in more casual contexts and vice versa. Sociolinguistics is primarily concerned with establishing the correlations that exist between the dependent variables –i.e. the linguistic phenomena– with the independent variables –the factors– since correlations reveal, in Chambers' words "the way in which language encodes social relations" (2009: 25). Thus, variationist sociolinguistics focuses on the space that exists between the 0% and the 100% of possibilities of application of a rule, rather than the two extremes (Turell 1995: 23).

Linguistic variation is present at all levels of language, since speakers can choose between different ways of saying the same thing in terms of pronunciation, grammar, vocabulary and any other linguistic level. This fact, known as **sameness of meaning** (Labov 1982, Sankoff 1982, Lavandera 1984), implies that despite variants may not be semantically equivalent, what counts for sociolinguistic research is that the forms "can be used interchangeably in some context even though they may have distinct referential meaning in other contexts" (Tagliamonte 2006: 73). Thus, a linguistic –dependent– variable is a set of interchangeable variants, which may correlate with independent variables such as linguistic factors, stylistic contexts and social factors such as gender, age or social class. Consequently, all the variants of a specific variable are normally used by all the speakers, but they will use them in different proportions depending on how they are affected by these correlations.

For a phenomenon to be a linguistic variable, it needs to be variable, continuous and quantitative (Labov 1966). It is variable in that it changes depending on the linguistic, stylistic or social context; continuous [3] in the sense that variants take on social significance depending on their linguistic distance (for variables such as vowel formants, which are gradual) or their linguistic differentness (for variables such t-glottalling, which can be considered categorical) from the standard variant; and quantitative in the sense that its significance is determined by their relative frequency (Chambers 2009: 25). Moreover, a sociolinguistic variable should be frequent, structural and have a highly stratified distribution, as Labov explains:

> First, we want an item that is frequent, which occurs so often in the course of undirected natural conversation that its behaviour can be charted from unstructured contexts and brief interviews. Secondly, it should be structural: the more the item is integrated into a larger system of functioning units, the greater will be the intrinsic linguistic interest of our study. Third, the distribution of the feature should be highly stratified: that is, our preliminary explorations should suggest

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[3] This use of the term ‘continuous variable’ from a sociolinguistic point of view is not to be confused with the concept of ‘continuous variable’ from a statistical point of view. In statistics, variables may be a) discrete, meaning that they take on a limited number of values, such as gender (either male or female) or social class; and b) continuous, which implies any value within a range of values on a scale, such as age, for example. A continuous variable from the sociolinguistic perspective can include both continuous (such as Labov’s variable (eh)) and discrete variables (such as Labov’s (r)) in statistical terms. Another clarification regarding common terminology with different meanings involves the different use of the term ‘categorical’, which in statistics is an alternative term for a discrete variable, whereas in sociolinguistics, it means lack of variation, and therefore, out of sociolinguistic interest.

> an asymmetric distribution over a wide range of age levels or other ordered strata of society. (1972: 8)

Labov clarifies that, when choosing a variable to study, there are contradictory criteria that may pull researchers in different directions. On the one hand, the feature should be salient if they want to study the relationship between social attitudes and language behaviour. On the other hand, however, it is also important that the speaker is not very conscious about the feature, since that will elicit a more real use of it and, in turn, a more reliable observation (Labov 1972: 8).

Sociolinguistic variables have traditionally been classified into three main types depending on speakers' awareness of them. Firstly, **indicators** are socially stratified –i.e. different social groups use them differently– but are not subject to stylistic variation, which means that speakers seem not to be very aware of their existence. **Markers**, on the other hand, are both socially and stylistically stratified, and speakers are more aware of them. Chambers and Trudgill (1998) explain that speakers may be more sensitive to the social meanings of markers because of three main reasons. Firstly, a marker is normally subject to comments and criticism by the community, a fact that the authors relate to the divergence between pronunciation and orthography. Secondly, a feature may be involved in an ongoing linguistic change, which means that a speaker may be more aware of it if their neighbours or friends use different variants. Thirdly, markers may have phonological implications, rather than just phonetic, in that they might be the source for neutralisation of phonological contrast, and thus speakers may be more aware of their effect. If for some reason the awareness of a marker increases and speakers are so aware of them that they –wrongly– identify it with the whole community, then the variable turns into a **stereotype**. Of these three types of variables, it is markers that are most subject to sociolinguistic study, and especially phonological variables, because they are more frequent than other kinds of linguistic variables (Watt 2007: 6). The majority of phonological variables analysed in the present study are markers, since they may show stylistic variation (such as t-glottalling, t-tapping, linking r), although some others are indicators (such as vowel alternation), which do not show stylistic variation.

In order to study a linguistic variable accurately, a two-step methodological process needs to be followed (Guy 1993; Tagliamonte 2006). Firstly, the researcher needs to identify the variants of the variables, i.e. what different realisations the variable has depending on different contexts, and also to define the **scope of variation.** In other words, depending on the researcher's hypothesis, s/he will need to define a certain context of study which might have a certain effect on the variation that the variable exhibits. Secondly, the data, which needs to be representative of the community under study, has to be **coded and quantified** properly.

In the case of phonological variables, defining their scope is as important as defining the variable itself or quantifying it properly. Sometimes, the scope of the variable may be the scope of the phoneme itself, which means that the variable may show variation in all the contexts containing the phoneme. For example, a process such as smoothing, by which words containing the triphthongs /aɪə/, as in *higher*, and /aʊə/, as in *tower*, may be pronounced [haə] and [taə], is a variable rule that applies to any word containing these phonemes independently of the context. However, most often than not the scope of the variable needs to be defined in a more restricted way, since the rule may not apply equally to all the contexts where the phoneme appears. A process such as t-glottalling does not happen whenever there is an underlying /t/, since it is phonologically conditioned, that is, the rule can only apply when the /t/ is in coda position[4]. However, the phonological constraint is not the only one that affects this process, since the **social indexing** that accounts for them –i.e. the correlations that the variable has with social factors– also needs to be identified. The process (or absence of the process) of t-glottalling in SSBE, for example, does not have the same social meaning in pre-consonantal position than in prevocalic position, since its production in pre-consonantal and final position (as in the words *foot* or *football*) is considered to be a feature completely established in SSBE, whereas its production in prevocalic position (as in the word *water*) is considered non-standard (see section 6.2.2.3 for further details about t-glottalling). Moreover, sometimes the scope of the variable may apply only to a very restricted group of words, as in the case of the alternative pronunciation of *again* [əgen]~[əgeɪn] that only happens in a very specific group of words (basically *again* and *against*). Defining the correct scope of the variable is an essential task, and doing it wrongly may compromise the whole study. As Gordon explains:

> The variation associated with a given variable is shaped by social and linguistic factors, but one cannot untangle the effects of those factors until the boundaries of the variation

[4] A consonant is in coda position if it is preceded by a vowel, and they both belong to the same syllable (Ashby & Maidment 2005: 145).

> have been delineated. Failure to properly define the variable clouds the picture of the variation and may introduce serious bias to the results. […] [C]learly defining the variable helps ensure that one is comparing apples with apples. (2007: 21)

Defining the scope of variation includes making decisions as what phonetic contexts are included and which ones are excluded. One such decision may be related to what has been called the 'type-token question' (Wolfram 1969; Tagliamonte 2006): the question of whether to include items that are very frequent every time they occur or to include only some of them, since including every instance of the variable may end up in a distortion of the results (Tagliamonte 2006: 95). An example of such decision would be not to include the word *during* in the analysis of yod coalescence that has been conducted in the present PhD dissertation, since it practically always presents yod coalescence, whereas another word such as *duke* may or may not present this phenomenon. Since *during* is a very frequent word, considering it together with the rest of words would have distorted the results and would not have led to an accurate interpretation of the variable rule (see 6.2.2.1 for further details on this matter). Of course, for reliability purposes, those kinds of decisions need to be stated explicitly in the study so that it is replicable (Tagliamonte 2006: 86).

Once the variables have been properly defined and the corpus of study has been collected, the variables need to be coded, which implies, in the case of phonetic/phonological variables, listening to the corpus, identifying the variants, and devising a coding scheme to classify each one accordingly (Guy 1993: 243). In the case of discrete variables, such as Labov's variable (r) in his New York survey, the codification is pretty straightforward, if we are to believe, of course, that there exist such “discrete variables” in phonetic phenomena. As a matter of fact, in phonetics, the majority of features are continuous, as in the case of yod-coalescence or variables involving vowels, which make them trickier to code. In this case, the investigator needs to impose a classificatory criteria and break the continuum into identifiable parts, which in the end means treating continuous variables as discrete (Gordon 2007: 21-22). In these cases, it is important to acknowledge that any division in the continuum is arbitrary, and if done, the investigator needs to ensure that the criterion in the division is consistently maintained (Chambers & Trudgill 1998: 52).

After the codification of the variables, a suitable quantifying methodology needs to be applied to the data, so that the investigator knows the numbers behind social indexing of variables, for which it is important to follow what Labov calls the ‘**principle of accountability’** (1972a, 1982). This principle says that all the realizations of a target variable, i.e. all the variants, must be taken into account in the relevant environments that have been defined. In other words, the instances where the variable could have occurred and it did not must be counted as well as the instances where it did occur. Then, the frequency of occurrence of variants can be calculated out of the total number of contexts in which it could have occurred but it did not.

The notion of linguistic variable, the correlations that variables show with linguistic and social factors, and the premises and protocols set by variationist sociolinguistics for their analysis are entirely relevant for the present PhD dissertation. The study presented here proposes a set of 14 sociolinguistic variables that are correlated with linguistic, stylistic and social factors, the analysis of which has been carried out following the premises established by sociolinguistics, which have been detailed in this section. As will be shown in Part II of this dissertation, the main objective of this study is to determine whether different individuals from the same speech community show different degrees of variation, which would only be explained by the speaker factor rather than social factors. Thus, the study of sociolinguistic variation is proposed as a useful tool to be applied in forensic linguistics. As will be shown in Chapter 2 and Chapter 3, variationist sociolinguistics and forensic linguistics are two disciplines very much related to each other, since both of them study variation. As explained in Chapter 1, variationist sociolinguistics focuses mainly on **variation in the group**, in the sense that it tries to define and explain the specific linguistic patterns exhibited by certain social groups, which are defined in terms of social factors such as gender, age, social class, etc. Similarly, forensic linguistics is also concerned with variation in the group. A very usual task to be undertaken by a forensic linguist is that of linguistic profiling, a situation that is given when only one linguistic –oral or written– sample is available and the expert is asked to provide information about the social characteristics that may define the individual that has produced that sample in order to narrow down the list of possible suspects. In such situation, the expert will need to resort to all the sociolinguistic research conducted about the geographical, social and stylistic factors with which the linguistic phenomena observed may be correlated. Apart from variation in the group, forensic linguistics is mostly concerned with **variation and the individual**, in other words, differences between different individuals –inter-individual variation– and differences within the same individual –intra-individual variation. In this sense, sociolinguistic research is also used in forensic speech and text comparison, where the forensic linguist is asked to compare two oral or written samples –the disputed and the non-disputed samples–, analyse the differences and similarities that they present, and reach a conclusion about the possibility that they have been produced –or not– by the same individual. In such cases, the expert's main focus is not social stratification in the linguistic phenomena *per se*, i.e. variation in a specific social group, but defining individual variation in order to determine whether the variation present may be due to inter-speaker or intra-speaker differences. Apart from this, in order to determine the consistency and/or distinctiveness of the linguistic phenomena analysed so as to establish whether the samples have been produced or not by the same individual, the forensic linguist may need to compare the samples under analysis with relevant population data, and this data very often comes from sociolinguistic research (see section 3.3 for further information about this matter). The present PhD dissertation is a clear example of the close relationship between sociolinguistic research and forensic linguistics, since it proposes the study of a set of sociolinguistic (phonological) variables as a useful tool to differentiate between samples produced by different speakers and identify samples produced by the same speaker. Chapter 2 goes deeper into the field of forensic linguistics, especially the area of forensic phonetics with which the present PhD dissertation is mostly concerned, and Chapter 3 elaborates on the notion of individual variation and its relationship with the field of forensic linguistics.

Chapter 2
Forensic Linguistics

The present chapter describes the field of forensic linguistics, and its sub-branch forensic phonetics, which serves as main framework for the present PhD dissertation. An insight into the origins of this field will be provided, as well as its major areas of interest and an overview of the major controversies that have arisen in the field. Of special interest is the definition of the forensic parameter as defined by the international community that is included at the end of the chapter, which is particularly relevant for the analysis of the variables proposed in the present study.

Forensic linguistics can be defined, in its broadest sense, as the interface between language and the law. Coulthard and Johnson (2007: 5) place the birth of the discipline as such in 1968, when Jan Svartvik published his case study *The Evans Statements: A Case for Forensic Linguistics*. Svartvik demonstrated that the language used in the witness statements by Timothy Evans when he was accused of murdering his wife and daughter (charges for which he was subsequently hanged) differed greatly from the language used in the disputed statements, thus demonstrating that Evans might have not been guilty. At first, the growth of the discipline was slow, and the first decades involved the work of individual linguists who were consulted sporadically in judicial processes involving linguistic evidence. However, according to Coulthard and Johnson, forensic linguistics has become a more widely known area in the past twenty years for different reasons. On the one hand, the scientific production in the field has radically increased thanks to the creation of two professional associations, the IAFL [5] (International Association of Forensic Linguists) and the IAFPA [6] (International Association for Forensic Phonetics and Acoustics), which organise international and regional conferences every year, and also to a journal that publishes research carried out exclusively on forensic linguistics, *The International Journal of Speech, Language and the Law*. On the other hand, the extent of this discipline has reached both legal agents -i.e. police forces, lawyers and judges– who are increasingly asking linguists for their collaboration to solve crimes, and the Media,[7] a situation that has contributed to the spread of this discipline to the lay public, equating it to other more widely known forensic disciplines such as forensic psychology or forensic anthropology.

Three main sub-branches are commonly distinguished within the area of forensic linguistics, which are summarised in Figure 1: Language and the Law, Language and the Legal Process, and Language as Evidence. The first area, **Language and the Law**, is concerned with the linguistic analysis of legal texts such as laws, acts, contracts or wills. Specialists working in this area focus on aspects such as the comprehensibility of legal documents, ambiguity of texts, the linguistic problems that language minorities suffer within the legal system and translation matters. Secondly, the work of the expert linguist within the framework of **Language and the Legal Process** regards the analysis of the language used in any judicial process by any of its participants. Aspects involved in this area include the language used by any participant in a legal

[5] http://www.iafl.org/
[6] http://www.iafpa.net/
[7] See for example the recent publication in The New Yorker on 13th July 2012 which was a considerably extensive article about forensic linguistics, mostly in the US. http://www.newyorker.com/reporting/2012/ 07/23/120723fa_fact_hitt

process, that is, the language of judges, suspects, witnesses, and victims (such as victims of child abuse), the linguistic aspects of police interviewing, the language used by lawyers in examinations and cross-examinations, the language used by asylum seekers, courtroom discourse and courtroom interpreting and translating. Finally, the area of **Language as Evidence** entails the linguistic analysis of any linguistic production that constitutes evidence in a judicial process. Within this major area, we can find different sub-disciplines. Authorship analysis involves the comparison of written texts such as e-mails, letters and SMS texts in order to determine whether they have been produced by the same author or not. Plagiarism detection involves the determination of whether two texts have been produced independently or, on the contrary, one is plagiarized from another. Apart from this, forensic linguists can analyse linguistic issues around trademark and patent litigations. Also, linguistic analysis can shed some light on the sociolinguistic characteristics of writers or speakers whenever there is only one linguistic sample but no suspect, which entails a process of linguistic profiling. Finally, forensic phonetics involves the analysis of spoken evidence. One of the commonest tasks in forensic phonetics is forensic speech comparison, which involves the determination of whether the voices in two recordings may be similar or different enough so as to affirm that they may or may not have been produced by the same person. This last sub-field will be explained in more detail in the next section, since it constitutes the main analytical domain for the present dissertation.

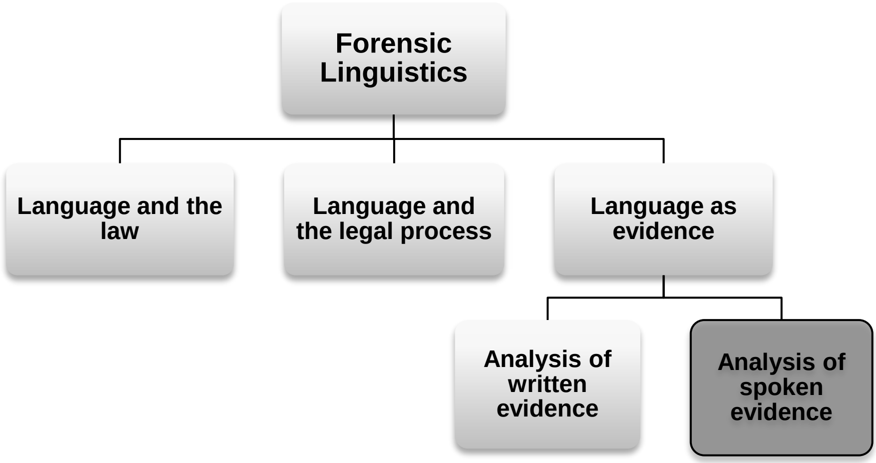


Figure 1: Main sub-branches of research within Forensic Linguistics.

2.1. Forensic phonetics and forensic speech comparison

Authors such as French (1994) and Foulkes and French (2001) have distinguished several areas of research concerned with the analysis of spoken evidence with forensic purposes. Based on these classifications and on recent developments of new areas dealing with the analysis of speech, this dissertation distinguishes six main areas of research within the analysis of spoken evidence with forensic application, which are summarised as follows and are illustrated in Figure 2.

Firstly, sometimes phoneticians are required to perform a job related to the acoustic signal, which might imply tasks like **quality enhancement of recordings**, so that the content can be deciphered, the **transcription** of the content of recordings, or an **analysis of their authenticity** if it is suspected that a recording might have been somehow altered or manipulated. Secondly, a

speaker profiling task may arise in a case where there is only one disputed recording but no suspects yet, in which case the phonetician may be required to analyse the sociophonetic traits present in the sample and give clues regarding the main linguistic characteristics of its speaker so as to narrow down the possible suspect candidates. Thirdly, sometimes the specific element under analysis may be a **disputed utterance or word** which needs to be deciphered, in that it may be particularly difficult to understand. The most common difficulties that might be encountered may be due to a bad quality or too much background noise, but other aspects such as a strong foreign accent can also be the cause of a disputed utterance (as in the case of the Greek doctor whose disputed word 'can' or 'can't' was fundamental, see Baldwin & French 1990; Foulkes & French 2001). Fourthly, a phonetician may also be required to evaluate ear-witness testimonies by means of **constructing a voice 'line-up'**. Constructing an accurate and fair voice line-up is a very complex task, and it should, although it is not always the case, involve the collaboration of an expert linguist (see Nolan & Grabe 1996; Nolan 2003). Fifthly, a very recent task that phoneticians have been asked to perform in forensic contexts is **Language Analysis for the Determination of Origin (LADO)**. LADO focuses on the determination of whether a speaker is actually from the place they claim to be. Foulkes and Wilson (2011) point out that this research area started to be developed in the 1990s due to an increase of asylum seekers, and, though expertise in this area is still rare, there has been an increasing presence of studies focusing on LADO in recent international conferences. Finally, the most usual task for forensic phoneticians is **forensic speech comparison**, which implies the comparison of a disputed sample –the speaker of which is not known– and a non-disputed sample –the speaker of which is known– in order to find similarities or differences, so as to reach a conclusion regarding the possibility of them having been uttered or not by the same individual.

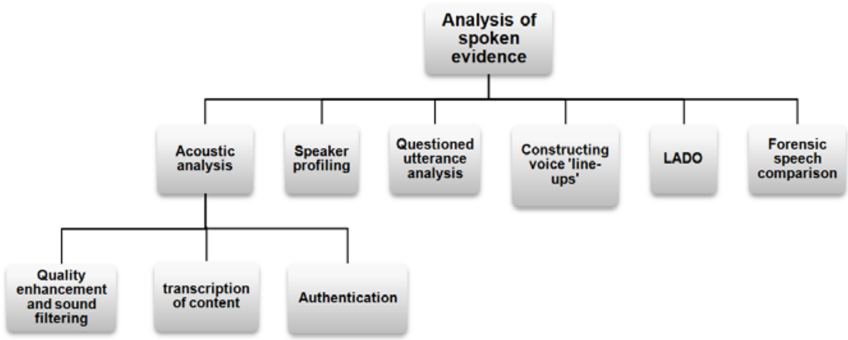


Figure 2: Main tasks involving spoken evidence. (Adapted from French 1994 and Foulkes & French 2001).

Forensic speech comparison, traditionally known as forensic speaker recognition, has been defined as "any activity whereby a speech sample is attributed to a person on the basis of its phonetic-acoustic properties" (Nolan 1994: 328). The term 'forensic speaker recognition' has lately been subjected to a remarkable debate, mainly the two different approaches by two groups, a group of UK-based and another group of Australian-based forensic phoneticians, through a series of articles published in the *International Journal of Speech, Language and the Law*: French and Harrison 2007 (UK), Rose and Morrison 2009 (Australia), and French *et al.* 2010 (UK). The debate lied around the way conclusions should be expressed in court (which will be detailed below), and also about the terminology that should be used. Both groups agree in the use of the term 'comparison' instead of 'identification', in the sense that the role of forensic phoneticians is not to make identifications, recognitions or verifications, but rather, to provide an assessment of whether the voice in the disputed sample fits the description of the suspect's. In this sense, the speech scientist provides the **trier of fact** (i.e. the judge or jury who needs to make decisions about facts in view of the evidence presented in the process) with the analysis derived from the comparison of the non-disputed and the disputed samples and it is the jury or the judge who will need to reach a decision about whether the two samples have been produced or not by the same speaker considering these and other pieces of evidence presented in the trial. However, they disagree on the use of the terms 'speaker' or 'voice'. Rose and Morrison (2009) adopt the term **forensic voice comparison** instead of the term used by the UK position statement **forensic speaker comparison**, alleging that the objects of comparison are recordings of voices and not speakers, in other words, they cannot comment on speakers –i.e. individuals– but voices. On the other hand, French *et al.* (2010) state in their rejoinder that "the fact that some of these features do not pertain to voice but to language and non-linguistic behaviours provides part of the basis for our referring to the forensic task as 'speaker comparison' rather than 'voice comparison' (French *et al.* 2010: 146). The present dissertation adopts a halfway position between these two terms, and uses the term 'forensic speech comparison'. This term emphasises, on the one hand, the fact that it is not only the voice that phoneticians analyse for forensic purposes, but also linguistic characteristics –as French *et al.* argue–, and on the other, the fact that it is not speakers that are being compared –following Rose and Morrison–, but their oral linguistic productions, i.e. their speech. At the same time, this term is analogous to the term 'forensic (written) text comparison' lately proposed in forensic linguistic terms (Turell 2010a), where the word 'text' is used rather than 'writer', precisely to highlight the fact that what is compared is written linguistic production. For these reasons, the present dissertation suggests that ‘forensic speech comparison’ is the most adequate term, and therefore, this is the term that will be used.

Despite this new terminology seems to be very accurate and as neutral as possible, it may not allow distinguishing between the different tasks comprised within the umbrella term ‘forensic speech/voice/speaker comparison’. Authors such as Nolan (1983, 1994) and Rose (2002), subdivide the task of ‘speaker recognition’ into different types depending on two major factors a) the person who performs the recognition –i.e. naïve v. technical speaker recognition; and in the case of technical speaker recognition, b) the type of task involved –that is, verification v. identification. Although these terms do not fulfil the latest requirements established by the international community, it is important to distinguish and define them in order to understand all the possible tasks involved in the analysis of spoken evidence, which are summarised in Figure 3.

Anyone can recognise a voice of a familiar speaker, as when somebody recognises a known voice over the telephone, although the speaker may not say their name. This type of **naïve speaker identification** is carried out without requiring any kind of special technique or phonetic analysis. Naïve speaker identification is often used as evidence in a trial, for example in cases where the victim, being the only person to have heard the offender’s voice, is required to identify it. This identification would typically be carried out with the use of a voice line-up, where different voices together with the suspect’s voice are presented to the victim so s/he can identify it (see Nolan & Grabe 1996; Nolan 2003).

If an expert phonetician is asked to carry out the recognition, there may be two different tasks in which they may perform. **Speaker verification** is a situation where "an identity claim from an individual is accepted or rejected by comparing a sample of his speech against a stored reference sample by the individual whose identity he is claiming" (1983: 8). In other words, verification involves a conclusion whether the **disputed sample** –from the offender– and the **non-disputed sample** –non-disputed or known in the sense that the suspect cannot deny that the voice in the recording is theirs– are consistent with having been produced by the same speaker. Conversely, **speaker identification** involves having a **disputed sample** to be compared to a set of samples from different suspects, which can be a closed set –and therefore it is sure that one of the suspect voices corresponds to the voice in the disputed sample–, or an open set –in which case it is not sure that the voice of the disputed sample might even be among the suspect samples. Therefore, the role of the expert in speaker identification is to decide if any –and if so, which one– of the suspect samples corresponds to the disputed sample.

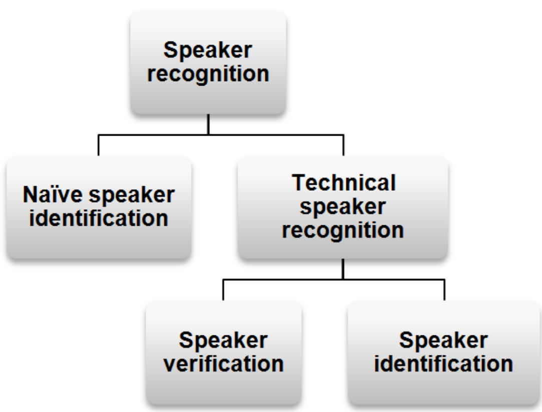


Figure 3: Types of speaker recognition following Nolan (1983) and (1994).

Technical speaker recognition, or following the new term hereby proposed forensic speech comparison, is carried out by experts who have been specially trained for this purpose and use special techniques to perform the required analyses. Several authors (Rose 2000; Nolan 1994; Baldwin & French 1990) have established two main approaches on which specially-trained phoneticians can base their comparison. On the one hand, **auditory analysis** is carried out by phoneticians by using solely their ear. As Nolan explains, here "ear" does not merely imply the physiological parts of the ear, but rather "a hierarchy of levels of processing in which, ultimately, the linguistic knowledge of the hearer is drawn on in a mental process of interpretation" (1994: 327). In other words, in auditory analysis, the phonetician makes use of their knowledge about general phonetics and phonology and the phonetics and phonology of the linguistic system at hand for the interpretation of the samples being analysed. On the other hand, **acoustic analysis** involves the use of specially developed techniques –normally involving specialised computer software aimed at the acoustic analysis of speech– together with the phonetician's knowledge of physics and the acoustic properties of the speech signal, especially those characteristics most relevant to the language under analysis.

There has been some controversy (see Baldwin & French 1990) as to which of these two techniques, auditory and acoustic, is the most appropriate in forensic speech comparison. The criticism against acoustic analysis is centred on the misleading concept of 'voice-prints' or 'linguistic fingerprints', an analogous term to fingerprints. The spectrogram has sometimes been erroneously considered as an objective capture of speech (e.g. Kersta 1962), by means of which forensic phoneticians could undertake their analyses and reach a definite conclusion. The nature of speech, and writing for that matter, is radically different from the nature of fingerprints or DNA. A single sample of DNA or a single fingerprint, if it is an adequate one, carries all the information necessary for the identification of the individual to whom it belongs, and it is completely identical to any other sample from the same individual. Conversely, any linguistic sample, either oral or written, and as long it may be, is just one of the many possible linguistic realisations that the subject is able to produce, and will never be identical to another sample produced by the same speaker in the same situation. Language is inherently variable, and nobody can say the same thing in exactly the same way twice. On the other hand, auditory analysis *per se* has also been criticised, in that in the context of such approach the analyst is not able to measure relevant features of speech such as vowel formants, fundamental frequency, voice quality etc. In view of the limitations of keeping each of the approaches to speech comparison separately, practitioners started to use both approaches as part of a complementary protocol. The **auditory-acoustic approach** combines the positive results and neutralises the negative aspects of each approach, since where the acoustic approach fails, the auditory approach will compensate, and vice versa.

Apart from the methods that should be used in this practice, there is another controversial issue within this field which affects the very question of whether forensic speech comparison should actually be carried out at all. According to Baldwin and French (1990), there are two opposite views on this. On the one hand, '**negativists'** consider that the infinite variability of speech makes it impossible to be able to reach reliable conclusions regarding whether the samples might have been produced or not by the same speaker. There are two different types of negativists, ultra-negativists (or ‘**ultra’s**’) believe that forensic speech comparison cannot be performed under any circumstance, whereas ‘**wets**’ argue that it is only valid to establish negative identifications, i.e. to say that two samples have not been produced by the same speaker. Baldwin and French consider that wets’ “middle ground is untenable” (1990: 4), in the sense that forensic speech comparison must be either accepted or rejected, but that it is not logical to have a position by which positive identifications are allowed and negative identifications are not. On the other hand, ‘**positivists’** maintain that it is possible and acceptable to produce both positive and negative identifications on the basis of phonetic and phonological properties.

Another major controversy that affects the field of forensic speech comparison regards the way conclusions derived from linguistic comparison should be presented in court. The way to express conclusions in court that has traditionally been most widely used in forensic speech comparison is the **probability scale**. Instead of using numbers to describe levels of probability, this scale uses words depicting levels of probability in order to avoid the idea that it is possible to reach an exact calculation of probability. Baldwin and French (1990) propose a scale with eight probability levels for a positive identification, and four levels for a negative identification, which is presented in Table 2.

Table 2: Verbal probability scale proposed by Baldwin y French (1990).

POSITIVE IDENTIFICATION	**NEGATIVE IDENTIFICATION**
Sure beyond reasonable doubt	*Probable*
There can be very little doubt	*Quite probable*
Highly likely	*Likely*
Likely	*Highly likely*
Very probable	
Probable	
Quite possible	
Possible	
…that they are the same person	… that they are different people

Several authors (e.g. Nolan 1991; Broeders 1999) consider that these levels are somewhat confusing, in the sense that it is not clear, for example, what the difference between two apparently synonymic terms such as ‘likely’ and ‘probable’ is. As a “provisional solution”, Broeders (1999: 235) proposes a new and simplified scale that tries to avoid this confusion (see Table 3).

Table 3: Verbal probability scale proposed by Broeders (1999).

With a probability bordering on certainty
Highly probably
Probably
Probably not
Highly probably not
With a probability bordering on certainty not
Possible
No judgement
…that they are the same person

However, other experts (Champod & Evett 2000; Rose & Morrison 2009 among others) argue that common statements such as ‘due to the high level of similitude between the compared samples, it is highly probable that the two samples have been produced by the same speaker’ are problematic. As Rose (2002) explains, statements based on probability express the probability of the hypothesis given the evidence, and this statement is not logical, since such statements cannot be made based on scientific evidence solely, but it is necessary to know other pieces of evidence that are part of the judicial process as well. In other words, the voice in the sample that belongs to the person who has committed the crime –the disputed sample– can resemble many other voices, and if the expert concludes that it is probable that that voice has been produced by the suspect, it can only be because s/he is aware of the existence of other pieces of evidence that relate the suspect to the crime. Consequently, the expert cannot reach a conclusion such as ‘it is probable that the two voices have been produced by the same person’ based solely on scientific evidence, since it is not possible to discard the possibility that the disputed voice could also resemble other individuals’ voices unrelated to the case. As Broeders himself points out, to reach such conclusion would involve transposing the conditional, or what is called the **prosecutor’s fallacy**, which would be:

> …to pronounce upon the probability of a hypothesis given the evidence rather than to pronounce upon the probability of the evidence given a hypothesis. […] Or again, the mere fact that the suspect wears size thirteen shoes does not make him more suspect than all other people with the same size shoes”. (1999: 236)

Therefore, to provide such statements requires having access to other evidence of the process, and that is the role of the trier of fact, and not the scientific expert's.

With the objective of moving away from the prosecutor's fallacy, the UK Position Statement (French & Harrison 2007) propose a new framework for the expression of conclusions. Firstly, they suggest taking a first decision in terms of the **consistency** of the samples. In other words, based on the similarities and differences that the samples show, the expert needs to decide whether the samples are consistent with the hypothesis that they were produced by the same individual. This first decision may have three possible outcomes about the samples:

1) The samples are consistent,

2) The samples are not consistent, or

3) The samples cannot lead to any decision.

A consistent outcome would lead to a **distinctiveness** test, by which the expert has to comment on how peculiar the similarities between the samples are. The authors propose a scale of five levels so as to rate the distinctiveness of the common features:

5) Exceptionally distinctive, i.e. "the possibility of this combination of features being shared by other speakers is considered to be remote" (French & Harrison 2007: 141).

4) Highly distinctive.

3) Distinctive.

2) Moderately distinctive.

1) Not distinctive.

In this sense, the UK group argues that the classical verbal probability scale may reflect a categorical decision, since in the end, what is being said is whether the samples are similar or not. Therefore, according to these authors, this new conceptual framework provides a solution for this limitation. Yet, they comment on one possible exception where a categorical conclusion may in fact be acceptable, namely when the samples constitute a closed set of suspects and it is certain that the person who has committed the crime can be found within it. In this case, if the voices are distinctive enough from one another, they justify the categorical expression of the results.

The design of this new framework for the expression of results leads Rose and Morrison (2009) to express their opposing views on this reasoning and the advantages of an alternative Bayesian framework in their response. Firstly, the authors argue that the UK Position Statement does not clarify how the expert needs to proceed when they make a decision about distinctiveness, which is a fundamental issue in order to help the judge or the jury reach a conclusion. Secondly, they suggest that the UK Position Statement seems to treat speech as if it was discrete, like DNA, which makes their approach to the nature of the evidence wrong. Finally, Rose and Morrison believe that it is contradictory that the UK Position Statement criticises the probability scale because it might be interpreted as a categorically conclusion, while they allow a categorical conclusion in the exceptional case of a closed set comparison.

Rose and Morrison (2009) claim that the appropriate conceptual framework to carry out forensic speech comparison is the **Bayesian likelihood ratio**, which represents the framework within which other forensic sciences are being developed. As the authors explain, a judicial process is about making decisions about uncertainties, and “the best way of quantifying uncertainty is by using probability” (2009: 143). Therefore, the best way to quantify this probability is to use Bayes’ theorem, which is used to calculate the probability of a hypothesis given the evidence.[8] According to these authors:

> The *likelihood ratio* is the most important metric in forensic voice comparison because it is a measure of the *strength of the evidence* in favour of the hypothesis, and it is what the expert should try to estimate. […] [It] is a ratio of probabilities, but these probabilities are probabilities of *evidence*, not *hypotheses*. The likelihood ratio quantifies how much more likely you are to get the differences between the suspect and offender speech samples assuming they have come from the same speaker than assuming they have come from different speakers. (2009: 144-145)

In this light, the main role of the expert within this framework is to quantify the strength of the evidence estimating its likelihood ratio, which is the probability of the evidence considering the hypotheses given by both the defence and the prosecution.

The main problem with the Bayesian framework in forensic speech comparison is, in contrast with DNA analysis, the lack of population

[8] See Champod and Evett (2000), Rose (2002), Rose and Morrison (2009) among others for a detailed account of the Bayesian likelihood ratio as applied to forensic speech comparison.

distribution data of the main phonetic parameters that are compared. The calculation of the likelihood ratio requires a suitable population distribution, i.e. a bank of relevant data of the linguistic characteristics that are to be analysed, in order to determine whether the similarities and differences found between the samples are strong enough to establish whether they have been produced by the same or by different individuals. Despite the fact that countries such as Australia and Spain, according to Rose and Morrison (2009: 158), are already compiling a population distribution for only some phonetic traits and for only some dialects of English and Spanish in order to adopt the Bayesian framework, its implementation still represents a major challenge for most countries around the world.

In a recent survey published at *The International Journal of Speech, Language and the Law*, Gold and French (2011) present the results of the first international survey on forensic speech comparison practices. This survey reflects the preferences of different countries that carry out forensic speech comparison as regards the methodology used, their conclusion framework and the phonetic features examined. As regards their conclusion framework, the authors explain that there is no consensus in the international community on how conclusions should be expressed in court, precisely due to the current debate. Results show that the most extended preferences are the verbal probability scale and the proposal by the UK Position Statement, especially when the methodology of analysis that is used is the auditory-acoustic approach, whereas the Bayesian framework is used by only a few countries. Therefore, the lack of relevant reference data, which is indispensable for the calculation of the likelihood ratio, still prevents many countries to apply this framework in their expression of conclusions.

Apart from the methodology to be used in order to compare oral samples and how the results should be presented in court, another major concern of forensic phonetics is to define what sort of parameters are to be analysed. Section 1.3 showed how a linguistic variable needs to be defined and coded from a sociolinguistic perspective, which is of major concern for the present PhD dissertation in that the variables analysed are sociolinguistic. But they are forensic too, in the sense that they are expected to be applied in forensic contexts, so the variables in the present study also need to comply with the characteristics required by forensic contexts. The next section looks deeper into what features forensic parameters need to have so that they can be regarded in forensic speech analysis.

2.2. The forensic phonetic parameter

Rose (2002) distinguishes two main dimensions which categorise the parameters to be used in forensic speech comparison. On the one hand, variables can be acoustic or auditory, and on the other hand, they can be linguistic or non-linguistic. Taking into account these two dimensions, there can be four possible types of parameters that speech scientists can consider when conducting forensic speech comparison, which can be seen in Table 4.

Table 4: Classification of forensic phonetic parameters according to Rose (2002: 34).

	LINGUISTIC	*NON-LINGUISTIC*
AUDITORY	AUDITORY-LINGUISTIC	AUDITORY-NON-LINGUISTIC
ACOUSTIC	ACOUSTIC-LINGUISTIC	ACOUSTIC-NON-LINGUISTIC

Auditory parameters would be those identified by the ear, and acoustic ones would be identified following the graphic representation of the sound by means of a spectrogram or a waveform. This classification is very much related to the two traditional positions that phoneticians have hold towards forensic speech analysis, i.e. the auditory and the acoustic approach, which were detailed in section 2.1. On the other hand, the term ‘linguistic’ is used by Rose as a synonym of phonemic. Thus, linguistic parameters would make reference to phonological processes involving any sound feature that “has the potential to signal a contrast” (2002: 44), whereas non-linguistic parameters would be those involving characteristics such as pitch or voice quality. These different types of parameters will be dealt with in more detail in section 3.1.1, which deals with the types of parameters related to speech that can discriminate among individuals.

Several authors have described the requirements that the forensic parameter should fulfil. Both Wolf (1971) and Nolan (1983) agree that the ideal characteristics of a forensic parameter are the following, stated in Nolan’s (1983) terms:

1. Show **high inter-speaker variability**, i.e. many differences from one speaker to another.
2. Show **low intra-speaker variability**, in other words, it should be consistent in the speech patterns of a particular individual and not be prone to changes due to external factor such as health, emotional condition or the communicational context.
3. Be as **resistant to attempted disguise or mimicry** as possible, that is, it should not be affected by different ways of disguising a speaker's voice.
4. Show **a high frequency of occurrence**, so that it is measurable in short samples.
5. Be as **robust in transmission** as possible, i.e. it should not be affected by transmission channels such as telephone or tape recording.
6. Be **easy to extract and measure**.

Rose (2002) makes an interesting point regarding the ideal parameter. If, for example, the expert were to analyse two parameters of a specific accent, they may be analysing two parameters which would be defined by that accent, which would mean that the two parameters would be dependent, and therefore they would only count as one item, not two. This is the reason why Rose (2002: 52) proposes a further characteristic to define the ideal parameter:

7. Each parameter should be as **independent as possible** of other parameters, in the sense that the truth or falsity of one variable should not affect one's assessment of the probability of occurrence of the other variable.

Variability is one of the major issues that an investigator faces when looking at linguistic samples for forensic purposes, as shown by the fact that having low intra-speaker variation and high inter-speaker variation are the first two characteristics that a variable should have so as to be considered in forensic analyses. Thus, the variability inherent in language greatly conditions the task of forensic speech and text comparison. This variability does not mean that comparison of linguistic samples for forensic purposes is not possible, years of research and expert witness work prove that it is not only possible, but it certainly constitutes a major contribution to forensic sciences, since it has helped solve a great number of cases which could have not been solved without the help of a linguist. Variation is inherent in language, and variation needs to be considered and accounted for when carrying out linguistic analysis. This is the reason why research on variation between individuals as well as within the linguistic production of a single individual is so fundamental in forensic linguistics, as the present PhD dissertation exemplifies. Chapter 3 is a detailed account of the relationship between inter-speaker variation and intra-speaker variation and the role of these two types of variation in forensic speech comparison.

Chapter 3
Variation and the individual

Variationist sociolinguistics and forensic linguistics are two related disciplines. For linguists conducting research and expert witness work in forensic contexts, findings regarding both dialectal variation across different speech communities and variation within the same speech community are fundamental. One of many examples of cases where the expert linguist has shed light on the differences or similarities between the accents found in the non-disputed and disputed samples is the Prinzivalli case (Labov & Harris 1994). Labov, who was consulted for the case as an expert in American accents, especially that of New York, demonstrated that the disputed recording and the suspect's non-disputed recording involved different accents, precisely a New Yorker accent and a Bostonian accent, which may sound very similar for someone raised in the West Coast (which was the case of the judge).

Apart from dialectal variation, forensic linguists are especially concerned with the variation found between different individuals of the same community –inter-speaker variation– and within the same individual –intra-speaker variation. The final role of a forensic linguist is to be able to identify idiosyncratic features which, if similar in both the non-disputed and the disputed samples, may lead to the conclusion that the samples could have been produced by the same person, and if different, they could have been produced by different individuals. However, this is a complex task since the investigator must always approach linguistic features from the perspective that none of them are invariant. In this sense, and applied to forensic speech comparison, Nolan (1997) introduces the term 'speaker space', which is a space that comprises several dimensions along which speakers have different patterns, and "because everyone's speech varies, each speaker occupies a region within the space" (1997: 746). Following this idea, forensic speech comparison would involve:

> Identifying the dimensions on which speakers are separated, discovering the variation which occurs for a given speaker on those dimensions, and, importantly, sampling the population at large to find out how common or rare particular values are. (1997: 746)

In other words, forensic speech comparison involves three main tasks: 1) identifying the parameters that are the source of inter-speaker differences; 2) determining the degree of intra-speaker variation that is likely to occur along these parameters; and 3) establishing the saliency of these parameters with relevant population data. These three main dimensions are explored in detail in the following sections.

3.1. Inter-speaker variation

Studies in general phonetics and forensic phonetics have traditionally classified two main sources of inter-speaker differences, 'organic' and 'learned' (Garvin & Ladefoged 1963, Wolf 1972). On the one hand, **organic** differences arise as the result of the physical divergences in speakers' vocal tracts regarding size and shape. Examples of organic parameters would be fundamental frequency, vowel formants, and voice quality. On the other hand, **learned** features are related to more linguistic phenomena, which speakers acquire as part of the use of their language. Learned characteristics would include dialectal traits, together with variation present in the speaker's speech community and social group.

According to Nolan, this organic vs. learned dichotomy is not very accurate and fails to account for the complexity behind individuality in language, in that "the two 'sources' of difference do not result in discretely different dimensions of variation in the speech signal" (1997: 748). In this view, the organic part of speech is very much influenced by learned traits, as in the case of vowel formants, for example, where the organic shape and size of the vocal tract are intertwined with the learned characteristics of the speaker's acquired linguistic patterns. Nolan proposes that the model should be constructed not around the notion of 'voice', but around the notion of 'speech communication', since a speaker's voice is:

> …the interaction of constraints imposed by the physical properties of the vocal tract, and choices which a speaker makes in achieving communicative goals through the resources provided by the various components of his or her linguistic system. (1997: 749)

Nolan's model proposes three main sources for inter-speaker differences: the 'physical mechanism', the 'linguistic mechanism', and the 'phonetic implementation', which are detailed in section 3.1.1.

3.1.1. Sources of inter-speaker variation

3.1.1.1. The physical mechanism

A speaker's anatomy imposes specific characteristics on the acoustics of the sounds they produce, their fundamental frequency and their voice quality. Laver defines voice as:

> … the very emblem of the speaker, indelibly woven into the fabric of speech. In this sense, each of our utterances of spoken language carries not only its own message, but through accent, tone of voice and habitual voice quality it is at the same time an audible declaration of our membership of particular social and regional groups, of our individual physical and psychological identity, and of our momentary mood. (1994: 2)

If we consider speech production the result of a 'source-filter' model, individuality in the acoustic signal is the sum of a specific laryngeal signal –which is determined by the characteristics of the larynx and vocal folds– and the disposition of the vocal tract –as filter of the signal– when producing speech sounds[9]. Following Laver's (1994) classification, voice quality is made of two main components: the organic and the articulatory component. The **organic component** corresponds to those aspects of the voice that are determined by the anatomical characteristics of a speaker's vocal tract, for example the length and volume of their vocal folds or the volume of their nasal cavity, which the speaker cannot control. However, despite being out of the speaker's control, rather than establishing absolute values, physiology determines

[9] See e.g. Rosen and Howell (2010) or Ladefoged (1962) for further information about the source-filter model.

ranges of values along which the speaker may vary, and these organic characteristics might also be influenced by contextual factors such as for example having a cold. On the other hand, the **articulatory component** refers to the settings of the articulators or phonetic habits that a speaker adopts, which “confer a recognizably personal style on their production of speech” (Laver 1994: 398). Characteristics such as speaking with a nasalised voice, or with the lips rounded are habits over which the speaker has control. Some of these articulatory settings are determined by the specific community to which speakers belong, but some others constitute idiosyncratic characteristics which are determined by speakers’ choices.

The most common features that depend on the physical mechanism that are analysed for forensic purposes fall within the categories of segmental and suprasegmental. Segmental features are those concerned with vowels and consonants. Nasal consonants, for example, have been claimed to be one of the most speaker-specific consonants because the shape, the size and the rigidity of the nasal cavity cannot be easily altered, which is translated into a low intra-speaker variation, and it is different for each speaker, which results in high inter-speaker variation (Nolan 1997: 750; Rose 2002: 135). Other discriminatory features related to consonants would be Voice Onset Time[10] (e.g. Allen *et al.* 2003), and also spectral characteristics of fricatives such as the frequencies where the highest concentration of energy can be found (e.g. LaRiviere 1975; Cicres 2011). As for vowels, the most reliable characteristics are formant frequencies, especially the first

[10] Voice Onset Time is the time lapse between the burst of the plosive and the start of the vibration of the vocal folds for the following vowel.

three formants. Vowel formants have traditionally been analysed by taking a stable point in the middle of their production and measuring their first three formants (Jessen 1997; Nolan & Grigoras 2005). However, recent studies show that measuring formant frequencies from a dynamic perspective, i.e. measuring their transitions towards the surrounding sounds, trigger better results, since those transitions seem to be quite speaker-specific. (Greisbach *et al.* 1995; McDougall 2004 & 2006; López Escobedo 2010). Regarding suprasegmental features, the most commonly analysed are fundamental frequency (e.g. Baldwin & French 1990, Rose 2002), intonation (e.g. Nolan 2002a; Cicres 2007), voice quality (e.g. Nolan 2005), and speech and articulation rate (e.g. Künzel 1997).

3.1.1.2. The linguistic mechanism

The linguistic mechanism involves phonetic and phonological aspects related to accent patterns, prosody and some aspects of voice quality, together with other aspects related to morphology, syntax and lexicon that are also present in speech. These aspects are enclosed in the speaker's acquired patterns referring to their specific accent –either a regionally or a socially defined accent, or both–, together with the individual choices that the speaker makes which constitute their idiolectal style, which will be commented on more deeply below in section 3.1.2. In relation to this, it is interesting to mention the view of some variationist sociolinguists who have moved towards a more individuating theory of language variation. According to Johnstone, "a large residue of inter-speaker variability is left even once differences in age, socioeconomic class, region, rurality, gender and contextual style are carefully considered", and variation can be understood as a resource for the expression of one's identity (1996: 16). In this sense, some studies show how sociolinguistic methods can be applied not only to study group variation that correlates with social factors, but also to differentiate individuals from a group sharing the same social class and geographical origin. Milroy and Milroy's research in Belfast is one of the first examples –if not the first one– of the application of variationist methodology to differentiate individuals from the rest of their community with forensic purposes. Milroy (1984) explains how in a community where all subjects belonged to the same linguistic variety and shared the same social background (Milroy & Milroy 1977, 1978), significant differences emerged between the subjects, since "all *individual* speakers had different quantitative scores on each of the ten variables studied, except in cases where a few speakers shared a 100% score on one variable out of the ten" (Milroy 1984: 61). Therefore, according to this perspective, differences between individuals respond more to their relationship to the local community, rather than to factors such as social class.

Studies that have investigated linguistic features for forensic purposes are not as numerous as the studies that deal with acoustic parameters such as the ones that have been mentioned in 3.1.1.1. Linguistic features are language- and dialect-specific, which means that no broad generalisations can be made since conclusions may only be applied to certain groups of individuals belonging to a specific language, dialect, social class, sometimes gender, age, etc. The analysis of phonetic/phonological parameters have helped solve many cases, the most famous of which is the Yorkshire Ripper case (Ellis 1994) where features such as h-dropping and the diphthongisation of the vowel /uː/ helped identify the criminal as coming from a specific region, in this case Sunderland. In addition, there have been several research studies that have centred on phonetic and phonological aspects of the linguistic mechanism. Nolan and Oh (1996) report differences in the realisations of the sounds /r/ and /l/ in SSBE between identical twins, which can only be explained by different individual selections that the siblings make. Similarly, Loakes (2006) also studied identical twins, and found evidence of different patterns between twin pairs in the degree of frication of the plosives /k/ and /p/ in Australian English. The process of frication of plosives in Australian English has also proved to be speaker-specific by other studies such as Loakes and McDougall (2004, 2007, 2010) (see section 6.2.2.5 for further information on frication of plosives). Besides, there have been other studies which have concentrated on phonetic and phonological features that are involved in diachronic sound changes. Moosmüller (1997) reports that the production of certain diphthongs that are suffering a process of monophthongisation in a German dialect spoken in Austria seems to be very speaker-dependent and resistant to different speech styles and to voice disguise. Moreover, de Jong *et al.* (2007a and 2007b) investigate whether vowels in SSBE which are undergoing change exhibit more speaker specificity than vowels that are more stable. de Jong *et al.* (2007a) observe that vowels /æ, ʊ, uː/, which are undergoing change perform better at speaker discrimination than other more stable vowels such as /iː, ɑː, ɔː/, especially /ɔː/. de Jong *et al.* (2007b) find more precise results, in that /æ/ and especially /ʊ/ seem to achieve the highest classification rates on the Discriminant Analysis whereas /uː/ does not seem to perform so well due to its high intra-speaker variation. Moreover, /iː/, despite being a pretty stable vowel also shows high inter-speaker variation and low intra-speaker variation, as well as a high classification rate.

These studies illustrate the discriminatory potential of phonetic and phonological characteristics, especially those undergoing sound change. Despite every individual in the community may eventually incorporate a sound change into their linguistic behaviour, if we look at the process at a synchronic point in time, we might see that speakers use the more conservative and the more innovative variants at different rates, which implies an idiosyncratic use of these features. These findings do not only have major forensic implications, since these features may help establish differences and similarities between samples more reliably, but they also show how essential it is to analyse linguistic patterns such as these, alongside acoustic parameters in order to attain a complete and trustworthy analysis of speech. As de Jong *et al.* put it:

> To understand the speech signal fully, and therefore to be able to exploit its potential for the identification of an individual to best effect, we need to appreciate not only its complex relation to the vocal tract which produces it, but also its determination by a linguistic system set in a social and historical context. (2007b: 140)

3.1.1.3. Phonetic implementation

This last source of inter-speaker differences in Nolan's (1997) model implies the adoption of the linguistic patterns into the constraints of the speaker's physical mechanism. Coarticulation phenomena, by which sounds are affected by surrounding sounds, may be a source for idiosyncratic characteristics which cannot be explained by anatomical differences and linguistic patterns. Some studies, for example, have actually demonstrated that nasal-plus-vowel and lateral-plus-vowel sequences show significant speaker-specific differences (Su *et al.* 1974; Nolan 1983).

As shown in this section, speaker individuality encoded in the physical and linguistic mechanism, as well as the phonetic implementation, is supported by research which demonstrate that, as much as two individuals may be as similar as possible in terms of physical characteristics and social upbringing (the most extreme case being identical twins) they still show differences in the linguistic patterns they use.

All the variables with which this dissertation is concerned belong to the linguistic mechanism, explained in section 3.1.1.2. As will be seen in section 6.2, the fourteen variables chosen in the present study refer to phonological processes regarding vowels and consonants, such as yod coalescence or glottalisation, all of which show sociolinguistic variation, either stable variation –normally correlated with social and/or stylistic factors– or variation due to diachronic change –which may in turn also be correlated with social and stylistic factors. The present dissertation is a contribution to the investigation of processes that exhibit variation with forensic purposes, an aspect that has not been much explored with the exception of the few studies that have been reported in this section (Milroy & Milroy 1977, 1978; Moosmüller 1997; Loakes 2006; Loakes & McDougall 2004, 2007, 2010; de Jong *et al.* 2007a, 2007b), which constitute fundamental references. Therefore, one of the major objectives of the present dissertation is to explore the speaker specificity behind the choices of different variants of the same phonological variable, and determine their forensic implications. Such choices constitute an individual use of language, what has been called idiolectal style. Section 3.1.2 analyses further the concept of idiolectal style, which is particularly relevant for the present dissertation, and its application to forensic linguistics.

3.1.2. Idiolectal style

Several studies show that despite the fact that two speakers may have had similar linguistic histories, they will probably differ in certain linguistic characteristics. Regarding phonological characteristics, Ferguson claims that:

> Some individual differences in phonology […] are not the dialectal type but are more clearly idiosyncratic and have such sources as accidents of language input, anatomical and physiological characteristics, different learning strategies and phonological hypotheses, or personality characteristics. (1979: 191)

Ferguson's example of such individual differences is the fact that some individuals coming from areas where /l/ is not usually velarised in onset [11] position, produce velarised /l/s with no apparent regional or social reason for this variation (Ferguson 1979: 191). In addition to this, Payne (1980 –cited in Johnstone 1996: 10) found out in his study that children moving to Philadelphia from other parts of the country acquired local features,

[11] Onset position is the position of any consonant before a vowel within the same syllable.

but none of them ended up with exactly the same system. Thus, it could be said, as Ferguson claims, that:

> The phonology of a language variety –the normal object of phonologists' study– is a composite of individual phonologies in which the shared structure inevitably has indeterminacies, fuzzy boundaries, and both dialectal and idiosyncratic variation. (1979: 197-198)

Although these studies are not directly related to forensic applications of linguistics, they very much influenced the concept of *idiolect* that arouse within the field of forensic linguistics around that time. One of the first authors to talk about the idea of idiolect from a forensic perspective –see Chapter 1 for the coinage and use of this term by structuralists– was Baldwin. This author defines idiolect as "the unique form of an accent/dialect typifying one given individual" (1979: 231), which is constituted by their linguistic preferences such as the use of particular words, the pronunciation of certain sounds, intonation patterns etc. In this sense, the concept of idiolect makes reference to the linguistic features that cannot be explained by social factors, and can only be the result of idiosyncratic choices. Within the field of forensic linguistics, other authors such as McMenamin (2002), Coulthard (2004) and Coulthard and Johnson (2007) have also adopted the concept of idiolect in their research and forensic expert witness work. Following Coulthard:

> The linguist approaches the problem of questioned authorship from the theoretical position that every native speaker has their own distinct and individual version of the language they speak and write, their own *idiolect*, and the assumption that this *idiolect* will manifest itself through

> distinctive and idiosyncratic choices in texts [...]. Thus, whereas in principle any speaker/writer can use any word at any time, speakers in fact tend to make typical and individuating co-selections of preferred words. (Coulthard 2004: 431-432)

According to this view, each speaker has a unique combination of linguistic patterns that separates them from the rest of members of the same speech community, and this linguistic individuality will be present in any oral or written linguistic production. However, some other authors have argued that the idea that two (sets of) samples can be identified as belonging to the same or different individuals by the fact that they show the same or two different idiolects is a hypothesis which, as interesting as it may be, has not only not been demonstrated yet, but its value in real forensic contexts is doubtful. Nolan, for example, challenges the mere existence of idiolect:

> It has not, to my knowledge, been demonstrated that every speaker of a homogeneous dialect has a reliable unique pronunciation. Furthermore, given the role of pronunciation as a marker of group identity, I suspect it is unlikely to be the case. (1994: 332)

Moreover, even if this hypothesis was in fact demonstrated, this author questions its usefulness in real forensic cases, in that they normally involve limited and short linguistic samples in which it might be difficult to find a reflection of an idiolect. In this sense, Nolan argues that:

> In practice, given the degree of free variation found in the speech of one person, and the short samples normally

> available in forensic circumstances, I would expect idiolect to be of little value in separating speakers of a homogeneous accent. Unless and until extensive research vindicates the usefulness of idiolect in speaker identification, I believe we must work on the assumption that two samples with matching linguistic-phonetic properties can perfectly well be from different speakers. (1991: 489)

Similar disbelieves are raised by Grant (2010) in the area of authorship analysis, as he talks about 'idiolect free' authorship analysis. Similarly to Nolan, Grant also questions the idea that even if the existence of idiolect could in fact be proved, it would not necessarily mean that a speaker's idiolect would be measurable in every instance of their linguistic production, whatever its length may be. He also argues that authorship analysis involves the identification of features that are **consistent** in the sense that they show a stable pattern within the same author, and at the same time **distinctive**, i.e. that they can distinguish that author from the rest of authors in the same community. However, the observation of such features is not an explanatory theory of idiolect. The question he poses is:

> …whether authorship analysis can be valid as the mere detection of degrees of consistency and the determination of degrees of distinctiveness, or whether in its practical application it must rest implicitly or explicitly on a particular and strong theory of idiolect. (2010: 509)

In other words, consistency and distinctiveness may constitute by themselves empirical evidence of the existence of idiolect, but they are not a theoretical explanation of idiolect. In this sense, authorship analysis which is based only on consistency and distinctiveness is defined as “idiolect free, or at least idiolect light” (2010: 509). According to Grant, a theory of idiolect should “provide an explanation as to why one individual’s production is consistent across texts, and must also explain why that individual’s language is distinctive as compared with that of other individuals” (2010: 210).

According to this author, there are two main theoretical models that try to explain idiolect. On the one hand, cognitivist theories suggest that our cognitive structures are similar across individuals in the same way that our biology is also similar, so these theories approach authorship analysis by trying to measure cognitive capacities regarding syntactic complexity and the mental lexicon. However, such theories ignore differences between individuals and only focus on shared commonalities. On the other hand, stylistic –or variationist– theories, argue that an individual’s idiolect arises out of their sociolinguistic history. However, none of these theories succeed in providing a strong theory of idiolect. What Grant argues for is a unified theory which accepts that idiolect is defined by both cognitive capacities –which are better at explaining intra-individual consistency– and each individual’s sociolinguistic history –which accounts better for inter-individual distinctiveness–, and that “each provide resources and constraints in the creation of a linguistic individual” (2010: 513). According to this unified theory of idiolect, “the cognitive capacity is itself structured but malleable and the sociolinguistic history is realised in incremental changes to that neuro-cognitive capacity” (514).

Furthermore, Grant distinguishes two different levels of distinctiveness between two (sets of) written samples. The first level of distinctiveness is referred to as 'pair-wise distinctiveness' by which the researcher can demonstrate that each sample shows its own consistent style, which may differ or be shared when the two samples are compared. This level does not exclude the possibility of there being another author who might show similarities with one or the other text, but it only considers the samples (which correspond to suspects) involved in the case. Authorship analysis at this level would be characterised as idiolect-free. The second level of distinctiveness is defined as 'population-level distinctiveness', which would occur if a person's style is very distinctive or even unique when compared to a reference population of equivalent texts.

Contrary to Nolan and Grant, Turell (2010a) argues for the idea of linguistic individuality, but she claims that the specific use of the concept and term 'idiolect' in the forensic linguistics framework is not accurate enough for two main reasons. On the one hand, it seems to ignore the controversy around the notion of idiolect within the linguistic theories of the 20th century (see Chapter 1). On the other hand, idiolects could only be described by means of innumerable quantities of data of every individual's linguistic production, which is an impossible endeavour to carry out. Yet, Turell maintains that the fact that each person uses their language in a different way cannot be ignored, and it is precisely this difference which is interesting for authorship analysis. Thus, Turell suggests the term 'idiolectal style', which she applies to authorship analysis, but is perfectly applicable to forensic speech comparison, in order to focus on this linguistic individuality that differentiates between different subjects:

> [The] concept 'idiolectal style', following the use of the term 'style' in pragmatics, is proposed as a notion which could be more relevant to forensic authorship contexts. 'Idiolectal style' would have to do primarily, not with what system of language/dialect an individual has, but with a) how this system, shared by lots of people, is used in a distinctive way by a particular individual; b) the speaker/writer's production, which appears to be 'individual' and 'unique' (Coulthard 2004) and also c) Halliday's (1989) proposal of 'options' and 'selections' from these options. (2010: 217)

This author also claims that the notion of 'idiolectal style' is very much influenced by the concepts of markedness and saliency. The term **markedness** was first introduced by the Prague School, by Jakobson and Trubetzkoy, and its relevance regarding the idiosyncratic value of a linguistic variable lies in Jakobson's conception that "the marked form conveys more precise, specific and additional information than the unmarked form" (Jakobson 1956, cited in Turell 2010a). In other words, the occurrence of a marked feature in an individual's linguistic production will be idiosyncratic if this feature gives more specific information about their idiolectal style than the unmarked form. The concept of **saliency** has been frequently used in corpus linguistics to refer to "all the words that stand out statistically when one subcorpus is compared to another subcorpus or to the totality of the corpus" (Abecassis 2002). Besides, a feature can be salient in two different ways. On the one hand, saliency can lie on the use of a particular linguistic feature over an alternative, and on the other, a feature may show a particular frequency of rate that becomes salient when compared with a reference corpus. In this light, a feature will be idiolectal when it is both marked, i.e. gives more specific information about the speaker's linguistic history, and it is salient, in the sense that it "stands out" when compared to the relevant population.

After commenting on the position of such authors as Baldwin, Coulthard, Nolan, Grant, and Turell, it is clear that both the concept of idiolect itself and its potential use in forensic cases are far from being uncontroversial matters in current forensic linguistics. The present dissertation adopts the concept of 'idiolectal style' proposed by Turell (2010a) in order to make reference to the group of features that are marked, salient, consistent within the same person, distinctive of those used by other individuals and dependent on each speaker's linguistic history which make up their linguistic individuality.

However, even those features that characterise an individual's use of language show variation, in this case, intra-speaker variation, which, as will be shown in section 3.2, also needs to be taken into account when separating an individual's speech from the speech of the rest of individuals in the same community.

3.2. Intra-speaker variation

According to Rose "it is a phonetic truism that no-one ever says the same thing in exactly the same way" (2002: 10). In this sense, Nolan talks about the fundamental concept of **plasticity**, which affects all levels of speech production. In this view,

> Variability is inherent in the speech performance of an individual, some of it volitional (as for example in stylistic variation and accommodation) and some of it imposed (as when physical or psychological states

> affect the detailed functioning of the vocal mechanism. (1991a: 486)

Even if we were to produce the same sentence two consecutive times in the same minute, the spectrograms, as physical representations of speech production, would never be exactly identical. In each parameter we produce, the disposition of our vocal tract is not absolute at any time, in the sense that there are always ranges within a particular space in which we can produce the same sound. For example, each speaker's fundamental frequency will have a range of frequencies within a continuum, where the maximum and minimum frequencies that their anatomy allows are found at each end. Each speaker will then adopt a preferred range because it is the most comfortable for them, but they will still have at their disposal other ranges which they may use at some point (Nolan 1983: 27). Moreover, our speech may also be affected by temporary physical factors such as the consumption of alcohol or drugs, and also by temporary physiological factors such as being stressed, anxious, angry or scared (Braun 1995; Nolan 2005). Boss (1996), for example, claims that special attention needs to be paid to the high intra-speaker variability that F0 may exhibit as a result of different emotional states, as exemplified by the subject in her study, who showed a considerably different range of F0 in the disputed sample due to the stress that he experienced during the robbery where it was recorded.

Apart from being influenced by temporary physical and physiological situations, a speaker's idiolectal style may also show variation that correlates with social and stylistic factors. The following sections 3.2.1, 3.2.2, and 3.2.3 detail the three main sources of intra-speaker variation that are most relevant for the present dissertation, namely, age, style, and language contact. First, age and its relation to lifespan change, as defined by Sankoff (2005), is one of the independent variables that are considered for the analysis of the linguistic variables, since for thirteen out of the sixteen speakers included in the corpus, there are samples in two measurement times, which are separated from each other by a delay of 10-25 years depending on the speaker (see section 6.1). Secondly, style-shifting has traditionally been explained as the main source for intra-speaker variation, as considered by Labov's attention-to-speech model. The corpus of study of the present PhD dissertation was compiled trying to control style-shifting by collecting only spontaneous speech (see 1.2 and 6.1 for details). Finally, language contact is another independent variable for which the corpus is stratified, since six of the sixteen speakers have been living in a long-term situation of language contact.

3.2.1. Change over time

In many real forensic situations, the disputed and non-disputed linguistic samples that need to be compared have been produced at different points in time. Sometimes they are separated by a period of several weeks, sometimes this time can be much longer and involve several years, even several decades, as in the case of the Yorkshire Ripper hoaxer trial (French *et al.*, 2006), where both samples were recorded within 27 years of distance. Although this last example is a very extreme one, non-contemporary samples in forensic contexts are "the rule rather than the exception" (Kunzel (2007: 110). Therefore, the main questions to be addressed are how stable is a speaker's idiolectal style throughout their adult lifetime and, also, what sort of changes or differences may be expected to be found when comparing non-contemporary samples produced by the same speaker.

The most obvious changes that may take place throughout an adult's lifespan are the effects that the process of ageing may have on a speaker's anatomy, which in turn might influence their voice. Several studies such as Linville and Fisher (1985), Linville and Rens (2001), Rebould *et al.* (2010), and Rhodes (2011) show that formant frequencies, especially F1, and fundamental frequency tend to be lowered in advancing age. Moreover, situations such as starting or giving up smoking, the effects of surgery on any part involved in the speech production process, loss of teeth or the use of prosthetic devices may as well have an impact on the speaker's acoustic resonances (Künzel 2007: 110).

The changes that a speaker's linguistic habits may undergo are closely related to the changes undergone by the speech community to which they belong. In 1.1, the two methodologies to study language change over time (apparent and real time) were exposed, as well as the five possible patterns of change which communities and individuals may undergo (stability, age-grading, lifespan change, generational change and communal change). In a forensic context, the patterns that imply change in the individual, especially age-grading and lifespan change, are of utmost importance whenever two non-contemporary samples are to be analysed. In sociolinguistic studies, the apparent time hypothesis, which states that an individual's patterns stay stable over time and that change occurs generationally (see section 1.1), has successfully been used to monitor changes in a community. There are many studies that have supported the apparent time hypothesis (e.g. Trudgill 1988; Labov 1994:101-107; Sankoff *et al.* 2001; Nahkola & Saanilahti 2004) in that they report that speakers' linguistic behaviour stays relatively stable over time. However, some of these studies also reveal evidence for age-grading and lifespan change. Nahkola and Saanilahti (2004) admit that middle-aged speakers showed an unexpected relative instability, since they show that their patterns changed as the community was changing. Older speakers, however, showed fairly stable patterns. Their results lead to the conclusion that "there is a point in time in which the idiolect is likely to stabilize, so that changes going on in the community are not generally able to keep on advancing in the idiolect, and the variation pattern becomes fixed. This point in time tends to come relatively late in the speaker's life". Moreover, they add that "[t]he sex of the speaker does not seem relevant in this" (2004: 88). These authors also introduce another factor that should be taken into account, which is the nature of the variation exhibited by variables. Their results suggest that features that are learned by the speaker as categorical, keep showing the same categorical pattern, whereas if the speaker acquires a feature as variable, it will show more variability throughout their lifetime, in the sense that the balance of the variants might change (2004: 90). Similar conclusions are drawn by Sankoff and Blondeau (2007), in that the majority of speakers show some adaptation towards the sound change taking place whereas only a very small proportion showed major changes. In this sense, they agree that the most stable group of speakers seem to be those that use a specific variant in a categorical or near-categorical way. Another real time study which evidences the changes that a speaker undergoes at the same time as the community changes (which represent Sankoff's interpretation of lifespan change) is Harrington's study (2007) on the speech of Queen Elisabeth II. From the Queen's yearly Christmas speeches, Harrington documents the changes that the Queen's speech is undergoing towards "a more modern, less aristocratic form of RP" (2007: 128), which includes features such as tensing of the HAPPY vowel /i/, fronting of the GOOSE vowel /uː/ and lowering and backing of the TRAP vowel /æ/. Another recent panel study that sheds some light on the linguistic changes that an individual can undergo throughout their lifespans is Bowie's (2005) study on religious speeches of speakers from Utah. The majority of speakers in this study show significant lifespan changes in the *fill-fell* merger, the raising of /æ/ before nasals and /u/-fronting.

The stability of a speaker's idiolectal style is of utmost importance in forensic linguistics, and also in the present PhD dissertation. The corpus of study is stratified for time, since it contains recordings of the same speakers in two measurement times with a time lapse of 10-25 years, with the aim of investigating the possible individual changes that speakers may undergo over time in the variables under analysis.

However, in a further study, Bowie (2010) claims that variation across an adult's lifespan cannot always be attributed to age itself. He argues for intra-speaker variation *per se*, in the sense that a speaker has at their disposition many alternatives to use in different situations depending on "their need to express whatever facets of their social identities are most important for that day and moment, and for the interlocutor(s) or audience with whom they are interacting" (2010: 65). Thus, the fact that a real-time study reflects variation across two points in time does not mean that that speaker has changed their patterns due to age, but that their speech may have been “sampled at several points displaying different parts of their linguistic repertories at each point (Bowie 2010: 65).

The kind of variation that Bowie refers to as “everyday intra-speaker variation” (2010: 65), may be prompted by some factor. Bowie’s remark actually introduces a further source of intra-speaker variation, that of the use of different patterns depending on the context or the interlocutor, i.e. the use of different styles, in order to express different social identities. This fact has traditionally been referred to as style-shifting, and it is explored more deeply in section 3.2.2.

3.2.2. Style-shifting

Differences in linguistic patterns that an individual may present at different times as the result of changes in the social context have traditionally been referred to as speaking style, or style. According to sociolinguists, these changes have social meaning, in that they can be accounted for by the particular situational context of the communicative interaction, the topic or particular purposes of the content, and by the social characteristics of the participants (Milroy 1992, Bell 2007). Labov defines the ‘principle of style-shifting’ as one of the principles from which the observer’s paradox follows:

> There are no single-style speakers. Whenever we first encounter a speaker in a face-to-face situation, we must assume that we are observing only a limited part of his entire linguistic repertoire. There may be some linguistic features that do not shift from one style to another, but every speaker

> will have a configuration of linguistic variables that shift from one context to another. (Labov 1972: 112)

Several theories have tried to account for **style-shifting**. Firstly, Labov (1972), distinguished between different styles depending on the level of formality involved and the amount of self-monitoring that speakers showed that accounted for speech variations, a perspective known as the '**attention-to-speech' model**. As seen in 1.2, Labov distinguished between five different styles in the sociolinguistic interview, namely casual speech, interview/careful speech, reading passage speech, word list speech and minimal pair speech. These different styles could be placed in a continuum, which ranges from a situation where minimal attention to speech is paid by the speaker to a situation where maximum amount of attention is paid, as he explains, "styles can be arranged along a single dimension, measured by the amount of attention paid to speech" (Labov 1972: 208).

However, some social psychologists such as Giles (1973) and sociolinguists such as Coupland (1984) and Bell (1984) realised that different styles were not only the result of the attention paid to speech, but rather, speakers shifted their speech patterns depending on their addressees, a theory known as '**accommodation**'. According to this theory, speakers change their speech patterns in order to become more alike to their addressees –this type of accommodation is called convergence, the most usual type of accommodation–, or to become more different to their addressees –known as divergence– (Bell 2007: 96). Following this theory, Bell (1984, 2001) developed the **'audience design' model**, which holds that speakers design their style for and in response to their addressees, depending on the assumptions and associations that they make of linguistic features with certain social groups.

Other theoretical explanations for style-shifting include the **'speaker design' model** (Wolfram and Schilling-Estes 2006) and the **'Hyperspeech & Hypospeech'** model developed by Lindblom (1990). On the one hand, the 'speaker design' model claims that speakers not only shift their speech depending on their audience, but also depending on certain characteristics they want to transmit to the listener, i.e. to fill roles. On the other hand, Lindblom's H&H model explains style-shifting as phonetically-motivated, in that the speaker adapts their speech by making it more clearly enunciated (hyperspeech) or less clearly enunciated (hypospeech) depending on the requirements that each context or listener demands. According to this theory, intra-speaker variation would respond to phonetic adaptation dealing with articulatory clarity, rather than being sociolinguistically motivated.

The fact that speakers may show variation due to differences in style and adaptations to contexts is crucial from a forensic perspective. It is indispensable to bear in mind that the speech present in a disputed recording, for example a conversation with a friend, may have taken place at a very different context that the undisputed recording, e.g. a police interview. When this is the case, the investigator needs to account for the possible differences in style that may result in intra-speaker variation, and not confuse this variation with inter-speaker variation. In the present PhD dissertation, style shifting has been controlled in the corpus of study. Both subcorpora (*LanCon* and *InSit*) contain interviews – both sociolinguistic interviews and broadcast interviews– which contain what could be considered spontaneous speech (see discussion in 1.2). Although style is a very interesting factor to investigate for forensic purposes, the present dissertation controls style shifting and stratifies the corpus according to two other factors. Change over time was developed in section 3.2.1. Section 3.2.3 provides an insight on the other factor for which the corpus is stratified: language contact. Considering speakers who remain in their speech community may exhibit lifespan changes and variations depending on specific contexts, the present dissertation also addresses questions regarding the stability of a speaker's linguistic patterns after settling in a very different community where a different language is spoken. Do these speakers also exhibit intra-speaker variation over time? If so, is that variation parallel to the variation exhibited by their peers who have remained in the community of origin, or is their speech affected by the second language in their new community? Section 3.2.3 addresses these questions and reviews the possible effects that a second language may have on a first language in such speakers.

3.2.3. Language contact

Language contact occurs through the interaction between two or more languages. In such situations, **interference** between the languages takes place, a situation that may in turn be the cause of language variation. Weinreich defined interference as "those instances of deviation from the norms of either language which occur in the speech of bilinguals as a result of their familiarity with more than one language" (1953: 1). At the time, this definition was applied to the effects that a first language (L1) could have on the acquisition of a second language (L2), but this same definition could also be applied to the effects that can take place conversely, i.e. the effects that an L2 can have on one's L1 (L2→L1 effects henceforth). These effects, also known as 'reverse' or 'backward' transfer, are manifested in the fact that "the first language (L1) of people who know other languages differs from that of their monolingual peers in diverse ways" (Cook 2003: 1). Following Cook, the question of L2 effects on the L1 arises out of the notion of **multi-competence**, which she defines as the "knowledge of two or more languages in one mind" (Cook 2003: 1). According to this view, because the L1 and the L2 exist in the same mind, they form a "language super-system", which allows speakers not only to use each language separately, but also to merge structures and switch between the two languages. Thus, both languages interact with and influence each other, a phenomenon that is referred to as cross-linguistic influence. Figure 4 shows a representation of cross-linguistic influence in bilingualism[12] (Schmid & Köpke 2007, Schmid 2011), which clearly shows that the L1 and the L2 influence each other in terms of phonetics and phonology, grammar, lexicon, semantics and pragmatics.

[12] Here the term 'bilingualism' follows the definition used in present-day linguistic research, which covers all levels of linguistic proficiency, i.e. it includes not only 'balanced bilinguals', but also 'minimal bilinguals' (Schmid 2011: 11-12).

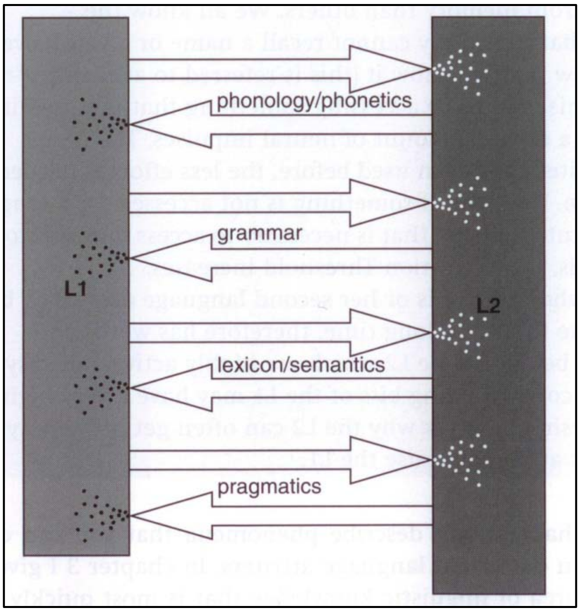


Figure 4: An integrated view of cross-linguistic influence in bilingualism (from Schmid & Köpke (2007: 3) and Schmid (2011: 15)).

According to Cook (2003), L2→L1 effects can be evaluated in three different ways: positive effects on the L1, negative effects on the L1 and neutral effects. Firstly, positive L2→L1 effects would be related to the concept of "brain-training", by which the knowledge of another language benefits the use of one's first language. Secondly, negative L2→L1 effects are commonly described in terms of language **attrition**, also referred to as language loss, in the sense that sometimes the acquisition of a L2 is correlated with the loss of some linguistic competence in the L1. Finally, it could also be the case that the L2 affects the L1 neither positively nor negatively, but only in a different way, in the sense that the effects become neither an advantage nor a disadvantage for the speaker.

Attrition has been broadly defined as "the non-pathological decrease in proficiency in a language that had previously been acquired by an individual" (Köpke & Schmid 2004: 5). In other words, attrition is the loss of some linguistic competence that was once acquired due to a lack of contact with the community where the language is spoken. In this sense, Schmid (2008) defines two possible scenarios where L1 attrition may occur: a) one where there is no kind of communication whatsoever with the L1 community (as in the hypothetical case of a person stranded alone in a desert island); and b) in a situation of migration, where the migrant's L1 is different from the language of the country of settlement and residence and a situation of language contact arises. This second scenario is the most relevant context of investigation in the present PhD dissertation, since one of the subcorpora (*LanCon*) contains data on speakers who have been in a long-term situation of language contact, whereas subcorpus *InSit* contains data on speakers who have not. The speakers within the *LanCon* subcorpus are members of the UK community established in Spain (see 6.1 for a description of the members of this community that are part of the present study, and Turell and Corcoll (2001) for a detailed account of the general UK community in Spain).

The process of L1 attrition has been described by some authors (Porte 2003) as a continuum, with "intact" knowledge of the L1 at one end to total loss at the other. And as usual when dealing with continua, the boundary between what is considered attrition and L2→L1 effects is a matter of subjective opinion by authors. Major (1992) is one of the few authors to study L2→L1 effects on the L1 phonetics. His study revealed that in the context of English speaking subjects settled in Brazil, their English VOT values showed a shift towards Portuguese VOT values. Major considers that "to a greater or lesser extent, all the subjects suffered loss of native English proficiency" (1992: 200), and therefore considers this shift in VOT values as a negative effect, i.e. as a loss. In fact, for this author, language attrition, or as he calls it, language loss is:

> (…) a broad term which can include complete loss, such as language death, loss of proficiency, and various forms of modification in language contact situations. These latter cases (modification of a first language) are sometimes excluded from the term language loss because speakers may continue to be completely fluent in their first language. However, in another sense these fluent speakers should be considered cases of language loss because fluency and proficiency are not synonymous. Therefore, in order to avoid confusion, the term first language loss refers to all forms of loss, complete or partial (modification). (1992: 190)

However, for other authors such as Cook, this same phonetic change is considered as a neutral effect, which "simply amount[s] to differences" (2003: 12).

Apart from whether any L2→L1 effect is good, bad or neutral, another question is whether L2→L1 effects and attrition should be considered the same phenomenon, or should be understood as two separate ones. Pavlenko defines L2 influence on L1 as "a phenomenon in its own right and cannot always be taken as evidence of L1 attrition" (2002: 47). In this sense, Pavlenko distinguishes five processes in the interaction between two languages (2002: 47):

1) Borrowing, or addition of L2 elements to the L1, as in lexical borrowing.

2) Restructuring, which implies the deletion or incorporation of L2 elements into L1, which results in some changes, substitutions, or simplifications.
3) Convergence, which would mean the creation of a unitary system, which is different from both L1 and L2.
4) Shift: which implies moving away from L1 structures or values to approximate those of the L2.
5) Attrition, or the loss of some L1 elements, which results in an inability to produce, perceive or recognize particular rules, lexical items, concepts, or categorical distinctions due to L2 influence.

Thus, for Pavlenko, the production of VOT values as in Major's study, or other studies on L2→L1 effects on VOT (Flege & Hillebrand 1984, Flege 1987), which implies a middle point between the VOT values for English and those for Portuguese, would constitute an example of an L2→L1 effect by means of a process of convergence, but it would not be regarded as attrition.

Furthermore, Pavlenko argues that L2→L1 effects do not involve a permanent loss of lexical items, rules or distinctions, whereas L1 attrition would imply such loss, and not only in production, but also in perception. In the case of phonology, attrition would mean that the attriter is not perceived as a native speaker of their L1 anymore by a monolingual speaker of their L1 community of origin (2002: 54). This fact has actually been reported by a few studies of some adult bilinguals where the L2 speakers are commented on the fact that their L1 sounds differently, or even non-native-like when they go back to their place of origin (Latomaa 1998, Pavlenko 2003, Prescher 2007). However, a slight L2 accent in their L1 production is not enough evidence for attrition. According to Pavlenko, “attrition in phonology should also imply that some bilinguals –just like foreign language learners– will exhibit perception/decoding delays and problems interpreting L1 intonation patterns” (2002: 54). This PhD dissertation will follow Pavlenko in her separation between L2→L1 effects and attrition, and will use the first term (or derivates of it) exclusively, unless the effects imply a loss of distinctions and rules, which will then be referred to as attrition.

Some authors have argued that, whereas L2→L1 interference is much commoner on linguistic domains such as lexicon, the phonetics and even more, the phonology of a L1 are not so influenced by a L2 (Schmid & Köpke 2007: 4, Bond *et al.* 2006: 166). Although such claims seem to be quite correct, there are a few studies which give evidence on L2→L1 effects on phonetics. As explained above, studies such as Flege and Hillebrand (1984), Flege (1987) and Major (1992) demonstrated that in the case of pairs of L1 and L2 languages with different VOT values –such as French and English or English and Portuguese– some convergence between the VOT values of both languages takes place. Besides, L1 vowels may also be affected by a L2, as demonstrated by studies such as Bullock and Gerfen (2004), which revealed a merger of mid front rounded vowels in French to an English-like rhotic schwa. This specific study not only exemplifies phonetic effects but also effects on phonological categories, since it revealed a neutralisation of two phonemic vowel categories, namely the rounded open-mid and close-mid vowels in French. Other studies about vowels are Bond *et al.* (2006), which shows that the quality of Latvian vowels can be affected by a long-term situation of language contact with Russian, and Sučková (2012), who reports a lack of vowel reduction by some speakers of English as L1 in a Dutch environment. Research on L2→L1 effects on consonants, apart from the aforementioned VOT effects, are almost non-existent except for de Leeuw (2008), which reports a shift of the quality of German /l/ (L1) towards the quality of this sound in English (L2). Finally, studies such as Mennen (2004), de Leeuw (2008) and Sučková (2012) show that intonation can also suffer changes due to L2→L1 effects.

These L2→L1 effects may have different sources and influencing factors that are derived from the situation of language contact in which they occur. According to the **Language Interaction Integrated Model** proposed by Turell (1997, 2001), language contact phenomena are constrained by both internal and external factors that are interconnected and influenced by each other, which are summarised in Figure 5. **Internal** factors, i.e. linguistic factors, include language proximity or distance and also language directionality (that is, the direction of the interference, L1→L2 or L2→L1). **External** factors characterise individual speakers and their linguistic histories, and may be in turn the cause for inter-speaker variation behind phenomena derived from language contact. External factors can be subdivided into four main types:

1) **Pragmatic** factors such as communicative needs and the type of interaction.

2) **Individual** factors, which are related to the individual speaker. Individual factors may be psycholinguistic, which would include the speaker's degree of competence in the L2 and also the degree of bilingualism. Attitudinal factors, which deal with positive or negative attitudes towards the

community of emigration, its culture and its language, and also the individual's attitude towards their country and language of origin. In other words, if the individual identifies with the new country, their motivation to learn and communicate with the L2 will be higher, and this may in turn have an influence on the effects that the L2 may have on the L1. This is well exemplified by Schmid (2002) and her study with German Jews who had fled Germany in the Second World War. Her research showed that those who developed more negative emotions with their country of origin showed more signs of L2→L1 effects and L1 attrition than those who kept a more neutral attitude towards it. Another interesting psycholinguistic factor can also be politeness, which may be the cause for migrants adopting a more standard variety of their L1, or even abandoning their local accent for an accent which other people in the L2 country may be more familiarised with in order for them to be better understood when they speak their L1 (Sučková 2012: 17). Finally, cognitive factors are related with aptitude, i.e. the individual ability to learn a language. Speakers who have a better aptitude might learn their L2 faster, as well as be able to retain their L1 competencies.

3) **Socio-individual** factors such as gender or age. As regards L2→L1 effects, it is believed that the younger the migrant learns their L2, the more likely they are to suffer L2→L1 effects or attrition (Flege *et al.* 2003, Köpke & Schmid, 2004). Age, in turn, is also related to the generation of emigration, whether it is first or second generation, which in turn might be correlated with predisposition to learn the L2. Educational

level has also been shown to correlate with L1 attrition. Jaespert and Kroon (1989) conclude that this factor is key to explain their results, which indicate that people with a high level of education are more likely to suffer less L1 attrition than subjects with a lower education. Other socio-individual factors are family type, whether it is mixed or not mixed, and the degree of contact with both languages, which also interact with psycholinguistic and attitudinal factors. Language contact makes reference not only to the amount of contact with their L1 and their L2, but also with the quality of this contact, which is even more important than quantity (Schmid 2007: 150). Regarding their L1, variables which may have an influence are the amounts of visits to their L1 country, whether the migrant uses their L1 in their work environment, or with their family and friends, whether they read in their L1 frequently, or whether they listen to L1 radio/television. On the other hand, contact with the L2 may depend on the age of arrival to the country of destination (which may usually be synonymous with age of acquisition (de Leeuw 2008: 37), the length of residence in the L2 environment, and similarly to their L1, in what social contexts the speaker uses their L2 (work, family, friends, etc.)

4) **Socio-collective**, which include factors such as the social structure of the community (whether it is more open or closed), its social history and its relation with migrations, i.e. whether settlements tend to be stable or non-stable and are well-integrated, the individual's social prestige before and after migration, the reasons for migration (whether political, economical, etc.), as well as the cultural distance or proximity

between both communities and the duration of the contact situation.

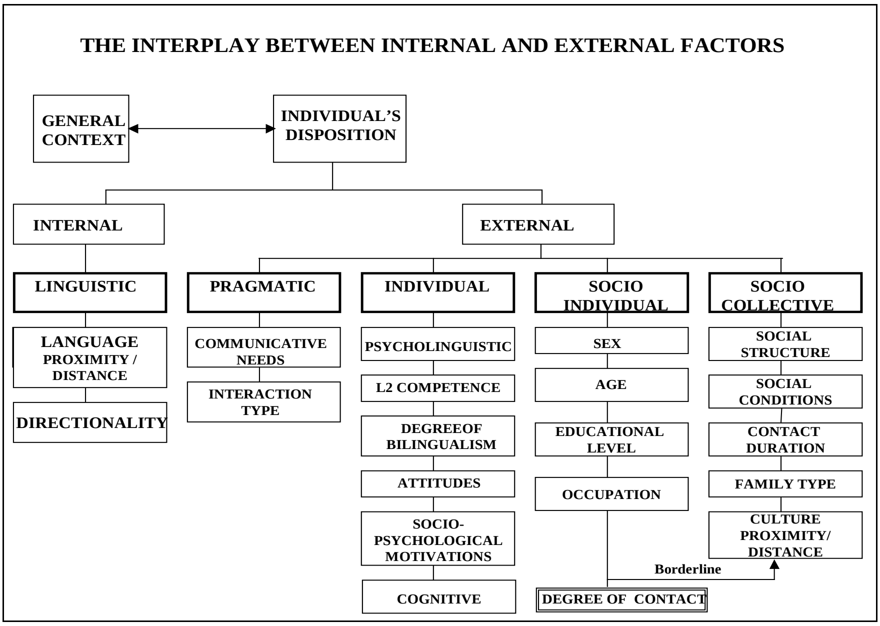


Figure 5: The Language Interaction Integrated Model (Turell 1997, 2001).

The way all these factors affect the individual and how they interconnect is what constitutes the individuality behind the phenomena that derives from a situation of language contact, in this case the L2→L1 effects and the process of attrition. Besides, the migratory process is very much related to identity, and language is "an inseparable part of our identity since we use it to construct, tell and retell our life-stories" (Prescher 2007: 193), so each migrant's identity will be encoded in the process of L2 acquisition and the effects that it can have on their L1. As a matter of fact, several studies on L2→L1 effects have shown that there exists great inter- as well as intra-speaker variability within what initially would be defined as a homogenous group (Flege & Hillenbrand 1984, Major 1992, 1997, Mennen 2004, de Leeuw

2008). Thus, a migrant's idiolectal style will be affected differently by many factors, which will be essential for the constitution of their individual and unique linguistic history.

Sections 3.2.1, 3.2.2 and 3.2.3 have shed some light on three of the possible factors that may prompt intra-speaker variation, namely, changes happening across an adult's lifespan, changes due to style-shifting, and changes due to a long-term situation of language contact, which are the most relevant factors for the present dissertation. The corpus of study has been collected controlling style-shifting, and it is stratified according to the two other factors, time and language contact, in order to observe the changes that these two situations may have on a speaker's linguistic patterns.

At the beginning of this section, we introduced three main dimensions involved in forensic speech comparison following Nolan's concept of "speaker space" (1997): 1) indentifying the parameters that are the source for inter-speaker differences; 2) determining the degree of intra-speaker variation that is likely to occur along these parameters; and 3) establishing the saliency of these parameters with relevant population data. Thus, once certain parameters that distinguish an individual from the rest of individuals of his/her community are defined, and the possible intra-speaker variation that they might show is identified, it is important to establish how salient these features are in comparison with the patterns that the other speakers in their community show. This fact is explored in section 3.3.

3.3. Comparing the individual with relevant population data

The third dimension in forensic speech comparison proposed by Nolan (1997), after defining inter- and intra-speaker variation, involves making decisions regarding the saliency of the differences and similarities found in two samples. So, the question to be asked is, to what degree do the features that we have found separate this speaker, or these speakers, from the rest of the members of their community? The best way of answering this question is by means of a contrast of these features with a relevant reference population, which will shed light on the distinctiveness of these characteristics. At present, having relevant population data with which speakers can be compared is not very often possible, and it constitutes the major challenge of current forensic linguistics. As Turell explains, in order to obtain reliable conclusions in forensic text and speech comparison, a task that is frequently described as impossible is needed, that of counting on giant data banks containing written and spoken linguistic samples representative of millions of idiolectal styles (2010b: 10), i.e. a **Base Rate Knowledge**.

According to authors such as Rose and Morrison (2009), there are two main drawbacks regarding the establishment of reference populations: a theoretical and a practical one. The theoretical problem lies on the question of what defines a relevant reference population. The obvious answer seems to be that the relevant population would contain as many speakers/writers as similar as possible to the speaker/writer of the samples in question. But, how many speakers/writers are enough? What characteristics do they need to share in order for them to be "as similar as possible"?

These questions involve relative and subjective decisions, so it is necessary that experts in the field agree on which samples are to be considered relevant and which not relevant, and also in the type of samples that are needed in terms of genre, size and other extra-linguistic aspects that may have an influence on speech. On the other hand, the practical problem is basically the impossibility of having reference data on all the linguistic aspects that a particular speaker/writer of a particular community can produce in terms of factors such as style. So far, we can rely on some reference data from sociolinguistic studies, which study particular linguistic aspects of certain linguistic communities, which are essential to forensic linguistics. Moreover, in forensic speech comparison we also have some reference data regarding acoustic aspects such as fundamental frequency or vowel formants. However, all these studies, as fundamental as they may be for current forensic linguistics practice, are available for only small sections of the population and for only some languages and only some linguistic varieties of these languages.

In the meantime, the closest situation to the utopia of having universal reference population data is the fact that forensic linguistics can nowadays rely, not only on the types of studies mentioned above, but also on advances in the field of corpus linguistics. Several studies (for example Coulthard 1994, Turell 2010a) have shown the major advantage of counting on reference corpora already available, both oral and written, whenever the expert needs to determine the rarity or distinctiveness of certain phonetic-phonological features and markers of authorship.

Therefore, it is essential that research in forensic linguistics sets its goal in the establishment of a Base Rate Knowledge for as many linguistic phenomena as possible. Forensic linguists need to bear in mind that the conclusions of any present study can constitute part of the reference population used by any other expert in a future case. This is one of the objectives of the present PhD dissertation, in that conclusions regarding the patterns that the subjects of this study exhibit in the variables under consideration will be an important contribution to the population distribution available to other forensic phoneticians conducting expert witness work.

Chapter 4
Analytical proposal

Part I of the present PhD dissertation has been an overview of those fundamental theoretical proposals. Chapter 1 focuses on the field of variationist sociolinguistics, in particular on its main theoretical proposals as regards the observation of change over time, the sociolinguistic methods used to overcome the observer's paradox and elicit speech as similar to the vernacular as possible, and the definition of the sociolinguistic variable, its coding and its quantification. These theoretical proposals are extremely relevant to the present study, especially the methodology for the study of individual and community change in real time, the method for the elicitation of spontaneous speech through the sociolinguistic interview and other interview strategies, and the definition of the sociolinguistic variable, since the fourteen variables under study are formulated and analysed following the sociolinguistic principles. Chapter 2 introduces the field of forensic linguistics and its most relevant area of forensic speech comparison, which is the main research framework for the present dissertation. Particularly relevant is the definition of the forensic phonetic parameter, which, together with the definition of the sociolinguistic variable, serves as base for the selection of the variables under analysis. Finally, chapter 3 exposes the main relationship between these two main areas of research, which centres on the study of individual variation for forensic purposes.

The analytical proposal of this PhD dissertation is the study of intra- and inter-speaker variation and the concept of idiolectal style, which is fundamental in present-day forensic linguistics. Our main focus is on the linguistic mechanism –as opposed to the physical mechanism (see section 3.1.1)– and the observation of the discriminatory potential of some phonological processes that show variation in the accent of the southeast of England (SSBE). These variables have been analysed following the main proposals of variationist sociolinguistics and forensic linguistics (see sections 1.3 and 2.2 respectively). With the aim of establishing the boundary between inter- and intra-speaker variation in the features analysed, the present dissertation proposes a protocol for the creation of an Index of Idiolectal Similitude (IIS) that can effectively determine whether two samples are more likely to have been produced by the same or by different speakers. This IIS is designed as a continuum between 0 and 1 where 0 indicates less similarity (inter-speaker variation) and 1 indicates more similarity (intra-speaker variation). On the one hand, samples from the same speaker in two measurement times (from a real-time study) have been analysed in order to account for intra-speaker differences over time, and on the other, samples from different speakers have been compared in order to observe inter-speaker differences.

The bases for this PhD dissertation can be found in three research projects conducted at ForensicLab, Institut Universitari de Lingüística Aplicada, Universitat Pompeu Fabra. The first project, *Idiolectometría aplicada a la lingüística forense*, funded by the Spanish ministry of Science and Education (EXPLORA-HUM2007-29140-E; PI: M. Teresa Turell) had a duration of one year (2007-2008). The second project, *Idiolectometría forense e Índice de Similitud Idiolectal*, funded by the Spanish Ministry of Science and Innovation (FII2008-03583/FILO; PI: M. Teresa Turell) had a duration of four years (2008-2011). The third project, *Hacia la consolidación de un Índice de Similitud/Distancia Idiolectal (IS/DI) en Idiolectometría Forense*, recently awarded and funded by the Ministry of Economy and Competitivity (FFI2012-34601; PI: M.Teresa Turell) will have a duration of three years (2013-2015). The common aim of these three projects is the creation of an Index of Idiolectal Similitude such as the one that has just been described created for three linguistic levels –phonological, morphosyntactic and discourse-pragmatic– for four languages, Catalan, Spanish, English and Arabic. For each module and language, a set of variables has been proposed similarly to the set of variables that this PhD dissertation has analysed for the phonological module of English. So far, six speakers have been analysed for the majority of modules (except for the Arabic modules, since this language has been added in the 2013 project), and four methods have been tested, one of which is the method proposed in the present PhD dissertation, which has been proved to be the most reliable one. Within the framework of these three projects, a preliminary study towards the establishment of an IIS for the phonological module of English was carried out in the form of a PhD dissertation proposal (Gavaldà 2009), which led to the present PhD dissertation. The corpus used in this preliminary study contained data from four speakers (three of them in two measurement times) and a set of 33 variables, which after that stage was reduced to the current set of 14 variables, a process that will be explained in section 6.2. The method for the calculation of the IIS was based on the calculation of the difference in the percentage of occurrence of the variables. Preliminary results of the PhD dissertation proposal, together with the general results that have been obtained for the other modules and languages within the framework of the two projects carried out at ForensicLab show that inter-speaker variation seems to be higher than intra-speaker variation, and that a speaker's idiolectal style seems to remain relatively stable over time. Thus, the calculation of the IIS is proposed as a reliable quantitative technique to separate between idiolectal styles that the forensic practitioner may have at their disposition, which might serve as a complement to other qualitative and quantitative methods in tasks involving forensic linguistic analysis.

PART II
The Study

Chapter 5
Objectives, research questions and hypotheses

Research in forensic linguistics is constantly looking for new idiosyncratic parameters that can help linguists acting as expert witnesses decide upon the possibility of two linguistic samples having been produced by the same individual. In comparison with other areas of forensic linguistics, forensic phonetics has counted on significant research for much longer, and therefore, many parameters have already been identified as useful to examine when conducting forensic work. However, most of these parameters are related to acoustic and physiological information encoded in speech, and not much research has been carried out with the aim of identifying linguistic processes that constitute individual choices as forensic parameters. In fact, only a few studies have been conducted that explore the discriminatory potential of phonological variables, and even less, that consider the idiosyncrasy inherent in the variation exhibited by some of these linguistic processes (the main studies carried out from this perspective were reviewed in section 3.1.1.2). Whenever variation is present in a linguistic process, a choice is presented to each speaker, who may then use it in a distinctive way, and it is the role of the forensic linguist to evaluate the individuality within each choice and its forensic value.

The present PhD dissertation investigates the relationship between inter- and intra-speaker variation and studies the discriminatory potential of fourteen phonological variables that exhibit variation. In order to quantify the linguistic distance between different idiolectal styles regarding these variables, a protocol for the creation of an Index of Idiolectal Similitude (IIS) is proposed, which can help distinguish between inter- and intra-speaker variation. The ultimate aim of this research is to provide linguists acting as expert witnesses with new linguistic information involving the idiosyncratic nature of these variables, as well as a methodology that can serve them as an extra tool in the exploration of linguistic variables in forensic contexts.

5.1. Objectives

As shown in Chapter 3, there is inter-speaker variation, which separates different individuals, and also intra-speaker variation, which exists within the same individual. The main objective of the present PhD dissertation is to explore inter- and intra-speaker variation and determine whether it is possible to distinguish between these two types of variation. In forensic speech comparison, the investigator needs to establish whether the variation found corresponds to differences between different speakers or, on the contrary, they are intra-speaker differences, which would make the expert conclude that the two samples could have been produced by the same speaker. For this aim, the present dissertation proposes a protocol for the creation of an Index of Idiolectal Similitude (IIS) that quantifies the idiolectal distance between two samples in order to determine whether they show inter- or intra-speaker differences. This IIS is conceived as a continuum (see Figure 6) between 0 and 1, where 0 indicates maximum difference and 1 indicates minimum difference. According to this conception, when two (sets of) linguistic samples are compared, and the IIS is applied, a result closer to 0 would indicate that the two samples under comparison would have been produced by different individuals and these samples would exhibit inter-speaker variation. A value at an intermediate position along the continuum would point out that there is also inter-speaker variation, but the slight increase in similarity would indicate that the two individuals might share the same linguistic variety. Finally, a value close to 1 would mean that there exists an expected intra-speaker variation but would lead the expert to conclude that the two samples are so similar that they could have been produced by the same individual.

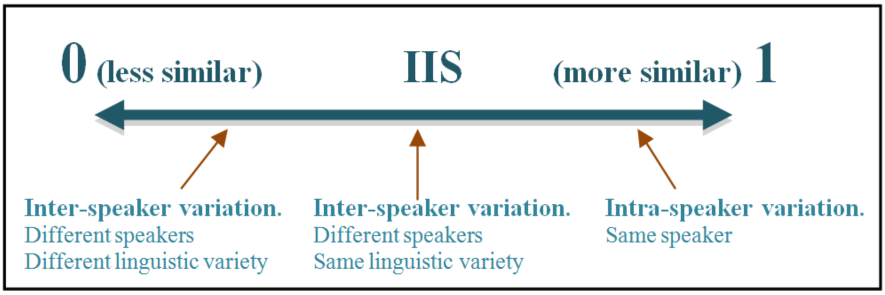


Figure 6: Representation of the Index of Idiolectal Similitude as a continuum.

The main research questions and hypotheses stated in the present dissertation are explained in section 5.2

5.2. Research questions and hypotheses

The present PhD dissertation addresses the following research questions.

> ***RQ1: Is inter-speaker variation higher than intra-speaker variation?***

RQ2: To what extent is a speaker's idiolectal style stable over time?

RQ3: How does a long-term situation of language contact affect a speaker's idiolectal style (intra-speaker variation)?

RQ4: How does a long-term situation of language contact affect inter-speaker variation?

RQ5: How does gender affect inter-speaker variation?

These five research questions will be tested by means of the IIS protocol that has previously been introduced. However, the present dissertation also wants to carry out an analysis of the discriminatory potential of each of the variables under study independently of the IIS protocol in order to establish if they would be good candidates to be considered in isolation in a forensic context. This sixth research question is formulated as follows:

RQ6: How discriminatory will each variable be when considering them in isolation?

This last research question does not pose any hypothesis, since some of the variables might and some others might not be very discriminatory, and an answer can only be given after conducting the analysis. Therefore, the hypotheses that are going to be tested through the analysis of the linguistic parameters under study and their effect on the IIS are related to the first five research questions.

Hypothesis 1 states that inter-speaker variation will be higher than intra-speaker variation. As regards the IIS, it is hypothesised that the IIS will be able to distinguish between samples from the same individual, which show intra-speaker variation and between samples from different subjects, which show inter-speaker variation. In this sense, IIS values resulting from the comparison of samples from different speakers should be closer to 0 (maximum difference) than those resulting from the comparison of samples from the same speaker, which should be closer to 1 (maximum similarity). Hypothesis 1 is formulated as follows:

1. Inter-speaker variation will be higher than intra-speaker variation.

IIS implication: IIS results obtained when comparing samples from the same speaker should be closer to 1 than those obtained when comparing samples from different individuals.

The second hypothesis concerns intra-speaker variation and idiolectal style, and states that a speaker's idiolectal style will stay relatively stable over a speaker's lifespan, following the apparent time hypothesis, although there is the possibility of some age-grading or lifespan change (see section 3.2.1). This fact should be shown by IIS values from the comparison between two samples of the same speaker (in MT1 and MT2) being close to the 1 endpoint of the continuum. This second hypothesis is stated as follows:

2. A speaker's idiolectal style will stay relatively stable time.

IIS implication: IIS results obtained when comparing samples from the same speaker in two measurement times (MT1 and MT2) will be close to 1.

Apart from changes over time, the second sociolinguistic factor explored in the present dissertation is language contact and possible L2→L1 effects. It has been shown that bilingual and multilingual communities present more inter-speaker variation and also intra-speaker variation, since speakers present different levels of proficiency and interference between the languages depending on different factors (see section 3.2.3). In this sense, it is hypothesised that speakers who have been in a situation of language contact (from the *LanCon* subcorpus) will exhibit greater intra-speaker variation than speakers who have not (from the *InSit* subcorpus). This fact is expected to be shown by intra-speaker IIS results comparing samples from speakers in the *LanCon* subcorpus being slightly closer to 0 than IIS results comparing samples from speakers in the *InSit* subcorpus. Hypothesis 3 is formulated as follows:

3. **Speakers who have been in a long-term situation of language contact will show greater intra-speaker variation than speakers who have not.**

IIS implication: intra-speaker IIS values will be slightly lower (closer to 0, showing more variation) for subjects in the *LanCon* subcorpus than for subjects in the *InSit* subcorpus.

As regards inter-speaker variation, there are two sociolinguistic factors considered in the present study. On the one hand, the division between the two subcorpora depending on whether the subjects' situation of language contact is also hypothesised to have an effect on comparisons between different speakers. In this sense, results when comparing samples from speakers within the same subcorpus, i.e. *LanCon* speakers on the one hand and *InSit* speakers on the other separately, are expected to be higher –and therefore show less variation– than when comparing two speakers from different subcorpora. Hypothesis 4 is stated as follows:

4. **Inter-speaker variation will be higher when comparing subjects from different subcorpora than when comparing subjects from the same subcorpus.**

IIS implication: inter-speaker IIS values will be slightly lower (closer to 0, showing more variation) when comparing subjects from different subcorpora than when comparing subjects from the same subcorpus.

On the other hand, gender is also a factor that may have an influence on inter-speaker variation of the speech patterns under study. Some of the variables under analysis show gender stratification, as in the case of variable 13, frication of /t/ between vowels, since the literature shows that women tend to fricate their /t/s more often than men (see section 6.2.2.5), and at the same time, men tend to produce more taps than women, which may be reflected in variables 10-12 (see section 6.2.2.4). Thus, it is hypothesised that comparisons between a man and a woman will show higher variation than when comparing samples of speakers of the same gender. This last hypothesis is stated as follows:

5. **Inter-speaker variation will be higher when comparing subjects of different gender (a man vs. a woman) than when comparing men with men and women with women.**

IIS implication: inter-speaker IIS values will be slightly lower (closer to 0, showing more variation) when comparing subjects of different gender than when comparing men with men and women with women.

After testing these five hypotheses each of the research questions will be provided with an answer. The answers to the first five main research questions will also address another major general question, which concerns not only the present dissertation but also forensic linguistics in general. When looking at two oral samples, is it possible to distinguish whether the differences are due to inter-speaker differences or due to intra-speaker differences? This question is translated into the general research question of this dissertation:

> ***General research question (GRQ): Is it possible to distinguish between inter- and intra-speaker variation?***

Figure 7 shows this general research question together with the six specific research questions and the main objective that is proposed in the present dissertation, which is the creation of an IIS. As seen in the diagram, the main objective and research questions are presented in the context of the overlap area between variationist sociolinguistics and forensic linguistics, which is the study of inter- and intra-individual variation and the idiolectal style for forensic purposes.

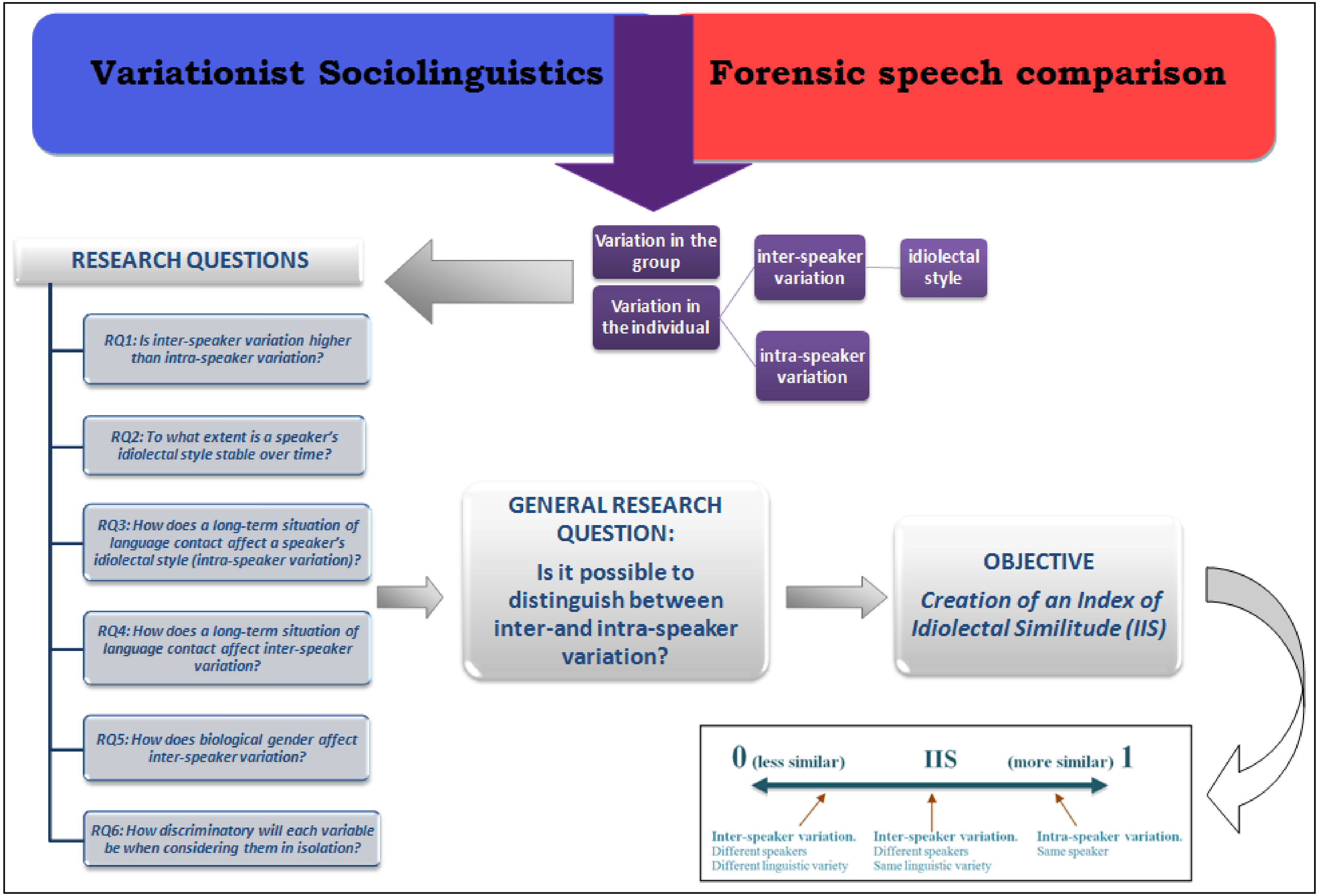


Figure 7: Schematic overview of the relationship between the theoretical background, research questions and objectives of the PhD dissertation.

The experimental design in the present PhD dissertation includes three main steps. Step one involves the collection of a corpus of study, which contains data on 16 speakers from the Southeast of England, who belong to the accent of Standard Southern British English (SSBE). The corpus has been gathered taking into consideration the three factors that were exposed in section 3.2 as sources for intra-speaker variation. Firstly, style has been controlled, since all the samples involve a similar context, that of an interview (either a sociolinguistic interview or a TV/radio interview), which elicit a kind of speech style that we can define as spontaneous. As stated in section 1.2, due to the observer's paradox, and the fact that an interview with a stranger with a recording device (in the case of sociolinguist interviews) and a public setting (in the case of the TV/radio broadcast interviews), the kind of speech collected from these situations may not be regarded as truly casual in terms of the sociolinguistic vernacular as defined by Labov (1966, 1972). Yet, the speech style derived from these kinds of settings has been considered to be analysable together with casual speech in a joint category regarded as spontaneous speech by several sociolinguists (Labov 1989, Rickford & McNair-Knox 1994). Secondly, one of the aims of the study is to observe how stable the speakers' idiolectal styles are over time (Research Question 2), for which a study in real time in sociolinguistic terms (as explained in section 1.1) has been conducted. For 13 of the 16 speakers, there are data in two measurement times (MT1 and MT2) with a time delay of 15 to 20 years depending on the speaker. This aim constitutes a major innovation of the present PhD dissertation, since there are not many studies in real time conducted with forensic purposes, and the ones that exist, (see section 3.2.1), are mostly centred on acoustic parameters rather than linguistic variables, which is the focus of the present dissertation. Thirdly, another aim of the study is to observe the possible effects that a long-term situation of language contact may have on the phonological behaviour of speakers (RQ 3 and 4). In order to do that, two subcorpora were created so that comparisons could be carried out between each other, one that contains data on speakers of SSBE who are living permanently in Catalonia, where Catalan and Spanish are spoken (*LanCon)*, and another one that contains recordings on speakers from the same area and the same variety of English who have remained in the same community of origin throughout their adult lives (*InSit*). This point is also a major innovation of this dissertation, since, to my knowledge, no study has been carried out that considers the possible effects that a L2 can have on the phonological patterns of speakers' L1 for forensic purposes.

One very important factor to bear in mind as regards the corpus of study is that although the framework of application of this PhD dissertation is forensic linguistics, and more specifically forensic phonetics, the corpus of analysis contains data on real spontaneous speech, but it does not contain speech that would typically be involved in a real forensic case. Real forensic cases might often imply samples that are short and have a bad-quality. However, this dissertation proposes that before being able to apply this methodology to real forensic cases, it is necessary to test the discriminatory potential of the variables under study and the methodology applied for the calculation of the IIS in linguistic samples involving a higher quality. In fact, numerous studies carried out with a clear forensic aim are conducted with a corpus of study containing non-forensic linguistic samples.

The second step of the experimental design concerns the selection of variables and their coding. The variables that the IIS considers are phonological variables, i.e. they are concerned with the linguistic mechanism, as explained in section 3.1. Thus, the variables deal with processes of insertion, deletion or change of vowels or consonants, such as yod coalescence and t-glottalling. The analysis of the variables was carried out following the auditory-acoustic method that was explained in section 2.1, which constitutes the approach used by the majority of phoneticians conducting forensic speech comparison (Gold & French 2011). Also, all the variables were formulated in a binary way, so that each variable contains two variants: variant 1 (the process) and variant 2 (the lack of process or any other possible realisation). The total of 14 variables that this study analyses were selected following whenever possible the indications made within the field of forensic speech comparison as to what constitutes a good forensic parameter, as stated in section 2.2, and they were coded following the premises from variationist sociolinguistics that were explored in section 1.3.

Finally, a method for the calculation of the IIS is proposed, which is based on the Chi-square statistical test. The method was developed so that it considers the 14 variables under study, calculates the differences in the frequency of occurrence of its variants, and gives the result in the form of a figure between 0 and 1 where 0 means less similarity and 1 indicates more similarity, which is how the IIS is conceived (see Figure 6 in section 5.1).

These three steps, which can be seen in the schematic diagram in Figure 8, are explained in detail in Chapter 6.

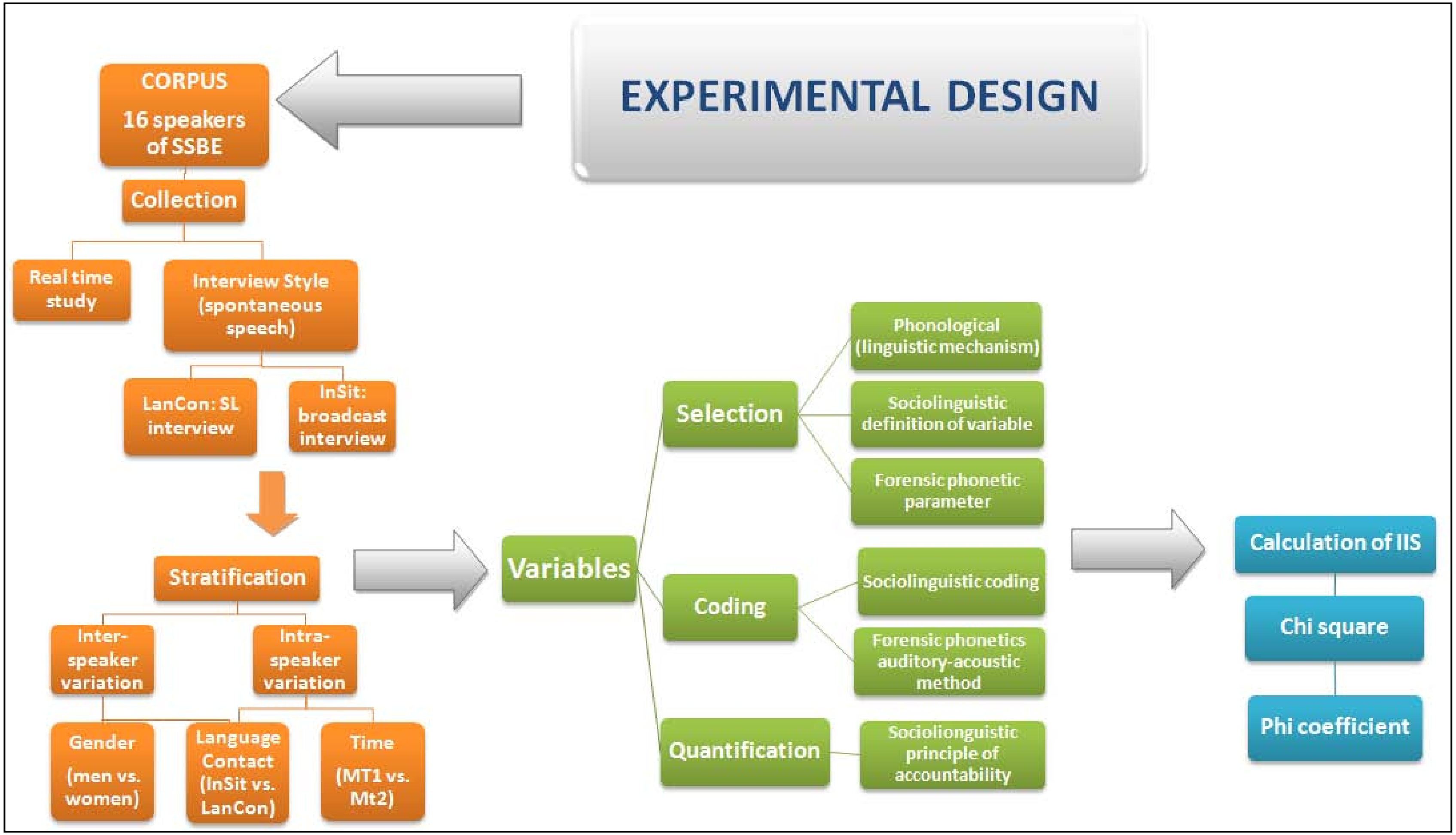


Figure 8: Schematic overview of the experimental design including collection and stratification of corpus, selection, coding and quantification of variables and creation of the method for the calculation of the IIS.

Chapter 6
Experimental design

Chapter 6 is dedicated to the experimental design. Firstly, in section 6.1, an account of the corpus is carried out, where the main characteristics of the subjects included in the *LanCon* and the *InSit* subcorpora are explained in depth. Secondly, in section 6.2, each of the variables included in this study are detailed, together with the main references that support their choice and analysis as part of the IIS protocol. Section 6.2.3 also includes a small section that explains the perceptual test that was carried out in order to validate the categorisation of some variables which posed an analytical problem due to their continuous nature and the inter-reliability test that was conducted afterwards. Finally, section 6.3 explains the method proposed for the calculation of the IIS, which is based on the Chi-square statistic.

6.1. Corpus of study

When the corpus of the present study was being compiled, the main objective was to obtain data from subjects who came from the same area of England, and spoke the same variety. The greater availability of subjects, especially within the *LanCon* subcorpora, was from the Southeast of England, therefore, that was the region from which the informants from the *InSit* subcorpora were selected.

The distinction between different accents of a language is gradual, rather than categorical, and so different accents of a single language that can be found within a specific region should be explained in terms of a continuum, rather than establishing clear-cut linguistic varieties. In the case of the Southeast of England, the continuum goes from a supraregional accent, i.e., Received Pronunciation (RP), which is considered not to have any regional traits and it can therefore be found in any other part of England[13], to the broadest regional Southeastern variety, i.e., Cockney. Somewhere in the middle of that continuum, there would be a variety that has been called Estuary English (EE), which has been considered as a middle ground between RP and Cockney, and is preferred by the middle classes. Estuary English is considered by some authors to be the main source for recent innovations undergone by RP, such as t-glottalling in intervocalic position, l-vocalisation and yod-coalescence in stressed positions (see Coggle 1993, Maidment 1994, Wells 1994; Fabricius 2000; Przedlacka 2002; and Hannisdal 2006 among others). Other authors consider these new features as internal sound changes undergone by RP, and prefer to make a separation between Traditional RP, and a more modern RP, which would include these innovations, and is usually referred to by another term such as Standard Southern British (SSB)[14] (Handbook of the International Phonetic Association 1999; Shockey 2003), Southern British English (SBE) (Ashby and Przedlacka 2011) or Standard Southern

[13] Rather than being a regional marker, RP is considered to be a social marker, since it was traditionally considered the accent of the upper and upper-middle classes who distinguished themselves from lower classes by their regionally neutral accent. This regional neutrality is claimed to be one of the main characteristics of RP (see Trudgill 2002: 172; Przedlacka 2005: 24 among others). However, this conception has been challenged by some authors who claim that RP is in fact a variety endemic to the Southeast of England, and that it forms a phonetic and phonological continuum with the regional varieties in the Southeast, a continuum that may not exist in other regions (Nolan 1999: 86-87).

[14] The Handbook of the International Phonetic Association states that SSB is “the modern equivalent of what has been called ‘Received Pronunciation”, which is the accent of the “Southeast of England which operates as a prestige norm there and (to varying degrees) in other parts of the British Isles and beyond” (1999: 4)

British English (SSBE) [15] (de Jong *et al.* 2007; McDougall and Nolan 2007; Knight 2012).

Figure 9 shows a representation of this continuum with all the possible varieties that can be found in the Southeast of England and the main names that these varieties have been given in the literature. As can be seen, the present dissertation classifies the participants included in the corpus of study as belonging to what has traditionally been labelled General/Mainstream RP, and has increasingly been called SSBE, which takes into consideration the recent developments that this accent has undergone. In fact, many of the variables under analysis are described as recent innovations in recent descriptions of the standard accent of the Southeast of England.

[15] John Wells states in his blog that this term has become increasingly popular, and he says that "I noticed it quite a few times at the Hong Kong ICPhS two months ago". Post from 19 October 2011. http://phonetic-blog.blogspot.com.es/2011/10/son-of-rp.html

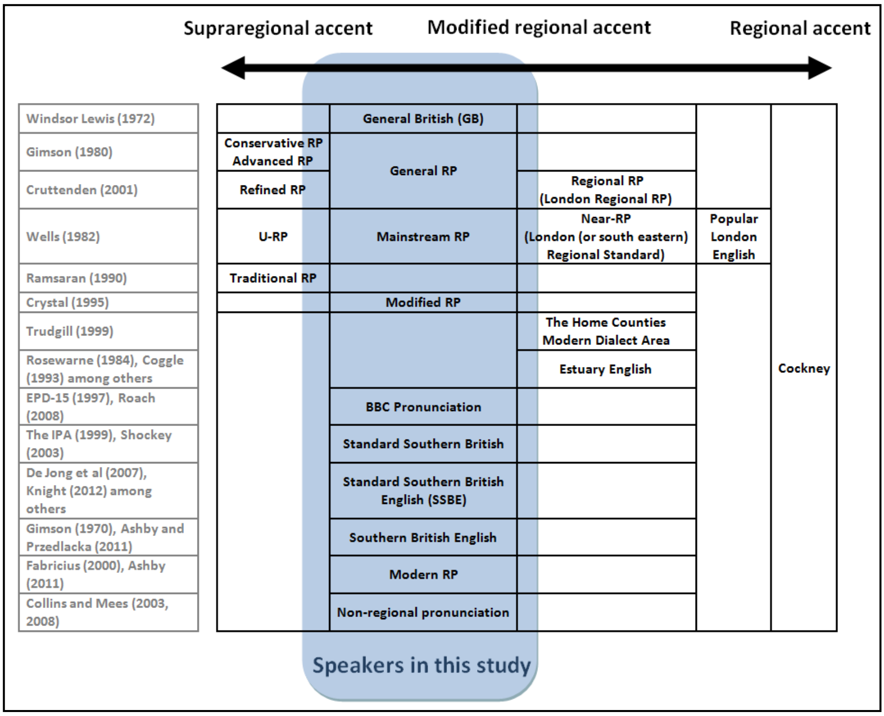


Figure 9: Accent continuum in the Southeast of England. Blue box shows where the accent of the speakers in this study would be situated. Adapted from Lilo (1995).

The subjects under study were all born in the 1950s (between 1950 and 1960) and raised mainly in the Southeast of England, i.e. London and the Home Counties. The area of the Home Counties includes the counties surrounding London: Kent, Surrey, East and West Sussex, Essex, Hertfordshire, Hampshire, Buckinghamshire, Berkshire, and Bedfordshire (Altendorf & Watt 2004: 181). For the majority of the speakers (13 out of 16) there are data in two measurement times in order to examine the stability of the speakers' idiolectal styles. Measurement time 1 (MT1) ranges from 1983 to 1998, and measurement time 2 (MT2) ranges from 2005 to 2011. The time gap between MT1 and MT2 for the same speaker can be between 10 to 25 years depending on the speaker. The duration of all the recordings is approximately 30 minutes on average (see Table 5 for a detailed account of the years included in MT1 and MT2 and the length of the recordings). The corpus of study contains two main subcorpora, and the speakers in each subcorpora differ between each other in their long-term situation (or not) of language contact. For anonymity purposes, each speaker has been given a number, and speakers will be referred to by this number, the subcorpus they belong to and whether they are male or female. Thus, speakers are presented as "*LanCon*_f_1", for example, which stands for female speaker from the *LanCon* subcorpus number 1. The two different subcorpora are detailed in sections 6.1.1 and 6.1.2.

6.1.1. The LanCon subcorpus

The *LanCon* subcorpus contains data on six English subjects (four men and two women) that moved permanently to Catalonia in the 70s and 80s and have been living there since then. Thus, they have been living in a long-term situation of language contact with Spanish and Catalan.

The data consists on sociolinguistic interviews conducted in two measurement times (MT1 and MT2) for three of the speakers (*LanCon*_f_1, *LanCon*_m_1 and *LanCon*_m_2). Having two measurement times for these speakers was possible because there were available pre-existing recordings from the 90s. The recordings in MT1 were conducted by students of English Studies at *Universitat Rovira i Virgili* during the 90s and were kept at the *Institut Universitari de Lingüística Aplicada* since then. The three speakers were selected from the rest of recordings from other

British speakers because they came from the same area (*LanCon*_f_1 and *LanCon*_m_1 grew up in Surrey, and *LanCon*_m_2 in London and Essex) and they belong to the same generation (born between 1951 and 1961). Also, all of them worked as teachers of English in Catalonia and were married to Spanish and/or Catalan partners. The same speakers were contacted and interviewed a second time in 2009 and 2010. Since there were no other recordings from other speakers that would suit the requirements of the study, three other subjects (*LanCon*_m_3, *LanCon*_m_4 and *LanCon*_f_2) were contacted and interviewed in 2011 in order to increase the number of subjects in this subcorpus, which implies that only recordings in MT2 are available for each of these three speakers.

All the six subjects in the *LanCon* subcorpus are currently teachers of English in language schools or at university or lecturers on English linguistics or English literature at a Catalan university. *LanCon*_m_4 was educated at a public school, *LanCon*_m_1 at an independent school, *LanCon*_m_3 and *LanCon*_f_2 at grammar schools and *LanCon*_f_1 at a secondary modern, there is no information on the type of secondary school the speaker *LanCon*_m_2 went to. As regards higher education, four speakers (*LanCon*_m_1, *LanCon*_m_2, *LanCon*_m_3 and *LanCon*_m_4) went to university. Moreover, all of them have been or still are married to a native speaker of Spanish and/or Catalan and have children who have been raised and educated in the Spanish system.

The *LanCon* subcorpus was the one that initially began to be collected for the purposes of this dissertation. The aim was to collect a second subcorpus of speakers who had not been in this situation of language contact in order to compare their phonetic/phonological patterns. Thus, the *InSit* subcorpus was created.

6.1.2. The InSit subcorpus

Going to the Home Counties and collecting data from native English speakers with equivalent sociolinguistic characteristics to the subjects in the *LanCon* subcorpus would have been a relatively easy task to carry out. However, the greatest challenge regarding the collection of the corpus for this dissertation has been that, apart from inter-speaker variation, we also wanted to test intra-speaker variation over time, which meant that we needed data from the same speakers collected at two different times with a considerable time gap between the two measurement times, i.e. a sociolinguistic real study needed to be conducted. After looking at existing corpora in spoken English, the possibility of finding a corpus that already existed and contained data suitable for the present study was discarded. Therefore, it was necessary to look for speakers whose sociolinguistic traits were as similar as possible to the *LanCon* speakers, and for whom there were recordings which were long enough, were as spontaneous as possible, and were available at two different times of their lives. The only way to reach this purpose was to collect data from famous people in a relatively spontaneous context (in order for them to be equivalent to the sociolinguistic interviews) from *YouTube* or TV and Radio channels.

The *InSit* subcorpus, labelled *InSit* after the expression *in situ*, contains recordings on ten English subjects (five men and five women) who were born around the same years as the *LanCon* subjects (from 1950 to 1961), they were also raised in the Southeast of England, and have remained in an English-speaking environment the greatest part of their lives.

The professions of these speakers fall within three main categories. Firstly, *InSit*_f_1, *InSit*_m_3 and *InSit*_f_2 are radio/TV presenters and stand-up comedians. Secondly, *InSit*_f_3, *InSit*_f_5, *InSit*_m_1 and *InSit*_m_2 are musicians. And finally, *InSit*_f_4, *InSit*_m_4 and *InSit*_m_5 are actors. Two of them went to a public school (*InSit*_m_1 and *InSit*_m_5), two went to independent schools (*InSit*_f_5, *InSit*_m_4), two went to secondary modern schools (*InSit*_m_2 and *InSit*_m_3) and four went to grammar schools (*InSit*_f_1, *InSit*_f_2, *InSit*_f_3 and *InSit*_f_4). All of them went to college except *InSit*_m_1, *InSit*_m_2 and *InSit*_m_3, who, as far as the information available on the Internet is concerned, did not pursue further formal education. Table 5 and Table 6 are a summary of the most relevant information of the subjects in both the *LanCon* and the *InSit* subcorpora and characteristics of their recordings.

Table 5: Length and years of recordings of all the samples.

	SPEAKER	MT1 MATERIAL		MT2 MATERIAL	
		YEAR(S)	LENGTH	YEAR(S)	LENGTH
InSit	InSit_f_1	1983-1989	16.42 min.	2007-2010	31.34 min.
	InSit_f_2	1986-1994	16.04 min.	2008-2010	34.49 min.
	InSit_f_3	1985-1993	30 min.	2005	31 min.
	InSit_f_4	1993-1996	26.15 min.	2008-2010	32.40 min.
	InSit_f_5	1992-1998	31 min.	2007-2009	24.23 min.
	InSit_m_1	1986-1994	38 min.	2008-2011	40 min.
	InSit_m_2	1989-1997	33.29 min.	2007-2011	32.49 min.
	InSit_m_3	1988-1994	22.50 min.	2007-2008	39.14 min.
	InSit_m_4	1986-1992	31.39 min.	2007-2009	35.21 min.
	InSit_m_5	1987-1995	34 min.	2009-2011	31 min.
LanCon	LanCon_f_1	1988-1994	22.50 min.	2010	28.28 min.
	LanCon_m_1	1992	26.17 min.	2009	25.55 min.
	LanCon_m_2	1988	38 min.	2010	35 min.
	LanCon_m_3	-----	-----	2011	26.25 min.
	LanCon_m_4	-----	-----	2011	35.48 min.
	LanCon_f_2	-----	-----	2011	30.34 min.

Table 6: Relevant personal information of the subjects of study.

	NAME	GENDER	YEAR OF BIRTH	PLACE WHERE THEY GREW UP	SECONDARY SCHOOL	HIGHER EDUCATION	JOB	CURRENTLY LIVING IN	RELEVANT PERSONAL INFORMATION
InSit	InSit_f_1	Female	1955	Kent/Surrey	Grammar school	University of London	TV presenter	London	
	InSit_f_2	Female	1957	Kent	Grammar school	Nursing school	Stand-up comedian	London	
	InSit_f_3	Female	1958	London	Grammar school	--	Musician	London	
	InSit_f_4	Female	1959	London	Grammar school	University of Cambridge	Actor	London/ Scotland	
	InSit_f_5	Female	1960	Hertfordshire	Independent school	Further education	Musician	England/US	
	InSit_m_1	Male	1950	Surrey	Public school	--	Musician	London / Wiltshire	
	InSit_m_2	Male	1954	London / Liverpool	Secondary modern school	--	Musician	Canada/US / London	Married to a Canadian
	InSit_m_3	Male	1951	Surrey	Secondary modern school	--	Radio/TV presenter	London	
	InSit_m_4	Male	1957	London/ Buckinghamshire / Norfolk	Independent school	University of Cambridge	Actor / Writer	London	
	InSit_m_5	Male	1959	Oxford	Public school	University of Cambridge	Actor	England/US	
LanCon	LanCon_f_1	Female	1952	Surrey	Secondary modern school	--	Teacher of English –Language school	Catalonia since 1972	Married to a Spaniard
	LanCon_m_1	Male	1961	Surrey	Independent school	University of Sheffield	Teacher of English -University	Catalonia since 1984	Married to a Catalan
	LanCon_m_2	Male	1951	Essex/ London	?	University of Kent	Teacher of English - University	Catalonia since 1986	6 years in Paris. Married to a Catalan
	LanCon_m_3	Male	1960	Sussex	Grammar school	Lancaster University	Lecturer on English literature- University	Catalonia since 1984	Married to a Catalan
	LanCon_m_4	Male	1957	Kent / Surrey (+ other countries)	Public School	University of London	Lecturer on English linguistics - University	Catalonia since 1982	3 years in Córdoba. Spaniard ex-wife
	LanCon_f_2	Female	1957	Surrey	Grammar school /sixth form college	Secretarial school + TEFL	Teacher of English – Language school	Catalonia since 1983	Married to a Catalan

6.2. Variables of analysis

The IIS module with which this dissertation is concerned is called ‘phonological module’, and before giving a detailed account of the variables that have been chosen as part of this module, we will clarify why the term ‘phonological’ and not ‘phonetic’ has been chosen.

Traditionally, phonology has been concerned with the study of discrete phenomena, such as phonemes, syllable structure and phonotactics, and rules that predict the occurrence of allophonic variants, which are all language-specific phenomena. On the other hand, phonetics is concerned with continuous –or gradient– phenomena, which is supposed to be universal, because they are automatic consequences of articulatory mechanisms (Keating 1996; Thomas 2011). In this sense, generativist phonology considers phonological rules to be language-specific rules which apply to the underlying representations of phonemes in order to obtain their allophones (Hayes 1995). According to this view, phonological rules would consist of processes such as assimilation, dissimilation, lenition, fortition, and epenthesis. However, this dichotomy between phonetics and phonology has been challenged by many phonologists, and phonology has increasingly accepted phonetics into its discipline (Thomas 2001: 256-7). In the 1980s, generativist phonologists (Pierrehumbert 1980; Keating 1985, 1988, 1990,) introduced the concept of phonetic rules as parallel to phonological rules. Phonetic rules, or phonetic implementations, relate discrete phonological categories to their surface gradient phonetic realisations, and they are also language or dialect-specific. Also, Optimality Theory considers a large number of constraints that are phonetic in nature. On the other hand, different approaches regard the border between the two disciplines to be in different points. Kingston and Diehl (1994) consider that phonology is strictly related to contrastive units, and that any language-specific phonetic rules, not to mention automatic articulatory processes, are to be part of phonetics. In contrast, Ohala (1990) claims that no difference between phonetics and phonology should be made because both disciplines are part of the study of sound patterns in language.

The present dissertation adopts the more traditional view and regards the variables with which this module is concerned as phonological variables. The reason for this is twofold. On the one hand, the variables in this module are concerned with processes such as elision, insertion or change of phonemes, as well as phonological rules that account for the adoption of particular variants in specific contexts, all of which have been traditionally regarded as being of concern to phonology. On the other hand, the project that serves for framework of this dissertation, whose research is dedicated to develop an IIS for other linguistic levels[16], envisages the possibility of developing a “phonetic module” of IIS, which would consider more ‘phonetic’ variables such as fundamental frequency, VOT, spectral characteristics of sounds, etc. Therefore, the traditional difference between phonetics and phonology in their application to IIS modules needed to be preserved.

[16] See Chapter 4 for an explanation of the projects that serve as framework of the present PhD dissertation.

However, it should be mentioned that I agree with other authors that challenge this dichotomy, and acknowledge that the definition of the processes at hand as phonological, and not phonetic, is rather problematic. The majority of variables, if not all, involve continuous processes, rather than discrete, where any boundary that is set is arbitrary. In the end, anything regarding speech sounds is continuous, and any attempt at a categorisation is subjective and artificial. However, the IIS, in all its modules, was initially conceived as having discrete variables, and this approach was also adopted by the phonological modules in order to be able to apply the same methodology that was applied in the other modules. In any case, processes such as the variables dealt with in this dissertation have very often been regarded as discrete, as it will be shown in the next section, and the best way to guarantee a correct coding of the variants is to ensure that the arbitrary divisions are consistently maintained (Chambers & Trudgill 1998: 52), which is what has been done in this research.

Before looking at the variables of study in the present PhD dissertation in more depth, it should be mentioned that in the course of the research conducted towards this dissertation, many phonological variables were analysed in preliminary studies (Gavaldà 2009) but were finally discarded and not considered in this study due to different reasons, which are explained below.

Smoothing is a process affecting vowels in SSBE by which the triphthongs [aʊə] and [aɪə] in words like *flower* or *higher* sometimes lose their second element, so that their pronunciation becomes more similar to a long monophthong with a quality that could be described phonetically as [aː] or [ɑː] (Wells 1982: 292). Hannisdal reports that this process is a case of stable variation rather than change in progress and that men and women differ significantly in their production of this variant (2006: 203), two facts that initially made this process look like a suitable candidate for the IIS protocol. However, preliminary analyses showed that this variable poses a major problem. The samples under study contained few instances of this variable, which meant that in some cases, it did not appear at all, and some comparisons could not eventually be carried out. Therefore, this process was discarded as a variable in the PhD dissertation.

Two other variables related to vowels that were considered initially were the reduction of the vowel in the word <my> from /aɪ/ to [i], e.g. *my [mi] favourite watch*, and also, vowel reduction in words such as *Sunday, Monday* etc, by which they may be pronounced [sʌndi] and [mʌndi]. These two variables were discarded because of two main reasons. On the one hand, only few speakers produced the reduced variant, and therefore, it was not useful for the majority of the speakers. On the other hand, due to the fact that these processes depend on a pretty reduced lexical set, they did not appear very usually, which made them quite unproductive variables.

Other variables were also discarded because their scope was reduced to only one or two lexical items. This was the case of the words *again* and *against*, which show variation between /eɪ/ and /e/, the word *often*, which can be pronounced with or without /t/, the word *actually*, which some speakers may pronounce [ækʃi], and the word *obviously* which shows variation between [bv] and [v]. In the case of the first two variables, only few speakers produced the less usual variant ([əgeɪn] and [ɒftən]), which made them useless to distinguish between the majority of speakers. Besides, the four variables had in common the fact that they showed very few instances, if any, in the samples studied.

Processes concerned with elision of consonants that were initially explored involve, firstly, elision of /d/ between /n/ and /z/ in words like *friends* and *depends*; secondly, elision of /t/ in consonant clusters especially across word boundaries, in words such as *last year* and *first thing*; and thirdly, the reduction of the forms *going to* and *want to* to *gonna* and *wanna*. All these variables showed few instances of occurrence and were finally disregarded as well.

The alveolarisation of the velar nasal in the ending *–ing* from /ɪŋ/ to [ɪn] was also initially studied, as well as the process of syllabic consonant formation of /l/ and /n/ in words like *button* [bʌtn̩] and *bottle* [bɒtl̩]. However, these two processes had in common the difficulty of codification, since in many occasions it was extremely difficult to decide upon one or the other variant due to the spontaneity of the speech under study and the coarticulation effects that they suffered (especially in the case of the nasal /ŋ/). Consequently, they were both discarded.

After the initial studies by which these variables were discarded, and after the reformulation of some others, a total of fourteen variables that were more robust and seemed more discriminatory were established as variables of study in the present PhD dissertation. These fourteen variables are summarised in Table 7. As can be seen in this table, there are some variables that deal with the same process. Variables 1 and 2 deal with the same process of vowel alternation (or vowel reduction); variables 3 and 4 consider yod coalescence; variables 7, 8 and 9 deal with t-glottalling, and variables 10, 11 and 12 are related to the same process of t-tapping. The formulation of different variables that deal with the same process is justified by the fact that each variable considers a different scope of variation (see section 1.3 for a definition of the scope of variation in a sociolinguistic variable). Despite dealing with the same process, each of the contexts included in each variable may correlate differently with the process under study, thus prompting different behaviours, which, if considered jointly, would be neutralised. As explained in section 1.3, defining the scope of variation of a variable is fundamental, and doing it wrongly can compromise the whole study. The formulation of the fourteen variables, their scope of variation and their coding are explained in more depth in sections 6.2.1 and 6.2.2.

Table 7: List of variables of study in the PhD dissertation.

<table>
<tr><th colspan="3"></th><th>VARIABLE</th><th>VARIANTS</th></tr>
<tr><td colspan="2" rowspan="2">VOWELS</td><td>1</td><td>Vowel alternation in ‘weakened’ be–, de–, pre–, re– and e– (enough, begin, depend).</td><td>1. /ə/
2. /ɪ/</td></tr>
<tr><td>2</td><td>Vowel alternation in terminations: -ible, -ily, -ity, -less, -let/-ret, -ate, -ace (possible, happily, delicate).</td><td>1. /ə/
2. /ɪ/</td></tr>
<tr><td rowspan="12">CONSONANTS</td><td rowspan="2">Yod Coalescence</td><td>3</td><td>Yod coalescence of [t, d, s, z] before [j] across word-boundaries (this year).</td><td>1. Coalescence [ʃ, ʒ, tʃ, dʒ]
2. No coalescence [s, z, t s, d z]</td></tr>
<tr><td>4</td><td>Yod coalescence of [t, d, s, z] before [j] word-internally (duty, student, studio).</td><td>1. Coalescence [ʃ, ʒ, tʃ, dʒ]
2. No coalescence [s, z, t s, d z]</td></tr>
<tr><td rowspan="2">Insertion of sounds</td><td>5</td><td>Insertion of [t] in the context of [n]__[s]: (since, once).</td><td>1. Insertion of [t]
2. No insertion</td></tr>
<tr><td>6</td><td>Linking /r/.</td><td>1. Linking /r/
2. No Linking /r/</td></tr>
<tr><td rowspan="3">T-Glottalling</td><td>7</td><td>T-glottalling (V_#V) in frequent words and lexical items with close syntactic linkage such as get up, but I, what if, out of…</td><td>1. Glottalling [ʔ]
2. Other variants [t] [ṭ] [ɾ]</td></tr>
<tr><td>8</td><td>T-glottalling intervocalically across word boundaries in lexical words (V_#V).</td><td>1. Glottalling [ʔ]
2. Other variants [t] [ṭ] [ɾ]</td></tr>
<tr><td>9</td><td>T-glottalling word-finally before pause.</td><td>1. Glottalling [ʔ]
2. Other variants [t] [ṭ]</td></tr>
<tr><td rowspan="3">T-tapping</td><td>10</td><td>T-tapping (V_#V) in frequent words and lexical items with close syntactic linkage such as get up, but I, what if, out of…</td><td>1. Tapping [ɾ]
2. Other variants [t] [ṭ] [ʔ]</td></tr>
<tr><td>11</td><td>T-tapping between vowels (V_V) in highly frequent words: pretty, whatever, getting, putting, British, Scottish, better, sitting, matter.</td><td>1. Tapping [ɾ]
2. Other variants [t] [ṭ] [ʔ]</td></tr>
<tr><td>12</td><td>T-tapping between vowels word internally and across word boundaries (V_(#)V).</td><td>1. Tapping [ɾ]
2. Other variants [t] [ṭ] [ʔ]</td></tr>
<tr><td rowspan="2">Frication of plosives</td><td>13</td><td>Frication of /t/ between vowels word internally and across word boundaries (V_(#)V).</td><td>1. Frication [ṭ]
2. Other variants [t] [ɾ] [ʔ]</td></tr>
<tr><td>14</td><td>Frication of /k/ between vowels word internally and across word boundaries.</td><td>1. Frication [x]
2. No frication [k]</td></tr>
</table>

6.2.1. Variables related to vowels

There is currently a certain tendency in SSBE to use /ə/ in non-final unstressed syllables when we would traditionally find /ɪ/. This phenomenon can be interpreted in two ways from a phonetic-phonological point of view. On the one hand, it could be considered as vowel reduction, since [ə] is a reduced vowel (reduced in the sense that it is shorter and more central). In fact, English is characterised by a process of vowel reduction by which many full vowels get reduced to schwa in unstressed position, as in the case of *economy* [ɪˈkɒnəmi]-*economics* [ɪkəˈnɒmɪks] where the vowel [ɒ] gets reduced to [ə] when that syllable gets unstressed. However, in the case of words such as *b**e**long* or *pos**i**tive*, which can be pronounced with [ɪ]/[i] or [ə], the phenomenon may be considered as vowel alternation between two equally weak vowels, since both realisations [ɪ] and [i], are as weak as [ə] (as explained in LPD 2008: 892).

Table 8 shows the two variables related to vowels. Variable 1 accounts for variation in the pronunciation of words beginning in what Wells calls 'weakened' *be-*, *se-*, *de-*, *re- pre-*, *des-* and *e-* (1982: 296) as in *besides, before, selection, depression, remember, present, desire, enough*. According to Wells (1983: 296) and Cruttenden (2001: 108), the preferred variant in these words is the more conservative /ɪ/, although /ə/ is also a possible variant. In the 3rd edition of the Longman Pronunciation Dictionary (LPD) (2008), Wells substitutes the symbol [ɪ] for the HAPPY vowel /i/, which accounts for a change in the quality of this vowel. In any case, the two variants of this variable are /ə/ on the one hand, and a higher and fronter vowel /ɪ/ or /i/ on the other[17].

[17] Despite the fact that these two variants have been considered together as one category, it might be interesting to look at them separately in future studies, since the variant [ɪ] seems to be a change in progress in itself.

Table 8: Variables related to vowels.

1	Vowel alternation in ‘weakened’ *be-, se-, de-, re- pre-, des- and e-* (*enough, begin, depend*).	1. /ə/ 2. /ɪ/
2	Vowel alternation in terminations: *-ible, -ily, -ity, -less, -let/ -ret, -ate, -ace* (*possible, happily, delicate*).	1. /ə/ 2. /ɪ/

As for the words that are included in this variable, it should be mentioned that the word *because* was taken out from the analysis. A preliminary study of this variable (Gavaldà 2009) shows a categorical preference by speakers towards the pronunciation of this word with /ɪ/, as expected, while some of them showed some variation in other words like *belong, behave or before*. Since the word *because* appeared numerous times in the data and it did not show the variation that the rest of words with those beginnings did, it was taken out from the analysis so as to avoid alteration of the final result (an example of the ‘type-token question’ discussed in section 1.3).

Variable 2 also deals with this type of vowel alternation and includes words with terminations *-ity, -itive, -ily, -ible, -less, -let/-ret.* Examples of words included in this variable are *quality, positive, happily, possible* and *careless.* The reason why these two variables have been considered independently rather than in a single variable is because the preferred variant for words in variable 2 appears to be /ə/ (Cruttenden 2001: 107; Wells 2008), and the preferred one for words in variable 1 is [ɪ], so a different behaviour is expected for the two variables.

As regards the analysis of the two variants, it was mainly done on auditory grounds. In order to support the categorisation carried out in this dissertation, these two variables were included in the perception test that was conducted in order to validate the categorisation of some variables that were more difficult to analyse due to their continuous nature (see section 6.2.3).

6.2.2. Variables related to consonants

6.2.2.1. Yod Coalescence

The process of yod coalescence [18] is a process of reciprocal assimilation by which the alveolar plosives and fricatives /t,d,s,z/ coalesce with a contiguous /j/ to form the sounds /tʃ,dʒ,ʃ,ʒ/ respectively [19]. This process can happen at a historical level, by which the only possible pronunciation of words such as *soldier* or *nature* is with the coalesced form [səʊldʒə] and [neɪtʃə], and also at a contextual level, where it is a source of variation. Yod coalescence at a contextual level can take place within the word, in words such as *duty* [dʒuːti] and *tune* [tʃu;n], and also across word boundaries, especially with phrases involving *you*, as in *told you* [təʊldʒu] and *let you* [letʃu]. This process has been present in SSBE for a long time, especially in rapid informal speech (Wells 1982: 331). Yod coalescence across word boundaries and within a word in unstressed position has traditionally been regarded as

[18] This process has sometimes been referred to as palatalisation (Shockey 2003). It is true that the sounds involved /t,d,s,z/ are affected by a contiguous palatal approximant /j/ and they become more “palatal-like”. However, /t,d,s,z/ become post-alveolar, rather than palatal, and thus the term may not be totally accurate, though, as Shockey argues, ‘the term is well-established and will no doubt continue to be used’ (2003: 45).

[19] Some authors tend to regard yod coalescence as affecting only alveolar plosives (Wells 1994; Hughes *et al* 2005). However, following authors such as Cruttenden (2001, 2008; Shockey 2003; Wells 2008), both alveolar plosives and fricatives are regarded to be part of the same process of yod coalescence.

established in SSBE (Wells 1994; Hannisdal 2006) whereas the same phenomenon within a stressed syllable has been considered as non-SSBE (Wells 1982, 1994). However, more recent studies have shown that it is now a more established change in SSBE. Cruttenden includes this last type of yod coalescence within the “changes well-established” within SSBE, which he defines as “typical of a majority of speakers of General RP” (2001: 83). Moreover, Wells notes in his 1999 survey that, contrary to his expectations, the non-coalesced forms are favoured by older speakers, whereas the youngest ones favour the coalesced forms in the word *tune*, more than in the other words, for which he hypothesizes that the change might be more accepted in more common words (Wells 1999: 9). Hannisdal’s findings in her study (2006) support this fact, and this author claims that “yod coalescence is entering Mainstream RP speech and should be included in updated descriptions of the accent” (Hannisdal 2006: 217). Apart from the question of whether the process should or should not be included within a description of RP (or SSBE), there is no doubt that this process, either in stressed or unstressed position is present in the speech of speakers from the Southeast of England, and it definetely shows variation. As a matter of fact, Hannisdal points out that all the speakers in her study show coalescent variants to some extent, and that there is “great amount of variation” (2006: 211), which in this context means inter-speaker variation. She also observes that there is intra-speaker variation, which, according to her findings, is not associated with certain lexical items, but to the fact that “yod coalescence is a mechanism for improving articulatory ease, and as such will typically sometimes be applied and sometimes not, under the same circumstances" (2006: 214). Thus, the implication of such variation is key in the present dissertation, in that each speaker may use this process differently, which may in turn make it a potentially discriminatory variable.

Despite the fact that yod coalescence equally appears in SSBE both word-internally –in stressed and unstressed position– and across word boundaries, these two contexts were separated when formulating the variables in this study. Table 9 shows the two variables that deal with yod coalescence. Variable 3 includes this process across word boundaries whereas variable 4 considers it word internally both in stressed and unstressed position. The reason for this division is that preliminary studies of the behaviour of this phenomenon (Gavaldà 2009) showed that speakers could have different patterns of variation depending on whether the sounds were found within the word or across word boundaries, so it was decided that these two contexts would be explored separately, instead of grouping them in the same variable.

Table 9: Variables related to the process of yod coalescence.

3	Yod coalescence of [t, d, s, z] before [j] across word-boundaries. (*this year*)	1. Coalescence [ʃ, ʒ, tʃ, dʒ] 2. No coalescence [s, z, t s, d z]
4	Yod coalescence of [t, d, s, z] before [j] word-internally (*duty, student, studio*)	1. Coalescence [ʃ, ʒ, tʃ, dʒ] 2. No coalescence [s, z, t s, d z]

It should also be taken into account that the word *during* was not included in the analysis of variable 4, since it shows a special pattern. According to Hannisdal,

> In earlier editions of EPD [English pronouncing dictionary] (from 1967 and up until the fifteenth edition in 1997) *during* is

> the only word where yod coalescence is accepted as an alternative before a stressed vowel. In LPD (Wells 2000) /tʃ, dʒ/ in stressed syllables is marked as non-RP, except in the word during. (2006: 213)

The categorisation of the two variants of the two variables related to yod coalescence was carried out on acoustic and auditory grounds. This process was also included in the perceptual test regarding the categorisation of some variables (see 6.2.3).

6.2.2.2. Insertion of sounds

The variables that are related to the insertion of sounds are T-epenthesis between [n] and [s] (variable 5), and linking /r/ (variable 6). Both variables are summarised in Table 10.

Table 10: Variables related to the insertion of sounds.

5	Insertion of [t] in the context of [n]__[s]: (*since, once)*	1. Insertion of [t] 2. No insertion
6	Linking /r/	1. Linking /r/ 2. No Linking /r/

6.2.2.2.1. T-epenthesis

Variable 5 deals with the insertion of [t] between a homorganic nasal [n] and a voiceless fricative [s] in words like *since* [sɪnts] and *once* [wʌnts]. This process may be regarded as part of a wider phonetic process of oral stop epenthesis[20] by which an oral stop can be inserted between a preceding homorganic sonorant (usually a nasal or a lateral approximant) and a following voiceless fricative which agrees in voicing with the stop (Mora 2002: 22). This

[20] Also known as 'intrusive stop formation' (Mora 2006).

process, which is not only found in English but in many other languages, has been regarded as the result of a mismatch between two articulatory movements by several authors (e.g. Harms 1973; Ohala 1974; Donegan & Stampe 1979). The velum –which is lowered for the nasal stop– has to raise to produce the following oral fricative; at the same time the obstruction in the place of articulation of the nasal has to be undone to create the stricture of close aproximation for the following fricative. If these two movements are slightly overlapped, a moment between the two movements is created by which the velum is raised but the complete obstruction in the oral tract remains, thus creating an oral stop homorganic with the nasal stop. Some studies (Anderson 1976, Harris 1994) show that the oral stop resulting from this mismatch is always shorter than the equivalent oral stop in a word with an underlying phonological stop. Thus, this process can be regarded as “purely phonetic” “caused by the physical constraints of the vocal tract” (Mora 2002: 23).

Nevertheless, there are other authors who suggest that speakers may have some control over this overlapping gesture, since it is not universal, but rather a language-specific rule. What is more, Fourakis and Port (1986) demonstrate that this process is not only language-specific but also dialect-specific, in that speakers seem to acquire this pattern differently depending on the accent of English. Their study shows that the American subjects always insert a stop between sonorant and fricative, whereas the South African speakers never produce it. As a matter of fact, Jones (1966 -cited in Fourakis & Port 1986: 200) state that the insertion of a stop between a sonorant and a fricative is found in American English, but not in British English. This statement suggests that this process, rather than being inevitable and universal, seems to be the result of a learned pattern. As Fourkis and Port explain:

> if the occurrence of a stop were dictated by intrinsic timing constraints on the articulators, as Ohala and Harms proposed, then the South African speakers should not have been able to maintain this segmental contrast. It seems then that the effect is not universal. (1986: 215)

Considering that this trait is produced differently depending on the accent, since this process seems to be “the product of a language-specific rule of stop epenthesis” (Fourakis & Port 1986: 215), the question lies on whether there is any speaker-specific nature on it, as these authors suggest, saying that these kinds of rules, which they call “phase rules”, are “variable in the details of articulatory output from speaker to speaker” (Fourakis & Port 1986: 218). In this sense, Cruttenden notes that “few RP speakers regularly maintain the distinction beetween /ns/ and /nts/ which is widespread in regional speech” (Cruttenden 2001: 187), which implies that there may be some speaker-specificity to the process. Similarly, Wells also mentions this possibility:

> There are those of us for whom *chance* and *chants* are homophones, and those of us for whom they are clearly different. The polling figures revealed a firm preference in *chance* for /ns/ (83% overall), firmer though among the old (87%) than the young (75%). Regionally, resistance to the epenthetic plosive is strongest among the northern English (90%), weakest among the southerners (81%). (1999: 43)

It must be taken into account that this poll is merely a perceptual poll, rather than a pronunciation test, and it may not reflect the actual pronunciation of the population interviewed, but their idealised version of it. As a matter of fact, Wells himself suspects that “for many this may reflect an idealistic preference rather than their actual pronunciation” (Wells 1999: 43). In any case, there might be a possibility of there being a speaker-specific element in this phonetic process, since it may as well be a process that takes place in very rapid speech and also in very careful speech. Thus, variable 5 is an attempt to explore the speaker specificity of this process beyond its mere phonetic nature.

In order to decide when a [t] was insterted and when it was not, the analysis was based solely on phonetic cues. A [t] was considered to be inserted whenever an explosion bar could be seen on the spectrogram before the fricative, as it is the case of the word audience produced by speaker *InSit*_m_1 shown in Figure 10. If such bar was not present on the spectrogram, then it was considered that there was not an insertion of [t].

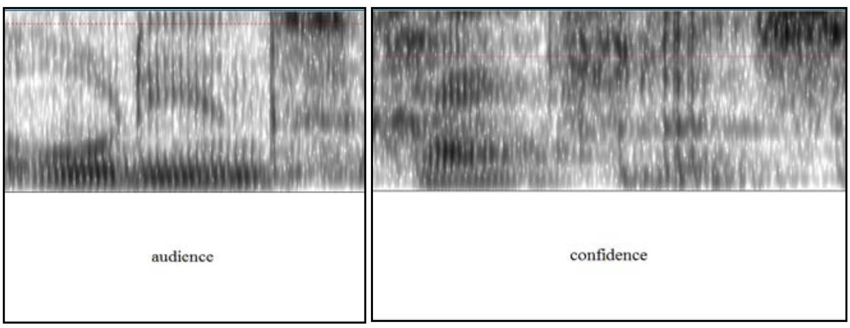


Figure 10: Spectrograms of the word *audience*, produced by *InSit*_m_1 (MT1), which shows an epenthetic [t], and the word *confidence*, produced by *InSit*_m_5 (MT1), which does not show this process of epenthesis.

6.2.2.2.2. Linking /r/

Linking /r/ is a kind of r-liaison, or r-sandhi, that takes place in non-rhotic accents of English. It is a hiatus-breaking mechanism, which implies the insertion of a historical /r/ –historical in that it was once pronounced, as is indicated by the <r> that remains in the spelling– in coda position when there is a vowel following. Thus, the word *far* is pronounced /fɑː/ in non-rhotic accents, but *far away* is pronounced /fɑːrəweɪ/. Linking /r/ happens both across word boundaries, as in the previous example, or across morphemes, as in *fear* /fɪə/ *fearing* /fɪərɪŋ/. Variable 6 considered in this study includes linking /r/ only in the former context, i.e. across word boundaries, since finding variation in the production of linking /r/ is more likely across word boundaries than across morphemes. There is another type of r-sandhi, intrusive /r/, by which an unetymological /r/ is inserted in the same contexts as linking /r/ takes place, i.e. after the vowels /ɑː,ɔː,ɜː,ə,ɪə,eə,ʊə/, as in the phrase *the idea is* /ði aɪˈdɪərɪz/. Although intrusive /r/ was examined in the preliminary analyses that led towards this PhD dissertation (Gavaldà 2009), it was then seen that the variable had very few instances of occurrence, and therefore was not a very productived variable.

These two processes of r-sandhi are mainly differenciated by a stylistic factor. Linking /r/ is considered to appear equally regarding different speech styles (Ramsaran 1978 quoted in Wells 1982: 286; Cruttenden 2001: 294), which makes it a general process in non-rhotic accents. In contrast, the non-etymological nature of the process of intrusive /r/ has historically led it to be considered as less prestigious than linking /r/[21]. The consequence of this stigma in intrusive /r/ may be the suppression of not only instances of intrusive /r/ but, by analogy, also of linking /r/, as Cruttenden explains:

> The focusing of attention on ‘intrusive’ /r/’s as an undesirable speech habit has led to the use by some speakers of a pause or glottal stop in such cases of vowel hiatus, with the result that, in avoiding ‘intrusive’ /r/’s, they have also abandoned other linking /r/’s in favour of a vowel glide or glottal stop. (2001: 289)

This unconsciuos avoidance of both intrusive and linking /r/’s, which could be interpreted as a kind of hypercorrection, might be a source for inter-speaker variation, depending on, on the one hand, the speaker’s degree of consciousness of the stigma present in intrusive /r/ and, on the other, the capacity to discriminate between the contexts of linking /r/ and intrusive /r/. As a matter of fact, Winsdor Lewis reports that:

> [T]he use or non-use of linking /r/ is a notable field for idiosyncratic variation on the part of individual speakers. One even finds in one and the same speaker on the one hand a tendency to drop common r-links and on the other free use of ‘intrusive’ r. (1975:39)

Thus, Windsor Lewis argues that every subject (BBC newsreaders in his study), may have different tendencies towards linking and intrusive /r/. In a much later study also considering newsreaders, Hannisdal (2006: 106) is surprised to find in the results of her study

[21] See Hannisdal (2006: 108) for a literature review on this matter.

that the use of linking /r/ in the subjects of her study is lower than expected, and that there is a great deal of inter-speaker variation. Some of the subjects generally favoured the Ø variant (2006: 159), whereas some of the speakers who favoured the linking /r/ variant showed different tendencies towards its realisation before a stressed vowel (2006: 166).

The analysis of this variable was carried out from an auditory point of view, since it is quite clear to distinguish between the production of an /r/ on the one hand, and the production of no sound, or a glottal stop on the other when it is between vowels.

6.2.2.3. T-Glottalling

T-glottalling is a widely explored variable in all accents of English, including SSBE[22]. The allophonic process by which the phoneme /t/ is realised as a glottal stop [ʔ] in coda position has always been a very variable feature in English, depending mainly on educational level, speech style and, also, phonetic context.

Glottalisation of /t/ before another consonant, both word-internally and across word boundaries, has been considered a feature established in SSBE for a long time (Wells 1982: 261). However, the prestige status of glottalisation before a vowel and before a pause within SSBE is not that clear. Wells claims that glottalling in preconsonantal environments is found in SSBE whereas prevocalic glottalling is not (1982: 299), although he considers that glottalling in the latter context –prevocalically– is a ‘characteristic distinguishing an educated London accent from traditional RP’

[22] See Fabricius (2000) for a wider account of the most relevant literature regarding t-glottalling in SSBE.

(1982: 324). Later on in his article *The Cockneyfication of RP*, Wells states that “among younger RP-speakers it can even be heard finally before vowels or in absolute final position” (1994). This difference in behaviour depending on the different contexts can be interpreted as the result of the sound change behind the process of glottalisation spreading to more contexts in SSBE. Thus, glottalling before vowels across word boundaries and in absolute final position are new contexts of application of this rule that are being upgraded as part of RP. Similarly, Cruttenden (2001) states that:

> Even before a following vowel the use of [ʔ] for word-final /t/ before a following vowel is now acceptable as a form of London Regional RP (Estuary English), e.g. in *get off, got it, right order*. (…) Some RP speakers will also use [ʔ] to realize /t/ when syllabic [n̩] follows, e.g. *cotton, certain*. But the use of [ʔ] for /t/ preceding syllabic [l̩], and, more particularly in unaccented intervocalic word-medial positions, is typical of regional varieties of English (e.g. those of Cockney and Glasgow), as in *kettle, butter, later*, such pronunciations are not even acceptable as part of London Regional RP. (2001: 164)

Then, it could be stated that we are not dealing with different processes happening in different contexts, which may or may not be prestigious within a specific accent, in this case Mainstream RP or SSBE. Rather, they are all different stages of the same sound change that is spreading at different speeds –and thus being acknowledged and accepted as part of SSBE at different stages– depending on the phonetic context. The fact that t-glottalling is a change in progress is shown by Tollfree (1999) among other authors, who observes that the two age groups in her study – between 15 and 30 years old on the one hand and between 54 and 89 on the other– show great disparity in the degree of t-glottalling in prevocalic position across word boundaries and before a pause, which, as she states, "suggests a change in progress: the phonologisation of T-glottalisation in SELRS[23]" (1999: 171).

Table 11 shows a summary of the three stages (or 'waves' as called by Fabricius (2000)) in the spread of t-glottalling within SSBE. Stage one would include the phonetic contexts where t-glottalling shows a near-categorical behaviour, i.e. the majority of speakers produce a glottal stop most of the times, which is in pre-consonantal position both within a word and across word boundaries. Stage 2 represents the phonetic environments where t-glottalling "has to some extent lost its stigma, but not yet acquired prestige" (Fabricius 2000: 145) in SSBE, and it is in this stage where inter-speaker variation mostly exists, depending on factors such as age -as Tollfree finds out– and especially speech style, since the degree of glottalisation (of both stage 1 and 2) is reduced in reading passage styles –in comparison with interview styles– (Fabricius 2000, Altendorf & Watt 2004). The phonetic contexts included in stage 2 are prevocalic position across word boundaries, before a syllabic [n̩] and before a pause. The next stage (and probably the last one) of this ongoing sound change is stage 3,

[23] Tollfree distinguishes two accent groups in her study of London speech which, rather than being categorical, constitute the two edges of a continuum from maximally to minimally broad regionalised varieties. On the one hand, Southeast London English, or SELE, includes medially to maximally broad varieties. On the other hand, Southeast London Regional Standard, or SELRS, would be the local form of near-RP (1999: 164). She argues that "SELRS serves as a more appropriate reference standard than the minority RP form in this region where even middle-class speakers have some regional characteristics." (1999: 183 note 2).

which is currently considered to belong to regional accents of English, such as Cockney, but not to SSBE, and not even London Regional Standard or Estuary English. The phonetic environments included in this stage are prevocalic position within a word and before a syllabic [l̩]. The behaviour in these contexts is categorical, in that the majority of speakers produce a /t/ rather than a [ʔ]. Altendorf (1999) reports that the production of glottal stops in these two positions is “almost non-existent in the most casual of the three styles and ruled out in the most formal style” (1999: 6) for the middle and upper (middle) class speakers, whereas it is still frequent for the working-class speakers. This author argues that this process, at this point of the stage, “can therefore serve as a ‘boundary marker’ between Cockney and EE” (1999: 6).

Table 11: Summary of stages in the development of the t-glottalling sound change in SSBE and the different phonetic contexts involved.

Stage of change		**Context**	**Example**
1	Completely established. Near-categorical behaviour.	__C[24]	*Football*
		__#[25]C	*About right*
2	Quite established. Shows variation, especially generational.	__#V	*About anything*
		__[n̩]	*Britain*
		__pause	*About*
3	Not established.	__V	*Water*
		__ [l̩]	*Bottle*

In this light, the variables regarding t-glottalling that have been taken into account in this dissertation mainly deal with the process at stage 2, which is where it shows more inter-speaker variation,

[24] The symbol C means any consonant (obstruent or sonorant) except syllabic consonants.
[25] The symbol # indicates word boundary.

and therefore has more sociolinguistic –and in turn forensic– relevance, with the exception of the context of a following syllabic [n̩][26]. The three variables can be seen in Table 12.

Table 12: Variables related to T glottalling.

7	T-glottalling (V_#V) in highly frequent words and lexical items with close syntactic linkage such as *get up, but I, what if*…	1. Glottalling [ʔ] 2.Other variants [t] [t̪] [ɾ]
8	T-glottalling between vowels across word boundaries in lexical words (V_#V).	1. Glottalling [ʔ] 2.Other variants [t] [t̪] [ɾ]
9	T-glottalling at the end of sentence before pause.	1. Glottalling [ʔ] 2.Other variants [t] [t̪]

Variable number 7 deals with glottalisation in highly frequent words and lexical items that tend to appear together, what Wells calls lexical items where "syntactic linkage is close" (1982: 324-325). This definition, which may be considered as somewhat unclear, is also applied to the process of t-tapping (variable 10, see section 6.2.2.4). It includes phrases where the /t/ is in prevocalic position across word boundaries such as *get up, but I, what if, out of* etc., where processes of lenition such as t-glottalling and t-tapping may be more prone to happen than in other contexts. In an initial analysis of the variables (Gavaldà 2009), this variable was formulated as including these two processes only in grammatical words, since many of these phrases with 'syntactic linkage' involve grammatical words such as *but, it*, or *that*. However, many other phrases involving lexical words are equally prone to suffer these allophonic processes, for example *lot of, what if, shut up*, and they often include phrasal verbs. Another consideration about what

[26] The reason for this exception is that there were very few instances of this context in the corpus analysed.

words should be included within this variable is lexical frequency, since it is an important factor that contributes to lenition. Both t-glottalling and t-tapping can be considered as processes of lenition affecting /t/ (Harris 1994, Ashby & Przedlacka 2010). T-glottalling “takes the form of debuccalization, the loss of the coronal gesture, with the residual reflex being realized with glottal stricture” (Harris 1994: 121), whereas t-tapping is clearly a process of lenition in that a voiceless plosive becomes a voiced tap, which involves presence of voice and a weaker obstruction of the airflow.

Table 13 summarises the main combinations of words that are included in this variable, which is the same combination for variable 10, which deals with t-tapping (see section 6.2.2.4). These contexts include a) a grammatical word (except ‘that’ (when it is a demonstrative) and ‘what’) that ends with a /t/ and is followed by any word beginning with a vowel, as in *about a* or *but I*[27]*;* b) lexical items where syntactic linkage is close (following Wells 1982), such as *despite of* or *sort of*; and c) common phrasal verbs or verb expressions, such as *shut up* or *put it*.

Variable number 8 accounts for t-glottalling in intervocalic position across word boundaries in lexical words that are not included in variable 7. Examples of words that would be included in this variable are *the par**t** I played, admi**t** it, caugh**t** off guard, star**t** again* etc.

[27] An exception to this rule was the phrase *at all*. It was not taken into account as part of this variable since none of the speakers studied produced either the glottalised or the tapped variant. It appears to be an exceptional case, in that does not seem as usual to tap *at all*, for example, than it is to tap *at us* in SSBE.

Finally, variable number 9 deals with t-glottalling before a pause. However, only grammatical and highly frequent words were considered in this variable, since they are the most common words appearing before a pause, and I did not want to combine them with lexical words. The lexical words that appeared before a pause in each recording were very few, so they could not constitute a variable in itself. In order not to include words that might have a different pattern, then, only grammatical words and highly frequent words were considered, such as *about, at, bit, but, it, lot, not, that,* and *what*.

Table 13: List of main combinations of words included in variables 7 and 10.

<table>
<tr><th colspan="4">Grammatical words + word beginning with a vowel</th></tr>
<tr><td>About
At
But
It
Not
That
What</td><td>+</td><td>All
Again
An / another
And
Are
I
If
Is
Us
...</td><td>Examples: About a, about another, at another, but I, but is, not if, that are, that I, that anybody, that area, what if, what I…</td></tr>
<tr><th colspan="4">Lexical items where syntactic linkage is close</th></tr>
<tr><td colspan="2">(a) bit of
Despite of
(a) lot of / about…
Let us / it…
Out of / into...</td><td colspan="2">Right away / in / up…
(A) sort of
Straight away / up…
Quite early / often…</td></tr>
<tr><th colspan="4">Common phrasal verbs or verb expressions</th></tr>
<tr><td colspan="4">Get/ Got a / away / into / up…
Might (h)ave
Sit in…
Shut up
Put up / it…</td></tr>
</table>

6.2.2.4. T-Tapping

The process of t-tapping, also known as t-voicing, is an allophonic process by which a /t/ is realised as a voiced alveolar tap [ɾ]. According to Hannisdal (2006), contrary to t-glottalling, t-tapping has not been as widely documented and studied in British accents of English than in other accents such as American and Canadian (e.g. Harris & Kaye 1990, Woods 1991) and Australian and New Zealand English (e.g. Holmes 1994), which are the accents this process is most commonly associated with. In fact, authors such as Wells argue that it is a process to be heard “only in certain casual styles in British accents ranging from RP to Cockney” (1982: 250), thus considering it an uncommon process in British English accents. However, there are some recent studies that have found evidence of t-tapping in many accents from all parts of the British Isles, in particular Newcastle (Watt & Milroy 1999), South East London (Tollfree 1999), Cardiff (Mees & Collins 1999), Glasgow (Stuart-Smith 1999) and Northern Ireland (McCafferty 1999). These studies show, according to Hannisdal, that “t-voicing is a supra-regional feature that is found in current accents in many areas of Britain” (2006: 113-114).

T-tapping can be interpreted as one of the results of the process of lenition, together with t-glottalling and frication of /t/, that happen to intervocalic /t/, normally after a stressed vowel and before an unstressed vowel, or between two unstressed vowels (Harris 1994), and as in most processes of lenition, its occurrence is mostly in highly frequent words (Shockey 2003). That is why, t-tapping has most often been associated with high lexical incidence words such as *getting* or *British* (Shockey 2003), and to words "where syntactic linkage is close" (Wells 1982, see process of t-glottalling in section 6.2.2.3) such as *that I, but if*… (Wells 1982, Tollfree 1999, Shockey 2003, Ashby & Przelacka 2010).

From a sociolinguistic point of view, t-tapping has been regarded as a middle point between the more socially stigmatised variant, the glottal stop [ʔ], and the more prestigious form, the alveolar plosive [t], thus being considered as "a 'compromise solution' for many who wish to avoid either of the more socially marked variants in intervocalic position" (Hannisdal 2006: 115). But if we need to state the prestige status of this variant, it would be on the non-prestigious end of the continuum, as it shows an increase of approximately 20% in interview style when compared to a more formal speech style (Hannisdal 2006: 197). The conclusion of this finding is twofold: on the one hand, it gives t-tapping a rather informal status among all the possible variants of /t/, and on the other, it shows that this process has some degree of intra-speaker variation depending on speech style.

Hannisdal's study proves that t-tapping can be a source for inter-speaker variation. On the one hand, there appear to be statistically significant differences between the use of t-tapping in men and women, being more frequently used by men than by women. This author reports that the average percentage frequency for [ɾ] is 42.5 for the men and 26.4 for the women in her study, a difference that is "highly significant" (2006: 190). These results confirm previous studies that already observed gender differences in t-tapping in other accents of English (Woods 1991; Holmes 1994; Watt & Milroy 1999), which is somewhat expected given the lower prestige status that this variant has in opposition to other variants such as /t/ or the fricated variant [t̹], and the fact that women tend to show preference towards more standard variants. What is particularly interesting about Hannisdal's findings is that t-tapping does not have a direct relation to speech rate, which contradicts previous studies that associated this process to high speech rates in descriptions of Mainstream RP or SSBE. Wells, for example, states that "the use of [ɾ] appears to be connected with the rate at which the person is speaking, since [ɾ] does not occur in slow speech, in hesitation, or before pause" (Wells 1982: 324-325). However, Hannisdal concludes in her study that the fastest speakers in her study did not necessarily use more [ɾ] than the speakers with lower speech rates, by which she can draw the conclusion that "the individual speech tempo does not influence the use of t-voicing" (Hannisdal 2006: 198). This means that inter-speaker variation cannot be explained by speech tempo, which highlights the possibility of them being the result of individual and idiosyncratic choices.

The variables in this dissertation related to t-tapping are three, which are summarised in Table 14. Variable 10 deals with t-tapping in highly frequent words and lexical items where syntactic linkage is close, which is the same scope of variation considered by variable 7 regarding t-glottalling (see section 6.2.2.3). An account for the environments and words that are included in this variable has been made in section 6.2.2.3 (see also Table 13). Hannisdal finds out in her study that t-tapping across word boundaries mostly affects word-final /t/ in function words such as *it, that, but, at, what*, etc., in phrases such as *it is, that it's, but if, at a, what about*, etc, and also in other short frequent words such as *not,* and *get*, and in expressions like a *lot of, a bit of, a set of'* (2006: 192), which greatly coincides with the formulation of variable 10 done in the present PhD dissertation.

Table 14: Variables related to T tapping.

10	T-tapping (V_#V) in highly frequent words and lexical items with close syntactic linkage such as *get up, but I, what if*…	1. Tapping [ɾ] 2. Other variants [t] [t̬] [ʔ]
11	T-tapping (V_V) between vowels in highly frequent words: *pretty, whatever, getting, putting, British, Scottish, better, sitting, matter*.	1. Tapping [ɾ] 2. Other variants [t] [t̬] [ʔ]
12	T-tapping between vowels word internally and across word boundaries (V_(#)V).	1. Tapping [ɾ] 2. Other variants [t] [t̬] [ʔ]

The second variable regarding t-tapping, variable 11, considers this process in intervocalic position within highly frequent words. Hannisdal's study (2006) provides an account of the words that are most frequently realised with [ɾ], on which the selection of the words to include in this variable is based. Table 15 shows the words that are most frequently realised with [ɾ], the percentage of the frequency of the tapped variant (%[t̬][28]), the absolute number of tapped variants (N [t̬]), the total number of realisations of each word (Total N) and the frequency per million words in the British National Corpus of spoken and written English (BNC FrQ).

[28][t̬] and [ɾ] are alternative symbols for t-tapping.

Table 15: Lexical distribution of word-medial t-tapping in words with a N≥ 10 frequency (from Hannisdal 2006: 194).

Word	% [t̬]	N [t̬]	Total N	BNC FrQ
pretty	83.3	30	36	52
whatever	76.9	10	13	132
getting	66.7	66	99	203
putting	59.1	13	22	76
British	45.5	207	455	357
hospital	38.7	36	93	180
Scottish	37.7	20	53	98
capital	35.9	55	153	138
criticism	32.3	10	31	59
better	18.6	11	59	143
little	16.3	20	123	306
security	12.7	27	212	158
city	8.4	23	273	275

The selection of the words to include in variable 11 was based on Hannisdal's list, but was modified according to the corpus under study in the present dissertation. The final list included the words that have a rate of t-tapping higher than 50% in Hannisdal's study, i.e. *pretty, whatever, getting, putting, British, Scottish, better* and *matter*. To this list, the words *gotta* and *better* were added. On the one hand, the word *gotta* is also considered in Hannisdal's study as a word which shows high degree of intervocalic t-tapping, in that the five times that this word appears in her corpus, the /t/ is always tapped. On the other hand, the word *better* was also included because, although it shows a low degree of t-tapping in Hannisdal's corpus, (18.6%), it is the second-most frequent word of her list, so it was considered that, being such a highly frequent word, it would also be prone to suffer t-tapping, as in fact some of the subjects in the present study showed.

The words in Hannisdal's list that were not included in variable 11 were discarded because of different reasons. Firstly, the words *hospital* and *little* were not taken into account in the analysis because they may imply a syllabic consonant formation of /l/, which means that the speaker not only has to choose whether to tap the /t/ or not, but also whether to syllabify the /l/ or not, which adds another degree of variability that the other words do not have. In fact, all the words where the /t/ appeared in a context where the /l/ or /n/ could be syllabified were not taken into account in any of the variables regarding allophonic processes of /t/ (variables 7-13) in order to control this source of variability. Secondly, the words *hospital, capital, criticism*, *security* and *city* were not considered in the variable because they did not show a high frequency of occurrence in the corpus under analysis (it needs to be taken into account that Hannisdal's corpus of study were broadcast news reports, where these words may appear very often).

The third variable that considers t-tapping is variable 12. This variable includes words where the /t/ appears in intervocalic position both within a word (any word other than those included in variable 11) and across word boundaries (in words not included in variable 10). Thus, the words that are included are mainly lexical words with low frequency of occurrence where the /t/ appears in medial position, and lexical words also with low frequency of occurrence where the /t/ appears in final position and is followed by any word beginning with a vowel with which there is no syntactic linkage or phrasal construction of any kind. The reason why these two contexts are regarded as the same scope of variation of variable 12 is because both of them are equivalent as regards the likelihood of t-tapping, which may be low, but may be present in some speakers.

6.2.2.5. *Frication of plosives*

The two last variables explored in this dissertation deal with frication[29] of plosives, a process of lenition by which a plosive loses its complete obstruction in the oral tract and, as a consequence, a homorganic fricative is produced. Both voiced and voiceless plosives may undergo this allophonic process, but only the voiceless plosives have been documented to suffer this process in some accents of English. Frication of plosives is a phenomenon mostly associated with accents of English such as Southern Irish English (Wells 1982, Hickey 1999, Jones & Llamas 2008), Liverpool English (Wells 1982, Marotta & Barth 2006, Watson 2007) and Australian English (Jones & McDougall 2009), though several studies report that it is also a common feature of other English accents such as Middlesbrough English (Jones & Llamas 2008), London English (Tollfree 1999), Newcastle English (Foulkes & Docherty 2006), American English (Lavoie 2002) and SSBE (Cruttenden 2001, Shockey 2003, Ashby & Przedlacka 2010, Buizza 2010).

Fricated /k/ is normally described in the literature with the symbol [x], which corresponds to a voiceless velar fricative, and describes accurately the sound that is produced as a result of this phenomenon. However, fricated /t/ has been symbolised in many ways in the literature. Authors such as Haslerud (1995), Tollfree (1999) and Loakes and McDougall (2010) use the symbol [tˢ], Cruttenden (2001) and Shockey (2003) use the symbol for the voiceless alveolar fricative [s], Hickey (1984, 1999) uses [ṱ] for this

[29] This process has also been named *spirantisation*, *reduction of closure*, *assibilation* or *fricativisation*. (See Jones and Llamas 2008 and Loakes and McDougall 2010 for a literature review on these terms).

sound in Irish English, where the diacritic means that the sound is continuant. Ashby and Przedlacka (2011) and Buizza (2011) use [t̞], where the diacritic indicates that the stricture of approximation is lower than that of a plosive, i.e., a fricative. I did not consider the first two symbols to be accurate to describe frication of /t/. On the one hand, the symbol [t^{s}] suggests an affricate realisation rather than a fricative, and in fact, this is the symbol used to indicate affrication of [t] in some accents such as Cockney (Wells 1982, Mott 2012). On the other hand, [s] suggests that there is some neutralisation between /t/ and /s/ when /t/ is fricated, but several studies show that this is not the case, since fricated /t/ is acoustically different from both fricatives /s/ and /ʃ/ (see Buizza 2011, for example). Hickey's option seemed accurate, but since he uses it specifically for Irish English, I decided to follow the authors who describe this process in SSBE (Buizza 2011 and Ashby & Przedlacka 2011) and use the symbol [t̞].

The phonological status of this process depends greatly on the accent. On the one hand, in some accents (including Australian English, SSBE and Middlesbrough English) frication occurs in phonetically weak environments, especially intervocalically and in word-final position), and is related to casual and/or fast speech. Moreover, speakers may not be aware of the difference between an alveolar plosive /t/ and its fricated counterpart [t̞]. According to Tollfree, in SELRS (Southeast London Regional Standard), "the plosive [t] is the prestige form, but according to informants fricated variants have a similar high status. In fact they are not distinguished from plosive variants by most speaker-hearers" (1999: 170). Similarly, frication of /t/ in Australian English is also outside the awareness of speakers and listeners, although it is a feature imitated in popular culture in Melbourne, which could indicate that speakers and listeners of that accent are more aware of its presence and of its prestigious status (Loakes & McDougall 2010: 176). On the other hand, frication of plosives in other accents such as Southern Irish English has a more phonological status. According to Jones and Llamas, frication of /t/ seems to have “some characteristics indicative of a more rule-governed phenomenon” (2008: 435) and its occurrence cannot be explained by the result of a process in casual or fast speech (contrary to what other authors such as Hickey had previously claimed (1984, cited in Jones & Llamas 2008).

In SSBE, where frication is the result of a connected speech phenomenon, it is not that clear to what extent this process is affected by casual or fast speech. Cruttenden argues that it is associated to “rapid, familiar speech, where speed rather than articulatory precision is the aim” (2001: 160). However, Ashby and Przedlacka argue that frication of /t/ is not exclusively a process occurring in casual speech in SSBE, but also in formal contexts or even in citation forms. Interestingly, they exemplify this fact with the spoken version of the word *butter* from LPD (which implies citation form), which is realised as a complete fricative (2011: 13). Thus, the fact that frication does not seem to depend on speech style – which implies low intra-speaker variation–, and shows different degrees of production in different speakers –i.e. high inter-speaker variation– would mean that frication of plosives may be a suitable variable to discriminate between different speakers. As a matter of fact, Elliott (2002, cited in Loakes & McDougall (2010: 161)), studied the degree of frication of /k/ in the word *okay* in Australian English and observed a high degree of inter-speaker variability and a relatively consistent pattern within the same individuals. Similarly, Ashby and Przedlacka state that the use of lenited segments “differ from speaker to speaker, being not only a function of style but to some degree idiosyncratic” (2011: 4). In addition to this, Lindblom (1990 cited in Loakes & McDougall (2010: 160)) explains that one of the reasons for the possibility of individual variation in the realisations of phonetic segments is the fact that:

> If the speech system operates so as to minimise ‘articulatory effort’…, we should expect it to undershoot phonetic targets quite often, but not necessarily in every single instance. The key point is: *Speakers have a choice* (Lindblom 1990: 415 author’s emphasis– cited in Loakes & McDougall 2010: 160)

Despite these indications, the discriminatory potential of frication of plosives in English has only been investigated in very few studies, mostly in Loakes (2006) and Loakes and McDougall (2004, 2007, 2010), which centre exclusively on Australian English. These authors find in their investigation that individual speakers show different frication patterns for /p/, /t/ and /k/, but that “the proportion of these consonants fricated is relatively consistent for a given individual across the two recording sessions” (2010: 170). Their correlation analyses show that /p/ and /k/ are the consonants which are more often fricated, and that both show low degree of intra-speaker and high degree of inter-speaker variation. Frication of /t/, on the other hand, does not show this pattern because /t/ was hardly ever fricated by the subjects in their study (2010: 172-173). Their explanation for this lack of frication of /t/ is that it seems to be favoured by "female speakers from higher socioeconomic backgrounds, and less preferred by male speakers and speakers from lower socioeconomic backgrounds" (2010: 176), and the subjects under their study were all male. In fact, previous studies on frication of /t/ report that this variant is much more favoured by female subjects (Haslerud 1995; Tollfree 2001; Jones & McDougall 2006, 2009). Thus, as they conclude, it seems that frication of /p/ and /k/ can be a useful parameter to explore when conducting forensic speech comparison in Australian English, but further studies need to be carried out concerning the frication of /t/ and the frication of these consonants in other accents of English (2010: 177). This is why the two plosives /t/ and /k/ were taken into consideration in the present study, because the subjects of the present study did show some frication of /t/ as well as /k/, and both consonants seemed to be potential variables for forensic speech analysis. On the other hand, initial experiments showed no instances of fricated /p/ in the subjects under study, in contrast to the plosives /t/ and /k/, so that is the reason why frication of /p/ was not considered in the research leading to this PhD dissertation. However, the fact that frication of /p/ has not been taken into consideration in this study does not mean that the possibility that frication of /p/ may be an idiosyncratic feature is being ruled out, and that it would not be interesting to investigate it in future research.

The categorisation of the two variables regarding frication of /t/ and /k/ has been quite problematic. It cannot be denied that the process of frication, as any connected speech phenomena, is a continuous process, rather than discrete, and its categorisation may be very tricky. The criteria followed to label the instances was based on previous references on this subject (Marotta & Barth 2006, Jones & Llamas 2008, Loakes & McDougall 2010), where fricated tokens were identified as those instances that showed friction noise throughout the duration of the consonant, where no silent gap (which represents the silent period of the plosive) was appreciated neither in the waveform nor in the spectrogram, and where no release burst was present in the spectrogram. Figure 11 shows an example of a realisation categorised as [t] and another realisation categorised as [t̞] respectively.

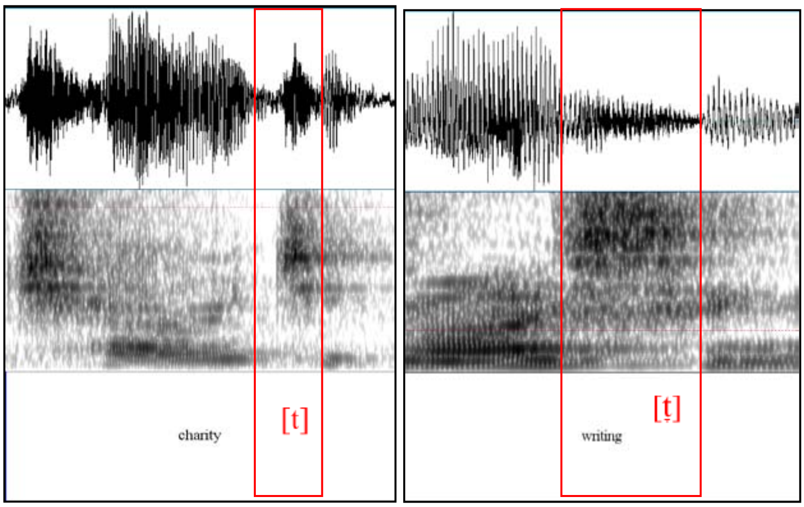


Figure 11: The word *charity* uttered by speaker *InSit*_f_5 (MT2) where /t/ is produced as a plosive on the left, and the word *writing* uttered by speaker *InSit*_f_3. (MT2) where /t/ is produced as a fricative, on the right.

Table 16 shows the two variables under study that regard the process of frication of plosives. The phonetic contexts under study concerning frication of /t/ (variable 13) and frication of /k/ (variable 14) is the same for both variables, i.e. inter-vocalically in unstressed position both word-internally and across word boundaries. These are the same contexts where other lenition processes may as well occur (see section 6.2.2.3 for t-glottalling and 6.2.2.4 for t-tapping), and similarly to variable 12 (t-tapping in the same environment), the scope of variation of these variables comprises words where the /t/ appears word-internally and words where it appears across word boundaries because both contexts seem to prone lenition, if not equally very similarly. In fact, Loakes and McDougall observe that the most common environment for frication of consonants is word-medial intervocalic following a stressed vowel, and that the second most common environment was word-final intervocalic following a stressed vowel (2010: 169), which would support the formulation of these two variables.

Table 16: Variables related to the frication of plosives.

13	Frication of /t/ between vowels word internally and across word boundaries (V_(#)V).	1. Frication [t̪] 2. Other variants [t] [ɾ] [ʔ]
14	Frication of /k/ between vowels word internally and across word boundaries (V_(#)V).	1. Frication [x] 2. No frication [k]

6.2.3. Perception test and inter-rater reliability test

6.2.3.1. Objective and design

Several of the 14 variables that are taken into account in the present PhD dissertation pose a major problem in categorisation. As explained in section 1.3, processes such as yod coalescence or frication of plosives always involve continuous phenomena which need to be broken into identifiable parts if the researcher is to consider them as discrete variables (Gordon 2007: 21-22). Despite the fact that this procedure is very common in phonetic and phonological analyses, it is necessary to bear in mind that any boundary placed within a continuum is arbitrary and artificial. Some authors, such as Chambers and Trudgill (1998: 52) point out that if a continuum is to be divided into discrete parts, what is important is to make sure that the criterion in the division of that continuum is consistently maintained. This is what has been done with the codification of all the 14 variables considered here, which has been detailed in the previous sections. However, since any decision is arbitrary, a test was carried out in order to ensure that the categorisations were taken correctly. A perception test was carried out with two British expert phoneticians, which included those variables concerned with phenomena particularly tricky to categorise. The aim of this test is to confirm that the categorisation of the particularly problematic variables that was carried out in the present study was similar to the categorisation that a native English phonetician would have done.

The variables that were tested were variables 1 and 2, concerned with vowel alternation (or vowel reduction) between [ə] and [ɪ], variables 3 and 4, concerned with the process of yod coalescence, and variables 13 and 14, which include the process of frication of /t/ and /k/ respectively. It was considered that the rest of variables, which are concerned with the process of insertion of [t], linking /r/, t-glottalisation and t-tapping did not pose such problems as regards their categorisation and were easy to categorise on auditory and acoustic grounds. Thus, the perception test only focused on those processes most problematic in order to create a less long and wearisome test for the participants.

The test included 20 examples of variables of the variables that show higher overall frequency of occurrence (variables 1, 3, 13 and 14) and between 13 and 14 tokens of the variables that have fewer instances of occurrence (variables 2 and 4). The final number of stimuli presented to the participants was 107, and they were all selected at random from all the 16 speakers included in the corpora of study, and presented in isolation to the raters. The stimuli were presented to the two raters by means of a PowerPoint presentation, where they could hear each item and the two possible categories produced by a native speaker of SSBE. Figure 12 shows an example of such slide, where the participant could listen to the word *become* that had to be rated, and they listened to ‘option A’, which was the same word produced with the vowel [ɪ] and ‘option B’, which was the word produced with a [ə] by a native speaker of SSBE.

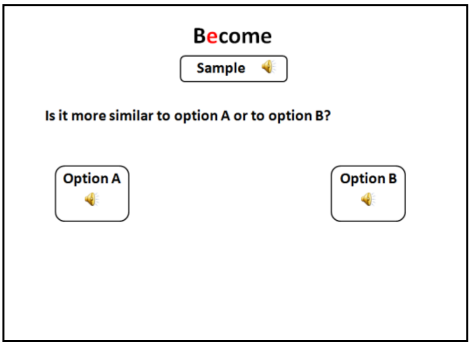
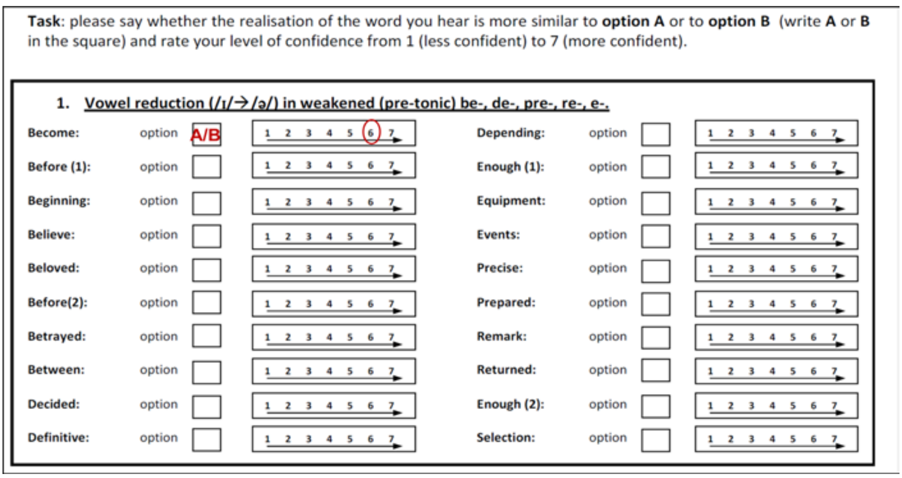


Figure 12: Example of a slide presenting the stimuli in the perception test.

Both raters were provided with a rating sheet (see Figure 13) where they had to write down whether they considered that the sample was more similar to option A or B, and how confident they were of their decision on a seven-point interval scale. A copy of such rating sheet can be found in the Appendix, where all the 107 stimuli in the perception test can be found.



Task: please say whether the realisation of the word you hear is more similar to **option A** or to **option B** (write **A** or **B** in the square) and rate your level of confidence from 1 (less confident) to 7 (more confident).

1. Vowel reduction (/ɪ/→/ə/) in weakened (pre-tonic) be-, de-, pre-, re-, e-.

Become:	option	A/B	1 2 3 4 5 6 7	**Depending:**	option		1 2 3 4 5 6 7
Before (1):	option		1 2 3 4 5 6 7	**Enough (1):**	option		1 2 3 4 5 6 7
Beginning:	option		1 2 3 4 5 6 7	**Equipment:**	option		1 2 3 4 5 6 7
Believe:	option		1 2 3 4 5 6 7	**Events:**	option		1 2 3 4 5 6 7
Beloved:	option		1 2 3 4 5 6 7	**Precise:**	option		1 2 3 4 5 6 7
Before(2):	option		1 2 3 4 5 6 7	**Prepared:**	option		1 2 3 4 5 6 7
Betrayed:	option		1 2 3 4 5 6 7	**Remark:**	option		1 2 3 4 5 6 7
Between:	option		1 2 3 4 5 6 7	**Returned:**	option		1 2 3 4 5 6 7
Decided:	option		1 2 3 4 5 6 7	**Enough (2):**	option		1 2 3 4 5 6 7
Definitive:	option		1 2 3 4 5 6 7	**Selection:**	option		1 2 3 4 5 6 7

Figure 13: Extract from the rating sheet that had to be filled in by the participants in the perception test.

6.2.3.2. Results

In order to test the degree of agreement in the categorisation of the items between the raters and the categorisation that was carried out in the present dissertation, an inter-rater reliability test was carried out. This test is suitable for our purposes in the sense that it is:

> …a measure used to examine the agreement between two people (raters/observers) on the assignment of categories of a categorical variable. It is an important measure in determining how well an implementation of some coding or measurement system works. (Elliot and Woodward 2007: 140)

The test that was carried out was a Cohen's Kappa coefficient (K), a test for inter-rater reliability that is used when there are two raters. This test was conducted comparing the decisions of 1) Rater A and Rater B; 2) Rater A and my categorisation; 3) Rater B and my categorisation. We can express conclusions by means of a contingency table such as the one shown in Table 17, where we can see the agreements and disagreements of Rater 1 and Rater 2.

Table 17: Contingency table showing agreements and disagreements between Rater A and Rater B.

		Rater_A		
		A	B	Total
Rater_B	A	48	9	57
	B	9	39	48
Total		57	48	105

The overall observed percent agreement, symbolised by Gwet (2010: 18) as P_a, can be calculated by summing the total number of agreements in category 1 (in this case 48) and the number of agreements in category 2 (in this case 39) divided by the total number of samples, which in this case is 105[30]. Thus, P_a of raters A and B would be 0.83, as the following formula shows:

$$P_a = \frac{48 + 39}{105} = 0.83$$

According to this result, both judges agree on 83% of the cases. However, this percentage is not enough, since there is the possibility that some of these agreements were due to chance, and this is not contemplated in this result. According to Gwet (2010: 19), it is necessary to estimate the expected percent chance agreement (P_e) to adjust P_a in order to obtain the Kappa coefficient. The probabilities for both raters A and B to classify a stimuli into category 1 represent the raw and column marginal percentages, which in the example on Table 17 correspond to 57/105=0.54 and 57/105=0.54. Thus, both judges would be expected to reach agreement on this category with probability 0.54 x 0.54 = 0.29. Similarly, the probability of reaching agreement on category 2 would be (48/105) x (48/105) = 0.21. Cohen's chance-agreement probability (P_e) is given by 0.29 + 0.21 =0.50.

Once P_a and P_e are defined, Cohen's Kappa coefficient is obtained by the following formula (Gwet 2010):

$$K = \frac{P_a - P_e}{1 - P_e}$$

[30] Despite the fact that there were 107 stimuli, some of them could not be rated by judges due to technical problems.

Here, the denominator indicates the maximum proportion of agreement, which is obtained by subtracting 1 to the proportion agreement expected by chance (P_e). Kappa's coefficient takes a value between 0 (no agreement) and 1 (maximum agreement). In our case, Cohen's Kappa coefficient would be 0.66, shown as follows:

$$K = \frac{0.83 - 0.5}{1 - 0.5} = 0.66$$

In order to interpret the agreement that the resulting coefficient represents, many authors take the Landis-Koch benchmark scale (Landis and Koch 1977), which defines a value higher than 0.81 as 'almost perfect' agreement, a value between 0.61 and 0.80 as a 'substantial' agreement, and a value between 0.41 and 0.60 as a 'moderate' agreement (see Table 18). In our case, the agreement reached by Raters A and B could be defined as substantial.

Table 18: Relationship between Kappa Coefficient and strength of agreement. (From Landis and Koch 1977: 165)

Kappa Statistic	**Strength of Agreement**
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost perfect

Apart from this rather qualitative interpretation of Kappa's coefficient, we can also obtain information about statistical significance, with which we can decide upon the hypothesis of null agreement (Pardo Merino & Ruiz Díaz 2002: 240). If we run such test with the decisions made by Rater A and B by means of SPSS, we obtain a significance of *p*= <0.001, for which we can reject the null hypothesis and conclude that there exists an agreement that is significantly higher than the agreement expected by chance.

Let us now see whether the original categorisation of such stimuli that I carried out originally also agrees with the categorisations by Raters A and B. Table 19 and Table 20 show the agreements and disagreements between my categorisation and Rater A's and Rater B's respectively.

Table 19: Contingency table showing agreements and disagreements between my categorisation and Rater A.

		My_categorisation		
		A	B	Total
Rater_A	A	45	13	58
	B	8	40	48
Total		53	53	106

Table 20: Contingency table showing agreements and disagreements between my categorisation and Rater B.

		My_categorisation		
		A	B	Total
Rater_B	A	46	11	57
	B	6	42	48
Total		52	53	105

The inter-rater reliability analyses using the Kappa statistic were found to be K= 0.604 (*p*=<0.001) as regards Rater A and my categorisation, and K = 0.676 (p=<0.001) as regards Rater B and my categorisation.

Table 21 shows a summary of the results obtained through the Kappa coefficient analyses carried out. As inferred from these results, there does not seem to be a difference between the decisions reached by the two expert phoneticians and my decisions regarding the items chosen as representation of all the categorisations carried out for variables dealing with vowel alternation [ə]-[ɪ], yod coalescence and frication of /t/ and /k/.

Table 21: Summary of Kappa analyses of inter-reliability tests.

	Kappa	Approx. Sig.
Rater A vs. Rater B	0.655	<0.001
Rater A vs. author	0.604	<0.001
Rater B vs. author	0.676	<0.001

Apart from the classification of the stimuli to one category or another, raters also had to report the level of confidence they had when deciding upon one or other category.

Table 22, Table 23 and Table 24 show the descriptive analysis of the results obtained regarding the raters' level of confidence. The information included in the three tables is the following: 1) the total number (N) of tokens analysed by raters, how many of these tokens were categorised with a low level of confidence (≤3 in a seven-point interval scale), how many with a high level of confidence (≥4) and the overall confidence mean; 2) the N of tokens that the raters categorised differently from my original categorisation (i.e. disagreements), how many of these tokens were categorised with a low (≤3) and a high (≥4) level of confidence, and the confidence mean when labelling these tokens; and 3) the N of tokens in which both raters agree between each other, and disagree with my categorisation, together with the percentage that these tokens represent from the overall number of tokens analysed by each rater.

Table 22: Raters' level of confidence and disagreement with my original categorisation for variables 1 and 2.

	Variable 1				**Variable 2**			
	RATER A		**RATER B**		**RATER A**		**RATER B**	
N tokens analysed	20				14			
General level of confidence (0-7)	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**
	8	12	1	19	5	9	5	9
	Mean: 3.8		Mean: 5.5		Mean: 3.9		Mean: 4.2	
N of tokens rated differently from my original categorisation	**6**		**2**		7		2	
Level of confidence of tokens rated differently (0-7)	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**
	2	4	0	2	3	4	0	2
	Mean: 4.2		Mean: 6		Mean: 3.7		Mean: 3	
N of tokens both raters disagree with my categorisation	2 (10%)				2 (14%)			

Table 23: Raters' level of confidence and disagreement with my original categorisation for variables 3 and 4.

	Variable 3				**Variable 4**			
	RATER A		**RATER B**		**RATER A**		**RATER B**	
N tokens analysed	19				13			
General level of confidence (0-7)	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**
	1	18	2	17	2	11	1	12
	Mean: 5.3		Mean: 5.9		Mean: 4.9		Mean: 6.1	
N of tokens rated differently from my original categorisation	**3**		**2**		4		4	
Level of confidence of tokens rated differently (0-7)	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**
	1	2	0	2	2	2	1	3
	Mean: 4		Mean: 7		Mean: 3.75		Mean: 5.25	
N of tokens both raters disagree with my categorisation	2 (10.5%)				2 (14.4%)			

Table 24: Raters' level of confidence and disagreement with my original categorisation for variables 13 and 14.

	Variable 13				**Variable 14**			
	RATER A		**RATER B**		**RATER A**		**RATER B**	
N tokens analysed	20		19		20			
General level of confidence (0-7)	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**
	8	12	4	15	7	13	1	19
	Mean: 4.9		Mean: 5		Mean: 4.05		Mean: 5.75	
N of tokens rated differently from my original categorisation	**3**		**4**		1		3	
Level of confidence of tokens rated differently (0-7)	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**	**≤3**	**≥4**
	2	1	1	3	1	0	0	3
	Mean: 3.95		Mean: 4.5		Mean: 3		Mean: 5.3	
N of tokens both raters disagree with my categorisation	2 (10%)				0			

If we compare each rater's overall confidence when assigning categories to the stimuli, rater B's level of confidence tends to be higher than rater A's for all variables. If we consider each process (vowel alternation, yod coalescence and frication of plosives), both raters seem to find tokens related to yod coalescence easier to categorise, since both of them show their highest level of confidence when rating tokens in variables 3 and 4, the mean level of confidence for the other variables are lower. The most difficult variable to categorise for Rater A seems to be variable 2, whereas it is variable 1 for Rater B. Since both variables deal with the process of vowel alternation, this process seems to be the most complex one to categorise.

Let us now consider the level of confidence involved in the tokens in which the raters disagreed with my original categorisation. The process with which there seems to be more disagreement between the raters and my decisions is vowel alternation, which, as commented on before, seems to be the trickiest process to categorise. Rater A shows a different categorisation of 6 tokens of variable 1 and 7 tokens of variable 2, whereas Rater B shows differences in 2 tokens in variable 1 and also 2 tokens in variable 2. As regards the level of confidence when labelling these tokens, both rater A and B show a higher mean of confidence to the overall mean in variable 1, whereas the confidence mean of tokens rated differently for variable 2 is lower than each rater's overall mean. Despite these differences, my original classifications always agree with at least one of the two raters, except for two tokens for each variable, with which both raters agree between each other's categorisation and disagree with mine. These tokens, with which no agreement with either of the two raters can be found, represent the 10% of variable 1 and the 14% of variable 2.

Variables related to yod coalescence do not show as many disagreements as the previous variables. Rater A disagrees with my categorisation in 3 tokens of variable 3 and 4 tokens of variable 4, and for both variables, confidence level when rating these different tokens is pretty lower than his overall confidence. Rater B disagrees with my analysis in two tokens of variable 3 and 4 of variable 4, and his mean level of confidence in these cases is higher than the overall mean for tokens of variable 3 and lower for tokens of variable 4. Similarly to what was commented on with variables 1 and 2, only 2 tokens for variable 3 and 2 tokens for variable 4 show agreement between both raters' classification and disagreement with mine (also a 10.5% and 14% of all the tokens analysed).

Finally, variables 13 and 14 show fewer disagreements on the whole. Rater A disagrees with my classification in 3 tokens of variable 13 and in 1 token of variable 14, also with a mean level of confidence that is much lower to his general mean level of confidence. Rater B disagrees with my classification in 4 tokens of variable 13 and 3 tokens of variable 14, with a level of confidence also a bit lower than his overall mean. Regarding tokens with which both raters agreed and disagreed with my classification, there are only two such tokens of variable 13 and none of variable 14.

As stated at the beginning of this section, the objective of the perceptive test and its subsequent inter-rater reliability test was to demonstrate that the analysis carried out in this dissertation –as represented by the stimuli selected for the test– was not significantly different from the analysis that an expert phonetician who is a native speaker of English could have done. The test only focused on the processes of vowel alternation, yod coalescence and frication of plosives, which are the most difficult processes to categorise.

As inferred from the Kappa coefficient, there is an agreement that is significantly higher than the agreement expected by chance when comparing each rater's analysis, and also my analysis with each of the raters'. Therefore, the three analyses seem to be equivalent to each other. Furthermore, the mean level of confidence of the two raters when labelling the tokens that show a different classification than my original one is generally lower than the mean overall level of confidence that they showed when labelling all the tokens of the same variable. Thus, both raters seemed to be less confident in the classification of those tokens that differed from my analysis, than when categorising those tokens with which they agree with my classification. In addition to this, out of the 106 tokens included in the test that were labelled (105 in the case of rater 2), my original analysis classified 96 tokens with the same category as at least one of the raters', which means that only 10 tokens (two for each variable except variable 14) disagreed with both raters, a figure that represents a 9.5% out of the total 106. On the other hand, the test also showed that the process of vowel alternation was the one that showed more complications when categorising, since raters seemed to be less confident, and more disagreements among the three of us arose.

In conclusion, the results of the perceptive test presented in this section have demonstrated that my categorisation of the variables that are most difficult to categorise is equivalent to any of the categorisations that two expert phoneticians could have carried out. Thus, this test has provided the analysis carried out in the present PhD dissertation with a further element of reliability.

6.3. Techniques of Analysis

Section 6.3 is concerned with the technique of analysis used in the present PhD dissertation for the calculation of the IIS. This method is derived from the Chi-square test, a statistical test used for the analysis of discrete variables such as the ones formulated for the IIS protocol. More specifically, the method for the calculation of the IIS is based on the Phi coefficient, which is derived from the Chi-square statistic. The chi-square is also the test used in the analysis of the discriminatory potential of each single variable which is shown in Chapter 8. All the statistical tests carried out were performed using the statistical package *IBM SPSS Statistics 19*.

6.3.1. The Chi-square test

The method that has been designed for the calculation of the IIS is based on the Chi-square test of independence (χ^2). According to several authors (McEnery & Wilson 1996; 84, Cantos 2002: 241-242; Butler 1985:112), the chi-square test is very usually used in linguistics since it has three main advantages. Firstly, it is not necessary to assume that the data is normally distributed, which is very often the case with linguistic data. Moreover, it is based on a 2x2 contingency table, which is a very common calculation for linguistic data, and it is easy to calculate, even without a computer statistics package. Also, differences in corpus size are not important, since the test compares the figures in the table proportionally (McEnery & Wilson 1996: 84). Finally, the chi squared test provides us with a statistical significance value in order to determine the probability that the differences found between the two data sets being compared could arise due to mere chance. The Chi-square test compares the observed frequencies with the frequencies that would be expected to appear by chance alone, which are known as the expected frequencies. The greater the difference between the observed and the expected values, the less likely it is that the observed differences are due to chance.

The major problem posed by the Chi-square test, which was occasionally encountered in the analysis of the variables in the present study, is that it is unreliable when the expected frequency in any cell is lower than 5 since “one of the assumptions behind the test, namely that the values correspond to a continuous rather than a discrete frequency distribution, is not valid under these circumstances” (Butler 1985: 122). Whenever this is the case, many authors (Woods *et al.* 1985, Butler 1985, Oakes 1998) recommend applying Yates’ continuity correction, which subtracts 0.5 from the result of the difference between the observed frequencies and the expected frequencies for each cell. The result of this correction is that the size of the chi-square value is reduced, thus increasing the *p-value* (Elliot and Woodward 2007:124).

The statistical analysis of the discriminatory potential of each variable individually (see Chapter 8) has been carried out by means of the Chi-square test, applying Yates' correction whenever it was needed, in order to obtain information of whether the differences found between samples are statistically significant or not. The Chi-square test and Yates' continuity correction also serves as base to the method for the calculation of the IIS that is explained as follows.

6.3.2. Method for the calculation of the IIS

As explained in Chapter 5, the IIS is conceived as an index from 0 to 1 where 0 indicates less similarity and 1 indicates more similarity. In order to calculate this IIS, we first calculate the Chi-square value, as explained above, and we get the Phi Coefficient (*φ)*. The Phi Coefficient is a measure of the extent of relation between two sets of discrete variables which take on only two values (Siegel & Castellan 1988: 232) and it is adjusted to the sample size. In this case, we are testing the relation between the independent variable (the sample) and the dependent variables (the 14 variables in the IIS). The Phi coefficient is the result of the square root of Chi-square divided by the total number of realisations of this variable (N):

$$\varphi = \sqrt{\frac{\chi^2}{N}}$$

In a 2x2 contingency table, Phi adopts a value between 0 and 1, which is very convenient for our purpose, and provides an indication of the strength of the relationship between the variables, similarly to a correlation coefficient such as Pearson's.

The first step to calculate the IIS is to obtain a Phi coefficient for each of the 14 variables comprised in the IIS. Secondly, we need to calculate the Phi-square values, i.e. the squares of each of the phi coefficients, because it represents the percentage of the variance of each variable. Thirdly, we calculate the mean of these Phi-squares, which represents the mean of combined variance (the variance of all the variables considered together), adjusting it to the total number of variables (N). Once this mean is obtained, we need to calculate its square root in order to obtain a value that is equivalent to each individual Phi coefficient, since it simplifies the possibility of comparing the total IIS index with the individual indexes that we would obtain for each variable separately. The last step towards the IIS is to subtract 1 to the final figure, since in our scale (the IIS scale) 0 represents maximum difference and 1 indicates maximum similarity, whereas it is generally the contrary in statistics, where 0 indicates lack of difference (=similarity). The formula to obtain the IIS is summarized as follows:

$$IIS = 1 - \sqrt{\frac{1}{N}\sum_{j}^{N} \varphi^2}$$

The results of the analyses carried out in the present dissertation are divided into two chapters. Chapter 7 deals with the results obtained with the experiments carried out with the IIS. This part centres on the ability of the IIS, as comprised of the fourteen variables under analysis, to distinguish whether two samples compared show intra- or inter-speaker variation, which in turn, involves information about them being produced by the same or by different individuals respectively. Chapter 8 is focused on each of the variables individually. Thus, an analysis of the discriminatory potential of each variable is carried out in order to distinguish which of them is more useful in a forensic context, out of the IIS protocol, in terms of their inter-speaker and intra-speaker variation and their frequency of occurrence.

Chapter 7
IIS Results

Chapter 7 details the results obtained for all the IIS calculations that have been carried out. Section 7.1 is concerned with the IIS results for the comparisons between samples from the same speakers, that is, intra-speaker comparisons, paying special attention to two factors: time and language contact. Section 7.2 accounts for the inter-speaker comparisons, i.e. comparisons between samples from different speakers, and is divided into three other sections. First, 7.2.1 details the inter-speaker IIS results according to the stratification of the corpus into two different subcorpora, in order to observe if speakers show any different patterns as a result of the difference in the situation of language contact. Secondly, 7.2.2 centres on the role that gender plays in inter-speaker results, thanks to the stratification of the corpus into data from seven women and nine men, so that we can examine how the IIS behaves depending on gender. Finally, section 7.2.3 carries out an analysis of the speakers' speaking tempo, with the aim to establish whether there is any correlation between the variables under study and the speaking tempo measure of articulation rate, which is a feature that may be the source for inter-speaker variation in itself.

Before dealing with the results obtained for the IIS, it is important to explain the colour and symbol coding that will be used in the graphs detailing the different comparisons that have been carried out. Table 25 details the list of symbols that are used, which try to follow a logic regarding colour and shape. Circles are used when dealing with the *InSit* subcorpus, whereas diamonds symbolise the *LanCon* subcorpus. When dealing with general comparisons made within the same or different subcorpus without detailing which subcorpora, a square is used, and comparisons between speakers according to gender will use a triangle. As for colours, intra-speaker comparisons always use brown, whereas inter-speaker comparisons are in blue, except for the general comparisons within the same subcorpus or between different subcorpora, which will use black and grey. Finally, when dealing with gender, pink is used for comparisons between women, purple for comparisons between men and yellow for comparisons between men and women.

Table 25: List of symbols used for the different IIS comparisons.

<table>
<tr><td colspan="2" rowspan="2">Intra-speaker comparisons</td><td colspan="2">Intra within InSit subcorpus</td><td>●</td></tr>
<tr><td colspan="2">Intra within LanCon subcorpus</td><td>◆</td></tr>
<tr><td rowspan="9">Inter-speaker comparisons</td><td rowspan="6">Subcorpora</td><td rowspan="2">Within InSit</td><td>MT1</td><td>●</td></tr>
<tr><td>MT2</td><td>○</td></tr>
<tr><td rowspan="2">Within LanCon</td><td>MT1</td><td>◆</td></tr>
<tr><td>MT2</td><td>◇</td></tr>
<tr><td colspan="2">Comparisons within the same subcorpus</td><td>■</td></tr>
<tr><td colspan="2">Comparisons between different subcorpora</td><td>□</td></tr>
<tr><td rowspan="3">Gender</td><td rowspan="2">Same gender</td><td>Only women</td><td>▲</td></tr>
<tr><td>Only men</td><td>▲</td></tr>
<tr><td>Different gender</td><td>Men-women</td><td>▲</td></tr>
</table>

7.1. Intra-speaker IIS results

Intra-speaker comparisons contrast samples from the same individual in the two measurement times, so an intra-speaker IIS value would be the result of comparing, for example, sample *InSit*_f_1 in MT1 against sample *InSit*_f_1 in MT2. All the IIS results are shown in the Appendix.

Table 26 exhibits the total number of intra-speaker comparisons that have been carried out. Ten intra-speaker comparisons have been performed for the *InSit* subcorpus, and three for the *LanCon* subcorpus, since there are data in two measurement times available for only three of the subjects in this subcorpus. Therefore, a total of thirteen intra-speaker IIS results have been obtained.

Table 26: Total N of intra-speaker comparisons.

Intra-speaker comparisons	*InSit*	10
	LanCon	3
	TOTAL N INTRA-SPEAKER COMPARISONS	**13**

Figure 14 shows all the intra-speaker results, where the *y* axis represents the IIS continuum from 0 to 1 and each point in the graph represents an IIS result. As explained in 5.1, the 1 end of the continuum indicates maximum similarity whereas the 0 end corresponds to maximum difference, so the higher in the IIS scale the value is, the more similar the samples are. As can be seen, all the intra-speaker IIS values are situated between 0.77 and 0.90, which means that comparisons between samples from the same speakers show a high degree of similitude, or what is the same, low variation. The intra-speaker comparison that shows most variation, as indicated by the 0.77 value, will be taken as the boundary between what should be considered intra- and inter-speaker variation. In other words, ideally, any IIS value lower than 0.77 should indicate inter-speaker variation –i.e. comparisons between samples from different speakers–, whereas any value higher than that, should be interpreted as showing intra-speaker variation, which would mean that the samples being compared could be considered to have been produced by the same person.

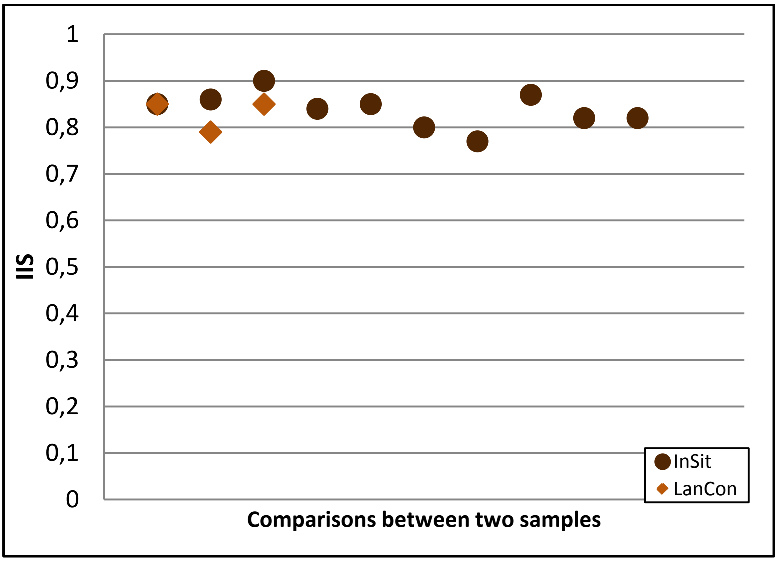


Figure 14: Intra-speaker IIS results for both *InSit* and *LanCon* subcorpora.

From these intra-speaker results we can infer conclusions regarding the research questions and the hypotheses stated in the study (see section 5.2) that are concerned with intra-speaker variation. RQ2 asks whether a speaker idiolectal style would remain relatively stable over a speaker's lifespan and the study hypothesises an affirmative answer to this question (hypothesis 2). Results confirm this hypothesis in the sense that comparisons between the same individual in MT1 and MT2 show little variation, and IIS results are quite close to the 1 end of the IIS continuum, which indicates maximum similarity. Therefore, the answer to RQ2 is that a speaker's idiolectal style, despite variation, remains relatively stable over time.

On the other hand, RQ3 wondered how a long-term situation of language contact affects a speaker's idiolectal style, and hypothesis 3 stated that speakers who have been in a language contact situation (*LanCon* speakers) would show greater intra-speaker variation than speakers who have not (*InSit* speakers). In this sense, it was hypothesised that these speakers would show higher intra-speaker variation, because the IIS would reflect an increase in variation as a result of their long-term situation of language contact. As shown in Figure 14, intra-speaker IIS values from *LanCon* subjects are very similar to intra-speaker values from *InSit* subjects, in other words, *LanCon* subjects do not seem to show more intra-speaker variation than *InSit* subjects after 10-25 years of language contact as it was initially predicted. Therefore hypothesis three is not validated, and the answer to RQ3 is that a long-term situation of language contact does not seem to have an effect on the phonological patterns under study so as to cause a higher intra-speaker variation than that of speakers who have not been in such situation.

7.2. Inter-speaker IIS results

Inter-speaker comparisons consist of contrasting two samples from different speakers, as for example, *InSit*_f_1 in MT1 against *InSit*_f_2 in MT1. Table 27 shows the total number of inter-speaker comparisons that have been carried out and their distribution considering subcorpora.

Table 27: Total N of inter-speaker comparisons.

Inter-speaker comparisons	**Within *InSit***	MT1	45
		MT2	45
	Within *LanCon*	MT1	3
		MT2	15
	Combining subcorpora	MT1	30
		MT2	60
	TOTAL N INTER-SPEAKER COMPARISONS		**198**

The measurement time factor has been controlled at all times when conducting inter-speaker comparisons. Samples in MT1 have only been compared to other speakers' samples in MT1, and the same with MT2, so no comparisons between a sample in MT1 and a sample in MT2 have been made. Thus, there are 45 comparisons between speakers from the *InSit* subcorpus in MT1 and 45 more in MT2. As regards the *LanCon* subcorpus, only 3 inter-speaker comparisons have been carried out in MT1 and 15 in MT2. Finally, when both subcorpora are combined, 30 comparisons can be carried out in MT1 and 60 in MT2. Consequently, the total number of inter-speaker comparisons is 198.

Figure 15 shows intra- and inter-speaker comparisons within the *LanCon* subcorpus. As we saw earlier, intra-speaker IIS values range from 0.85 to 0.79, i.e. closer to the 1 endpoint of the continuum, which indicates maximum similarity. As regards inter-speaker results, the majority of IIS values (14 out of 18 comparisons, which makes up 77.78%) are situated between 0.63 and 0.77, whereas 4 out of 18 comparisons (22.22%) give results higher than 0.77 (the lowest intra-speaker IIS value).

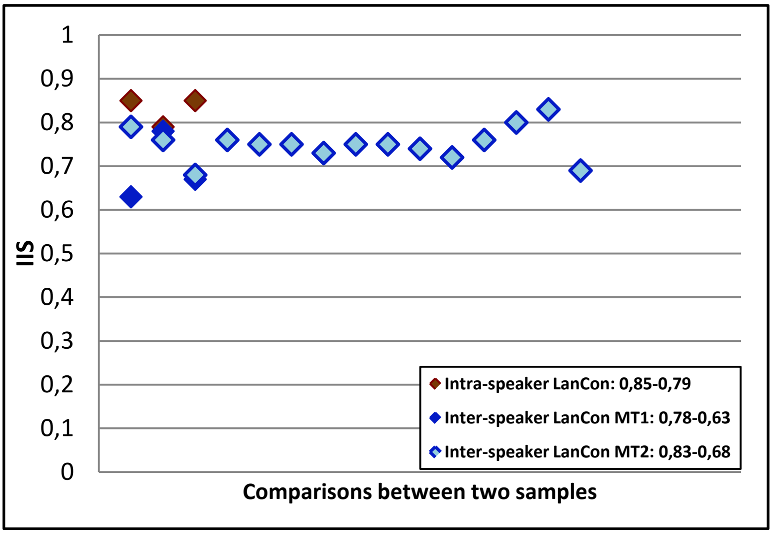


Figure 15: Intra and inter-speaker comparisons within the *LanCon* subcorpus.

Inter-speaker results within the *InSit* subcorpus can be seen in Figure 16. Within this subcorpus, intra-speaker IIS values are situated between 0.77 and 0.90. As regards inter-speaker comparisons, 77 comparisons out of 90 give results lower than 0.77, which represent 84.40% whereas 13 out of 90 (14.44%) are higher than 0.77.

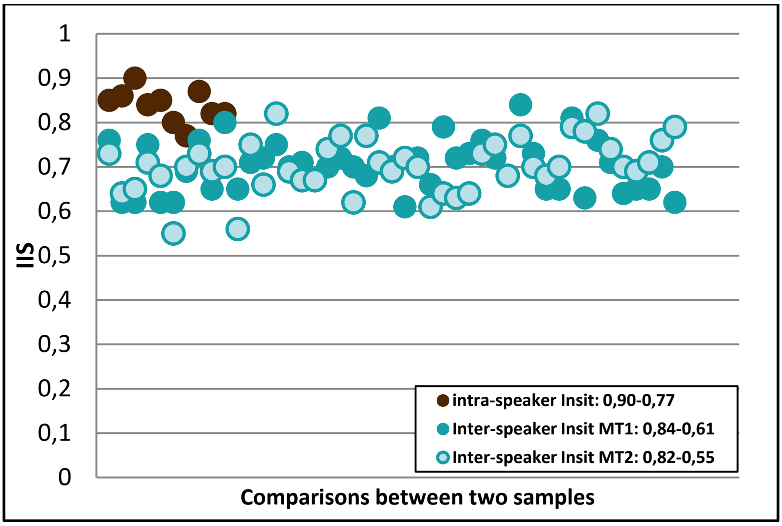


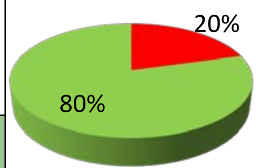
Figure 16: Intra and inter-speaker comparisons within the *InSit* subcorpus.

The first research question proposed in this study (RQ1) was whether inter-speaker variation was higher than intra-speaker variation. Hypothesis 1 stated that inter-speaker variation would in fact be higher than intra-speaker variation. The inter-speaker results obtained for both the *LanCon* and the *InSit* subcorpora would validate this hypothesis, in that for both subcorpora, comparisons between samples from the same speaker obtain higher IIS results –indicating lower variation–, whereas comparisons between samples from different speakers are predominantly lower in the continuum, indicating higher variation.

Despite the fact that hypothesis 1 seems to be validated in that inter-speaker comparisons are generally lower than intra-speaker comparisons in the IIS continuum, and therefore the answer to RQ1 seems to be affirmative, we need to consider those inter-speaker comparisons whose IIS values appear within the same range of intra-speaker values, i.e. higher than 0.77, which is the lowest intra-speaker IIS result. The fundamental problem with this overlap is that inter-speaker IIS values higher than 0.77 could wrongly lead to the conclusion that two samples would come from the same speaker, when in fact they were produced by different speakers, who show very similar patterns. As we can see in Table 28, the percentage of inter-speaker values that could be erroneously interpreted as showing intra-speaker variation is 20.20%, which in absolute numbers means 41 out of the total 198 inter-speaker comparisons that were carried out. If we look at it from the positive perspective, we can say that the IIS is able to discriminate samples from different speakers 80% of the times, which means 158 comparisons out of the 198.

Table 28: Summary of inter-speaker comparisons whose IIS values are higher than 0.77 and could wrongly be interpreted as an intra-speaker comparison.

N of total **inter-speaker comparisons**	N of comparisons higher than 0.77	% of values higher than 0.77	% of values lower than 0.77
198	**40**	**20.20%**	**79.80%**



Yet, we need to look at that 20% in depth to try to account for the factors responsible for these speakers showing similar variation, which results in high IIS values. In order to do that, the data are going to be analysed according to two factors. On the one hand, inter-individual variation will be explored considering the subcorpora the speakers have been classified into (*LanCon* and *InSit*), and on the other, considering their gender.

7.2.1. Inter-speaker results according to subcorpora

RQ4 asked how a permanent situation of language contact would affect inter-speaker variation. The hypothesis associated to this research question (Hypothesis 4) stated that inter-speaker variation would be higher when comparing subjects from different subcorpora than when comparing subjects from the same subcorpus. In this sense, it was hypothesised that the inter-speaker values resulting from comparing subjects within the same subcorpus would be slightly higher –showing less variation– than when comparing speakers from different subcorpora. Figure 17 shows the IIS results for the inter-speaker comparisons carried out between speakers within the same subcorpus and speakers between different subcorpora. As can be seen, all inter-speaker results are situated within the same range independently of the subcorpus factor. IIS values within the same subcorpus range from 0.84 to 0.55, whereas the values resulting from combining speakers from two different subcorpora are situated between 0.87 and 0.58. Consequently, hypothesis 4 seems not to be validated by these results.

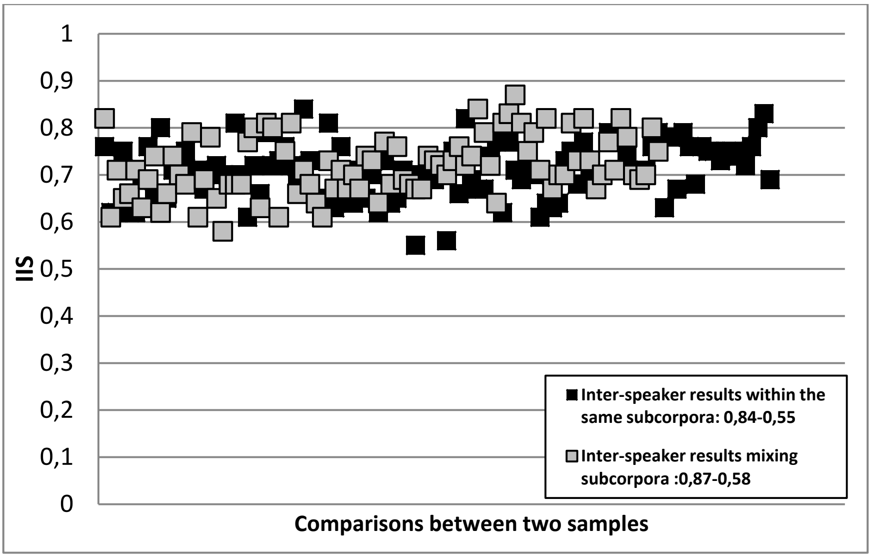


Figure 17: Inter-speaker results within the same subcorpora and between different subcorpora.

The similar distribution of the IIS results for both groups may be seen more clearly in a box plot, which is shown in Figure 18. The *y* axis in this box plot shows only the range of IIS values within 0.54 and 0.87 (which is where all the values are found). A box plot is more useful in this case because it shows where the most frequent values of the distribution are found. As can be seen, the median is practically the same, and the distribution of the most frequent IIS values (represented by the box) is also very similar. A one-way ANOVA test was carried out in order to confirm this similarity, which showed that there is no significant difference between these two distributions [F(1,196)=1.405; *p*=.237].

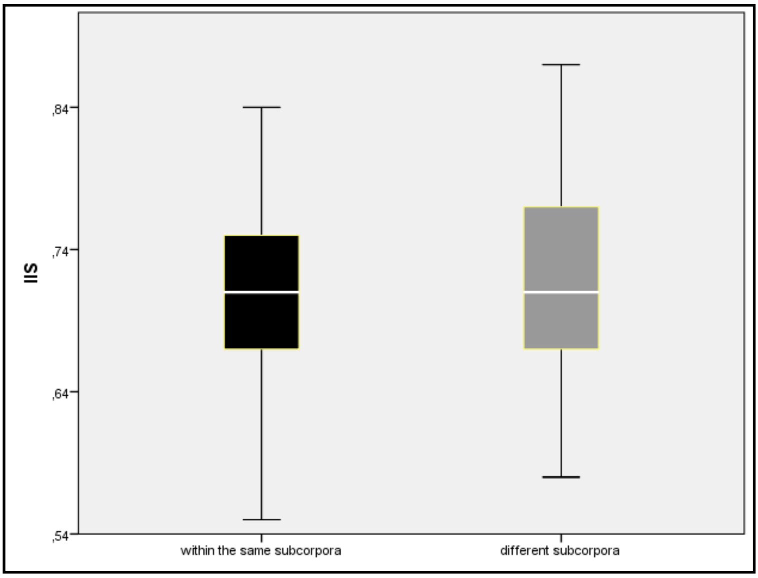


Figure 18: Box plot showing inter-speaker IIS values resulting from comparisons within the same subcorpora and between different subcorpora.

However, it might be necessary to go a bit deeper and look at differences that may arise depending on whether comparisons are carried out between speakers from the *LanCon* subcorpus or between speakers from the *InSit* subcorpus, since these two subcorpora might show differences between them. Figure 19 shows a box plot with the distribution of inter-speaker IIS values within the *InSit* subcorpus and within the *LanCon* subcorpus respectively, both divided into two groups depending on the measurement time.

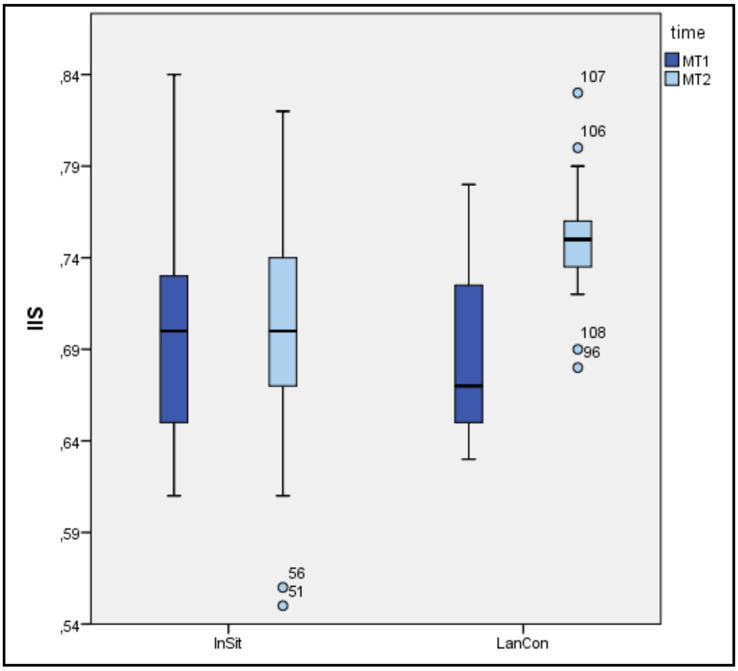


Figure 19: Box plot showing inter-speaker IIS values resulting from comparisons within the *InSit* subcorpus and within the *LanCon* subcorpus in MT1 and MT2.

In this plot we can observe that the distribution of the IIS values is quite similar within the *InSit* corpus in MT1 and MT2, as confirmed by the one-way ANOVA test which is not significant [$F(1,88)=.025$; $p=.874$]. Thus, speakers within the *InSit* subcorpus show a similar inter-speaker variation irrespectively of whether they are compared in MT1 or MT2. The distribution of IIS values within the *LanCon* subcorpus seems to be different, since the IIS values in MT1 are 0.63, 0.67 and 0.78, whereas the median for the values in MT2 is 0.75, and the most frequent values are around that range. The limited data available for the *LanCon* subcorpus in MT1 does not allow the possibility to carry out an ANOVA between MT1 and MT2 in this subcorpus. However, we can compare the distributions between the *InSit* and the *LanCon* subcorpora in MT2 statistically, which also seem quite different. The median of IIS values for the *InSit* subcorpus is 0.70, whereas, as we have seen, it is 0.75 for the *LanCon* subcorpora, a difference that is statistically significant [$F(1,58)=8.210$; $p=.006$]. What we can infer from these results is that IIS inter-speaker values within the *LanCon* subcorpus in MT2 are generally higher than values for the *InSit* subcorpus in the same measurement time. Consequently, it would be possible to say that after a long-term situation of language contact, speakers do not show more inter-speaker variation, but they actually show less inter-speaker variation. Another piece of data that confirms this observation is the percentage of IIS values higher than 0.77. In Table 29, which shows a summary of all the IIS inter-speaker comparisons that are higher than 0.77 classified according to subcorpora, we can see that the percentage of such values for *InSit* comparisons is 14.44% (13 out of 90) whereas it is 22.22% (4 out of 18) for *LanCon* comparisons. Again, inter-speaker variation between speakers from the *LanCon* subcorpus seems to be lower than inter-speaker variation between speakers from the *InSit* subcorpus, which is contrary to what was expected. These results seem to suggest that the answer to RQ4 may be that inter-speaker variation is affected by a permanent situation of language contact – or more specifically, being permanently away from their community of origin–, since *LanCon* speakers have become generally more alike after being more than twenty years away from their community.

Table 29: Summary of inter-speaker comparisons whose IIS values are higher than 0.77.

	Subcorpus	Measurement Time	N of total comparisons	N comparisons higher than 0.77	% IIS values higher than 0.77	% IIS values lower than 0.77
Inter-speaker comparisons	Within *InSit*	MT1	45	5	11.11%	88.89%
		MT2	45	8	20.00%	80%
		total	90	13	14.44%	84.40%
	Within *LanCon*	MT1	3	1	33.33%	66.67%
		MT2	15	3	20.00%	80%
		total	18	4	22.22%	77.78%
	Mixing subcorpora	MT1	30	7	16.67%	83.30%
		MT2	60	16	30.00%	70%
		total	90	23	25.56%	74.40%
TOTAL			198	40	20.20%	79.80%

7.2.2. Inter-speaker results according to gender

The second factor to take into consideration in inter-speaker comparisons is the speakers' gender. RQ5 posed the question of how gender affects inter-speaker variation, and hypothesis 5 stated that inter-speaker variation would be higher (and so IIS values would be lower) when comparing men with women than when comparing men with men and women with women. Figure 20 shows inter-speaker results when comparing only men with men (in purple), women with women (in pink) and when comparing men with women (in yellow). Although it is not a radical difference, there seems to be a tendency for comparisons between women to have higher IIS results than comparisons between men, and in turn, comparisons between men and women tend to be lower than the latter.

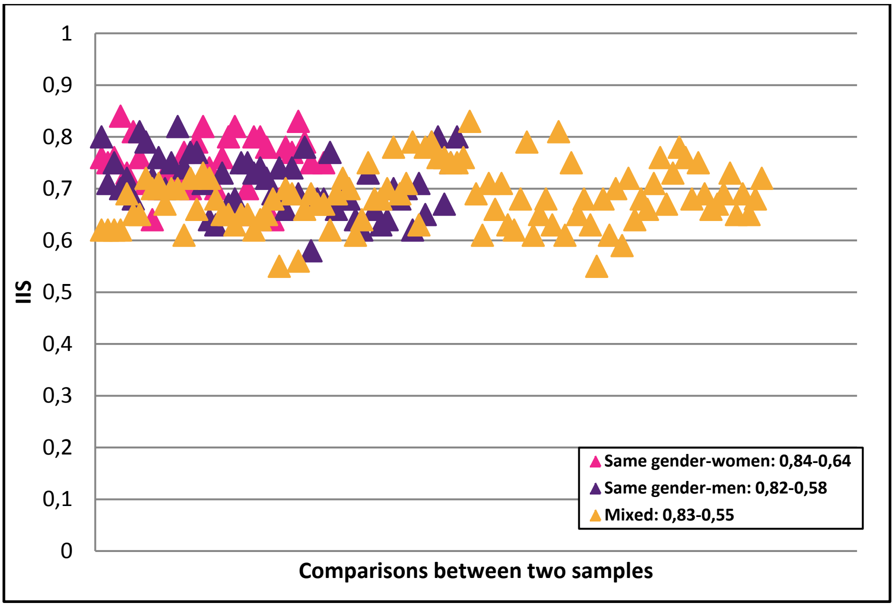


Figure 20: Inter-speaker IIS results according to gender.

This tendency may be seen more clearly in a box plot, which is shown in Figure 21. The median for comparisons between women is 0.76, and the majority of the IIS values are situated between 0.79 and 0.71. When comparing men, the median is situated at 0.71, and the majority of values can be found between 0.75 and 0.68. If we compare men with women, the median is 0.68 and the majority of values are between 0.65 and 0.72. From these figures we can infer that, in general terms, IIS results for comparisons between women seem to give higher IIS values than comparisons between men, and in turn, comparisons between men and women seem to be lower than those resulting from comparisons between speakers of the same gender.

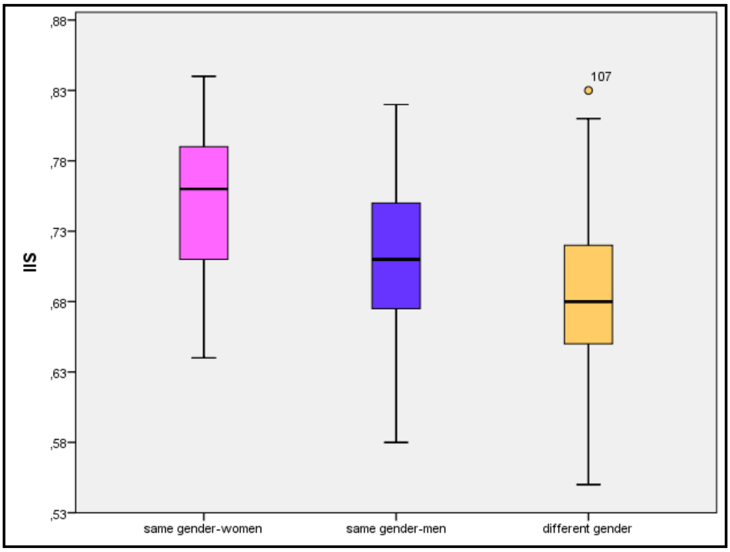


Figure 21: Box plot for inter-speaker results according to gender.

One-way ANOVA tests were performed in order to assess the statistical significance of these observations. The difference between the distribution of IIS values for comparisons between women on the one hand, and between men on the other is significant [F(1,89)=11.357; *p*=.001;eta-squared=.113]. The difference is also significant when contrasting the distribution of the IIS values resulting from the comparison between women on the one hand, and between men and women on the other [F(1,140)=36.197; *p*=<.001; eta-squared=.205] and when contrasting IIS values from comparisons between men on the one hand, and between men and women on the other [F(1,161)=8.008; *p*= .005; eta-squared=.047]. In this sense, hypothesis 5 seems to be confirmed, since comparisons between men and women show significantly higher inter-speaker variation (i.e. lower values in the IIS continuum) than comparisons among subjects of the same gender. And interestingly, comparisons among women tend to show less variation (higher IIS values) than comparisons between men, which might indicate that it may be likely to find more variation when comparing samples from male speakers.

Another way of looking at similarity between men and women is looking at the inter-speaker comparisons whose IIS values are higher than 0.77, which are shown in Table 30. If we look at the general figures at the bottom of the table, we can see that the percentage of such IIS values for comparisons between women is 44.44%, which in other words means that the IIS is able to correctly identify that two samples have been produced by different women only 55.56% of the times, which is a pretty low proportion. On the contrary, IIS values higher than 0.77 for comparisons between men are reduced to practically half of the previous percentage, namely 21.05%, which would mean that the IIS is capable of distinguishing between samples produced by men 78.95% of the times, which indicates a higher performance of the IIS. As expected by previous observations, the percentage of comparisons between men and women that give IIS results higher than 0.77 is quite low, 11.43%, which means that the IIS is able to correctly identify that two samples have been produced by two different speakers when they are of different gender 88.57% of the times. These results confirm the conclusions reached regarding hypothesis 5 stated above, in that inter-speaker variation is lower when comparing speakers from the same gender than when comparing men with women. Besides, results regarding variation between women and between men seem to reflect different patterns of variation of the variables studied, since men seem to show more inter-speaker variation than women.

Table 30: Summary of IIS values higher than 0.77 according to gender.

Subcorpus	M. Time	Type of comparison regarding gender	total comparisons	N IIS values higher than 0.77	% IIS values higher than 0.77
Within *InSit*	MT1	Same gender – women	10	2	20%
		Same gender– men	10	3	30%
		Men-women	25	0	0%
	MT2	Same gender – women	10	3	30%
		Same gender– men	10	3	30%
		Men-women	25	2	8%
	TOTAL JUST WOMEN		**20**	**5**	**25%**
	TOTAL JUST MEN		**20**	**6**	**30%**
	TOTAL MIXED		**50**	**2**	**4%**
Within *LanCon*	MT1	Same gender – women	0	0	--
		Same gender– men	1	0	0%
		Men-women	2	1	50%
	MT2	Same gender – women	1	1	100%
		Same gender– men	6	0	0%
		Men-women	8	2	25%
	TOTAL JUST WOMEN		**1**	**1**	**100%**
	TOTAL JUST MEN		**7**	**0**	**0%**
	TOTAL MIXED		**10**	**3**	**30%**
Mixing subcorpora	MT1	Same gender – women	5	3	60%
		Same gender– men	10	2	20%
		Men-women	15	2	13.33%
	MT2	Same gender – women	10	7	70%
		Same gender– men	20	4	20%
		Men-women	30	5	16%
	TOTAL JUST WOMEN		**15**	**10**	**66.67%**
	TOTAL JUST MEN		**30**	**6**	**20%**
	TOTAL MIXED		**45**	**7**	**15.56%**
TOTAL same gender –women			**36**	**16**	**44.44%**
TOTAL same gender-men			**57**	**12**	**21.05%**
TOTAL men-women			**105**	**12**	**11.43%**

Another interesting observation lies in the fact that comparisons between men and women within the *LanCon* subcorpus tend to show less variation than equivalent comparisons within the *InSit* subcorpus. In the case of the *LanCon* subcorpus, when comparing men with women, the IIS gives results higher than 0.77 30% of the times (3 out of 10), which indicates that it is able to discriminate that they are different speakers only 70% of the times. As regards the *InSit* subcorpus, this percentage is considerably lower, only 4% (2 out of 50), which indicates that within the *InSit* subcorpus, the IIS is able to discriminate almost always (96% of the times) that the speakers are different when they are a man and a woman. If we combine samples from both subcorpora, the percentage of values higher than 0.77 when comparing men and women is 15.56%, which is still quite low. This adds further information to what has previously been observed regarding inter-speaker variation within the *LanCon* subcorpus, since it seems to be lower than inter-speaker variation within the *InSit* subcorpus, up to the point that even men and women seem to show less inter-speaker variation (i.e. more similarity) when they have been in a permanent situation of language contact.

7.2.3. Speaking tempo as an inter-speaker variation factor

The present section is a brief analysis of one of the factors that may have an influence on the inter-speaker variation that has been shown in the IIS calculations, namely speed of delivery. Many, if not all, of the phonological phenomena analysed in this dissertation by means of the 14 variables formulated for the IIS may somehow be affected by the rate at which individuals speak. For example, all the allophonic variants of /t/, namely frication, glottalisation and tapping may be regarded as processes of lenition, which may be prone to appear in quick deliveries. In fact, t-tapping is considered by some authors as a process that tends to happen only in rapid deliveries (Wells 1982: 324-325) although some later findings contradict this idea (Hannisdal 2006) (see section 6.2.2.4 on t-tapping). Other processes such as yod coalescence may also be regarded as a type of assimilation that may be more likely to occur in rapid rather than in careful speech. The aim of the analysis presented in this section is to make sure that the inter-speaker variation that has been found in the IIS calculations is actually due to individual and idiosyncratic differences (or choices), and not to differences in the subjects' speed of delivery.

Two main ways have been distinguished to measure speed of delivery (Goldman-Eisler 1968, Laver 1994, Rose 2002). On the one hand, articulation rate (AR) measures the syllables per second that the speaker delivers disregarding pauses and, on the other hand, speech rate (SR) measures the syllables per second including pauses. In forensic analysis, articulation rate has proved to be a more reliable measure, and has been reported to be less dependent on the context (Künzel 1997), and for this reason, AR is the measure that has been used to analyse the speech tempo of the speakers in the present study.

The analysis was carried out with one minute of speech, where the pauses and runs ("the stretch of speech that contains no pauses" (Miller *et al.* 1984: 219)) were separated. Both silent pauses as well as filled pauses were disregarded. The syllables were counted from a phonological perspective, that is, the possible syllable reduction processes that may occur were not considered. For example the word *university* may be pronounced [juːnɪˈvɜːsəti], with 5 syllables, or [juːnɪˈvɜːsti] with 4 syllables, and what was counted was the 'ideal' phonological pronunciation (the first one). The rationale behind this procedure is that compressing syllables, although determined by tempo, may be regarded as an individual choice, and if a speaker talks faster, and tends to compress syllables more often, counting the number of syllables s/he should have produced will reflect this higher speed in the final AR measure better than counting the number of syllables really produced. Finally, after separating pauses from runs and counting the number of syllables in each run, the total number of syllables was divided by the total duration of all the 'runs'. The AR measure is expressed in syllables per second.

Figure 22 and Figure 23 show the average number of syllables per second produced by female and male subjects respectively. No different graphs are shown separating speakers by subcorpora because speakers in both subcorpora show similar results. The articulation rate of all the speakers is found between 4.3 and 6.9 syllables per second. As seen in the graphs, intra-speaker variation in AR is quite low, an observation that agrees with previous studies (Goldman-Eisler 1968, Künzel 1997). Regarding the 13 speakers for whom there are data in two measurement times, 4 speakers (31%) show a lower difference than 0.3 syll/sec between both samples (*InSit*_f_3, *InSit*_f_5, *InSit*_m_4, *LanCon*_m_1). Besides, 7 speakers (54%) show a difference between 0.5 and 0.7 syll/sec (*InSit*_f_1, *InSit*_f_2, *InSit*_f_4, *LanCon*_f_1, *InSit*_m_1, *InSit*_m_3 and *LanCon*_m_2). Finally, only 2 speakers (15%) show a difference of 0.9 between both samples. If we consider the speakers who show a variation higher than 0.5 syll/sec from MT1 to MT2 (since those who show 0.1 or 0.3 can be considered as being very stable), the direction of the change, i.e. whether it is an increase or a decrease in AR over time, does not seem to follow any specific pattern. Four speakers show an increase over their lifespans (*InSit*_f_1, *InSit*_f_2, *LanCon*_f_1, *LanCon*_m_2), whereas five speakers show a decrease (*InSit*_f_4, *InSit*_m_2, *InSit*_m_3 and *InSit*_m_5). These observations do not allow us to reach any clear conclusions regarding the effects of ageing in speech tempo. There could be two alternative explanations: a) that speakers are affected differently and some of them increase their AR and some others decrease it; or b) that the course of time (in middle-aged speakers) does not have an effect on speech tempo and the variation present is most likely due to differences in the context and the specific situation where the recordings took place. Despite the fact that AR has proved to be a measure that shows low intra-speaker variation, the question of what causes the little variation that exists is an interesting question for future research.

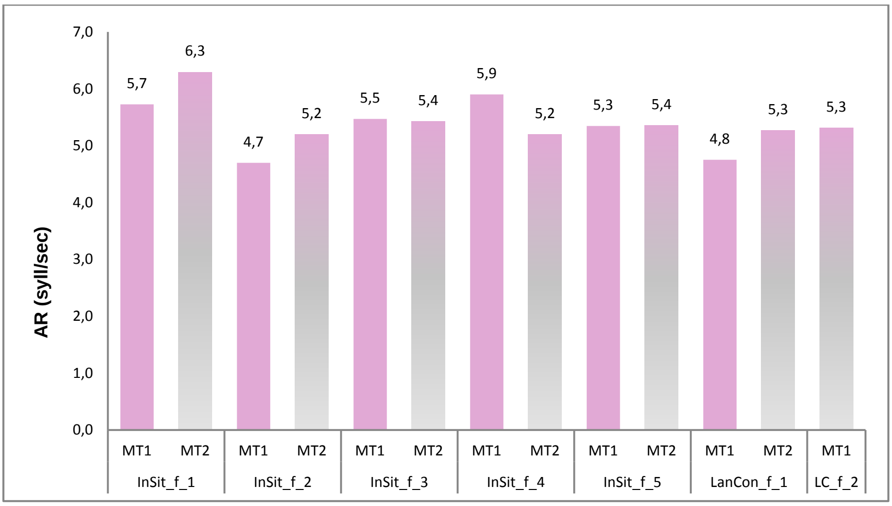


Figure 22: Articulation rate of *InSit* and *LanCon* women. Figure indicates syllables per second.

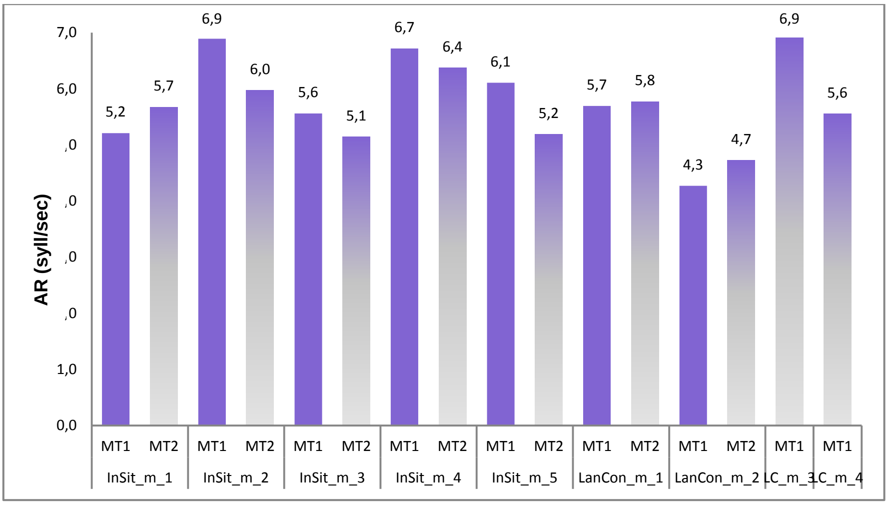


Figure 23: Articulation rate of *InSit* and *LanCon* men. Figure indicates syllables per second.

As seen in Figure 22 and Figure 23, inter-speaker variation is clearly greater than intra-speaker variation. Speakers *LanCon*_m_2, *InSit*_f_2, and *LanCon*_f_1 exhibit an average AR (between samples in MT1 and MT2) equal or lower than 5 syll/sec. On the other hand, speakers *InSit*_f_1, *InSit*_m_2, *InSit*_m_4 and *LanCon*_m_3 show an average AR of equal or higher than 6 syll/sec. The rest of speakers show an average AR between 5.3 and 5.7. These results confirm previous reports about the usefulness of a measure of articulation rate in forensic contexts, since it shows low intra-speaker variation and high inter-speaker variation.

In any case, the aim of this section is not to analyse articulation rate *per se*, but rather, to look at the possible influence that speaking tempo may have on the inter-speaker variation that the variables under study show. This analysis is carried out by means of Spearman's correlation coefficient (ρ)[31], which analyses the correlation between AR (measured in syllables per second) on the one hand, and the percentage of realisation of variant (a) of each of the fourteen variables studied (measured in a percentage).

Table 31 shows the matrix of correlation coefficients of the fourteen variables with articulation rate, and Figure 24 shows the corresponding scatterplot matrix. No correlation between AR and the fourteen variables is significant [ρ=from -.256 to .341; *p*= from .071 to .975]. Besides, all the points in the scatterplots are scattered around the graphs, indicating a non-linear relationship. From these results it is possible to state that speech tempo is not a factor that influences either of the variables under study, and consequently, the inter-speaker differences that the speakers show are due to individual and unique realisations of the linguistic phenomena considered by the fourteen variables.

Table 31: Matrix of Correlation Coefficients for the IIS variables and Articulation Rate.

			Art_rate	Var_1	Var_2	Var_3	Var_4	Var_5	Var_6	Var_7	Var_8	Var_9	Var_10	Var_11	Var_12	Var_13	Var_14
Rho de Spearman	Art_rate	Coeficiente de correlación	1,000	,236	-,016	-,256	-,187	,006	,341	-,140	,187	-,105	,260	,074	,261	,189	,211
		Sig. (bilateral)	.	,219	,932	,181	,330	,975	,071	,477	,418	,596	,174	,720	,198	,327	,273
		N	29	29	29	29	29	29	29	28	21	28	29	26	26	29	29

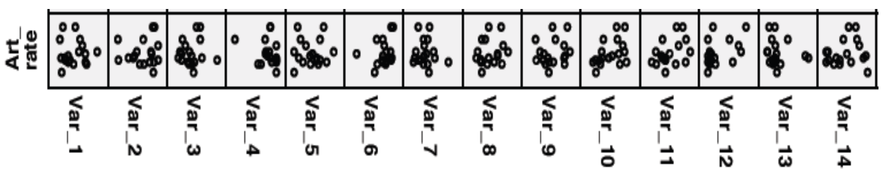


Figure 24: Scatterplot matrix for the IIS variables and Articulation Rate.

[31] Normality tests were carried out (Shapiro-Wilk & Shapiro) in order to determine the normality of the distribution. Some of the variables had non-normal distributions, hence the use of Spearman's coefficient (ρ) instead of Pearson's (r).

The results reported in this section indicate that speaking tempo, more specifically, articulation rate, does not correlate with any of the IIS variables. Therefore, the differences between speakers in the production of these variables cannot be explained by differences in their speed of delivery, and can only be explained by the fact that they represent idiolectal choices.

Chapter 8
Results of the analysis of the discriminatory potential of the variables

Chapter 8 is concerned with an analysis of all the variables considered in this dissertation from an independent point of view, i.e. in isolation from the rest of the variables. The results of the IIS calculations that have been considered previously in this section are concerned with how the IIS, as constituted by all the 14 variables together, is useful to discriminate between different speakers. Conversely, here the variables are considered separately so as to determine the intra- and inter-speaker variation that each variable exhibits as realised by the subjects in this study. This analysis will allow us to establish the discriminatory potential of the variables studied for future applications in forensic contexts that may or may not involve the IIS tool, which should provide an answer for the sixth research question (RQ6) that motivates the present dissertation. On the other hand, we will also comment on the general tendencies that the different speakers in the corpus exhibit as a group, rather than as individuals. As stated previously in the dissertation, three independent variables are taken into account as factors that can influence the pattern of the dependent variables. Firstly, change over time is accounted for by the two measurement times (MT1 and MT2), which can shed some light on the patterns that these processes exhibit over a speaker's lifespan. Secondly, the division of the corpus into seven women and nine men will help establish differences in the patterns of the variables according to gender. Finally, possible effects of a second language on the first will also be explored by looking at the different behaviour that the processes may exhibit according to the two subcorpora in the dissertation: the *InSit* subcorpus has five men and five women in both measurement times (MT1 and MT2) and the *LanCon* subcorpus has two women (only one in MT1) and four men (only two in MT1).

Besides, instead of looking at the 14 variables as though some of them were not related to some of the others, the variables that are part of the same allophonic processes will be taken into account jointly. For example, all the variables considering any of the allophonic processes that can affect /t/, i.e. t-glottalling, t-tapping and frication of /t/, will be grouped together, since they are strongly related to one another. Thus, rather than considering these variables independently of one another, the analysis will benefit from a joint observation. The six processes that are analysed in this section are the following:

1. Allophonic processes affecting /t/: t-glottalling, t-tapping and frication of /t/ (IIS variables 7-13).
2. Alternation of weak vowels [ə] and [ɪ] (IIS variables 1 and 2).
3. Yod-coalescence (IIS variables 3 and 4).
4. Insertion of /t/ (IIS variable 5).
5. Linking /r/ (IIS variable 6).
6. Frication of /k/ (IIS variable 14).

The analysis will be carried out in two ways. On the one hand, the behaviour of the variables will be examined from a descriptive perspective by means of the calculation of the percentages of occurrence of each variant. On the other hand, statistical significance will also be taken into account by means of the Chi-square test, which indicates whether the distribution of the variants between two samples is significantly different or not[32]. The main difference between the two perspectives, apart from the statistical significance that the Chi-square test provides, is the fact that the percentages are calculated for each speaker individually, whereas the Chi-square test compares the distributions of two samples. Finally, correlation analyses by means of Pearson's and Spearman's coefficients will also be carried out in order to establish the linearity behind the relationships among variables.

8.1. Allophonic realisations of /t/: glottalling, tapping and frication

The three allophonic processes that can affect /t/ in unstressed onset position that have been studied in this dissertation, namely glottalling, tapping and frication, are considered jointly in this analysis, rather than independently. For the purpose of the calculation of the IIS, these processes were formulated into binary variables, for which one of the realisations, for example t-glottalling, was variant (a) against all the other possible realisations, which constituted variant (b). However, in the present analysis, rather than considering these processes as unrelated variables, they have been regarded as different allophones of the same phoneme /t/, which can normally appear in the same context. I have found it more convenient to study the patterns that these allophones exhibit

[32] Throughout this chapter, reference made to significant differences always imply statistically significant differences at the level *p*=<.05 shown by the Chi-square tests.

in the different contexts under study, in order to shed some light on the preferences of the speakers towards the use of all the possible variants in different contexts. The five contexts considered are summarised in Table 32.

Table 32: The five contexts considered for the analysis of the phonological processes affecting the allophonic realizations of /t/.

Context	IIS variable
1. Between vowels across word boundaries (V_#V) in frequent words and lexical items where syntactic linkage is close.	**Variable 7**: T-glottalling (V_#V) in frequent words and lexical items with syntactic linkage such as *get up, but I, what if, out of*… **Variable 10**: T-tapping (V_#V) in frequent words and lexical items with syntactic linkage such as *get up, but I, what if, out of*…
2. Between vowels word-internally (V_V) in highly frequent words.	**Variable 11:** T-tapping (V_V) between vowels in highly frequent words: *pretty, whatever, getting, putting, British, Scottish, better, sitting, matter.*
3. At the end of a word before a pause.	**Variable 9:** T-glottalling at the end of a word before a pause.
4. Between vowels across word boundaries (V_#V) in any context except context 1.	**Variable 8:** T-glottalling between vowels across word boundaries in lexical words (V_#V).
5. Between vowels word-internally and across word boundaries (V_(#)V) in any context except context 1.	**Variable 12:** T-tapping between vowels word internally and across word boundaries (V_(#)V). **Variable 13:** Frication of /t/ between vowels word internally and across word boundaries (V_(#)V).

8.1.1. Context 1: Intervocalically across word boundaries (V_#V) in highly frequent words and lexical items where syntactic linkage is close (variables 7 and 10)

This context is considered by variable 7, which deals with t-glottalling, and variable 10, which considers t-tapping in highly frequent words and lexical items such as *get a, out of, what if* etc. Figure 25 and Figure 26 show the percentages of realisation of the four possible allophones of /t/ in these contexts, i.e. [t] [ɾ] [t̞] and [t], by the subjects in this study, where different tendencies depending on gender and subcorpora can be seen.

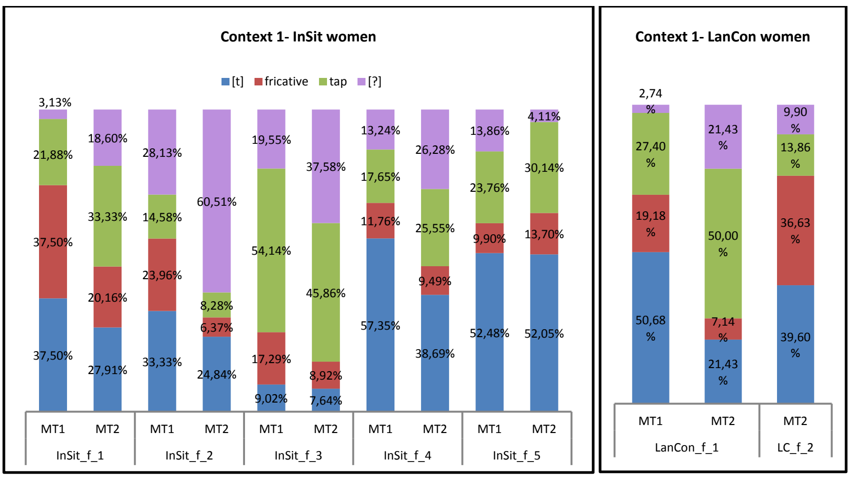


Figure 25: Allophonic realisations (%) of /t/ V_#V in highly frequent words and lexical items where syntactic linkage is close (variables 7 and 10) for female speakers (*InSit* on the left and *LanCon* on the right).

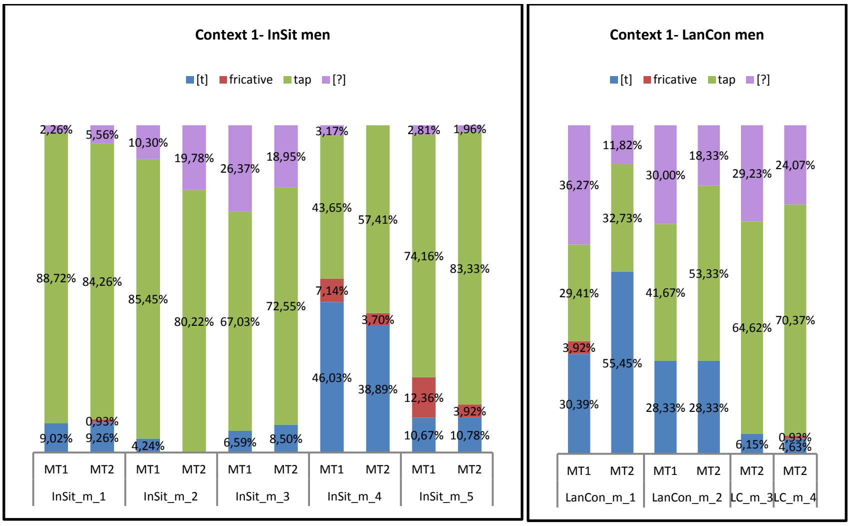


Figure 26: Allophonic realizations (%) of /t/ V_#V in highly frequent words and lexical items where syntactic linkage is close (variables 7 and 10) for male speakers (*InSit* on the left and *LanCon* on the right).

Variable 7: /t/-glottalling in highly frequent words and lexical items where syntactic linkage is close such as *get up, but I, what if, out of*.

As regards t-glottalling, *InSit* women seem to use this variant more often than men in the same subcorpora, which seems to be associated to the fact that men show a noticeable preference towards t-tapping. Similarly, *LanCon* men seem to use t-glottalling more often than *InSit* men on average, and at the same time, they use t-tapping at a lower proportion. However, both *LanCon* male speakers for whom there are data in MT1 and MT2 show an increase in the production of taps in MT2, which seems to be parallel to a decrease in glottal stops. This slight increase in the percentage of t-tapping is also the case for three *InSit* men (*InSit*_m_3, *InSit*_m_4 and *InSit*_m_5), but the other two speakers (*InSit*_m_1 and *InSit*_m_2) show a slight decrease over time.

Intra-speaker variation in t-glottalling seems to be much higher for women than for men, since the majority of women exhibit an increase in this variant from MT1 to MT2, an increase that could be said to coincide with the increase in the production of glottal stops in their community, except *InSit*_f_5, who suffers a decrease in this variant. This observation is confirmed by chi-square tests, which show that all the 6 women show statistically significant intra-speaker differences when comparing samples in MT1 and samples in MT2. On the contrary, men do not seem to show such intra-speaker variation, since only two of them (out of 7) show significant intra-speaker differences, *InSit*_m_2, who has an increase from 10.30% to 19.78% and *LanCon*_m_1, who decreases his production of glottal stops from 36.27% to 11.82%. Intra-speaker variation does not seem to be affected by the subcorpora factor for either women or men.

Inter-speaker variation seems to be quite high both for female and male subjects, but perhaps it is more noticeable for women, since they produce this variant much more often, which leaves room to more differences in the proportions of usage. When comparing *InSit* women, 13 out of the 20 comparisons (65%) between women in this subcorpus show significant differences, and the only possible comparison between women in the *LanCon* subcorpus, in MT2, is also significant. If we compare women from different subcorpora, 73% of the comparisons (11 out of 15) exhibit significant differences. Thus, the high inter-speaker variation that this variable exhibits is apparent, and this variation is very high both considering subcorpora separately and combining them: a total of 69% of the comparisons between all the women in both subcorpora (25 out of 36) show significant inter-speaker differences as inferred from the Chi-square tests.

Inter-speaker variation between men seems to be influenced by the subcorpora they belong to. *InSit* men exhibit significant differences in 13 out of 20 comparisons (65%), which is pretty high variation. *LanCon* men, however, only show significant differences in 2 out of 7 (29%) of comparisons. If we combine men from both subcorpora, 18 out of 30 comparisons exhibit significant differences (60%), a result that could indicate that male speakers show different patterns of behaviour depending on the subcorpora they belong to, which in turn makes inter-speaker variation across subcorpora quite high. Despite the fact that *LanCon* male speakers seem to have a more similar pattern of t-glottalling in this context among each other than *InSit* speakers, an observation that should be taken into consideration for forensic applications, a total of 33 out of 57 comparisons (58%) between all men in both corpora show significant results, so we can say that inter-speaker variation is also generally high when comparing men.

There are a few conclusions that we can infer as regards the discriminatory potential of this variable in a forensic context, which are summarised in Table 33. Firstly, female speakers show lifespan change in this process, since the process of t-glottalling is currently in progress as previously stated (see section 6.2.2.3), so in the case of having non-contemporary samples, we should be aware that differences in the production of glottal stops between the samples would be high even if they were produced by the same speakers. Men do not show such intra-speaker variation over time, so it might be a suitable variable to bear in mind when comparing samples produced by male speakers. Secondly, men who have been in a situation of language contact seem to be more similar between each other in the production of this variant in this context, since the inter-speaker variation they show is low. Apart from this, if the samples to be compared are contemporary, t-glottalling in context 1 seems to be quite a suitable variable to consider, since it shows high inter-speaker variation for both women and men. In case of having non-contemporary samples, the researcher needs to be aware that women in particular show lifespan change, which may lead to high intra-speaker variation over time.

Apart from intra- and inter-speaker variation, it is also important to look at the frequency of occurrence of a variable in order to infer conclusions about its potential forensic application (see 2.2 for details on suitable forensic parameters). This variable has quite a high frequency of occurrence, since it appears 108 times on average in each sample, which makes it even a better candidate to be taken into account in a forensic context.

Table 33: Summary of discriminatory potential of variable 7.

<table>
<tr><td rowspan="2">Intra-speaker variation
(% of comparisons that show statistically significant differences (χ^2 test)</td><td colspan="2">Women:
6 out of 6 (100%)</td><td rowspan="2">High for women (lifespan change), quite low for men</td></tr>
<tr><td colspan="2">Men: 2 out of 7 (29%)</td></tr>
<tr><td rowspan="3">Inter-speaker variation
(% of comparisons that show statistically significant differences (χ^2 test)</td><td colspan="2">Women: 25 out of 36 (69%)</td><td rowspan="3">Very high, especially for women</td></tr>
<tr><td>InSit men: 13 out of 20 (65%)</td><td rowspan="2">Men in general: 33 out of 57 (58%)</td></tr>
<tr><td>LanCon men: 2 out of 7 (29%)</td></tr>
<tr><td>Frequency of occurrence of the variable</td><td colspan="2">Range = between 33 and 177 realisations in the samples studied
Mean = 108</td><td>High</td></tr>
<tr><td colspan="4">Forensic implications: high discriminatory potential for comparisons between male and female, but with non-contemporary samples, the investigator needs to be aware of the lifespan change affecting especially women, which may lead to high intra-speaker variation over time. Also, men who have been away from their community seem to have a more similar pattern than men who have stayed in their community.</td></tr>
</table>

Variable 10: /t/-tapping in highly frequent words and lexical items where syntactic linkage is close such as *get up, but I, what if, out of*.

As shown in Figure 25 and Figure 26, there is an evident gender difference, since men produce t-tapping in much higher proportion than women, especially *InSit* male speakers. These observations were expected and confirm previous studies which claim that t-tapping is much more preferred by men than by women in SSBE (see section 6.2.2.4).

Intra-speaker variation in the production of t-tapping in this context seems to be quite low for both men and women, except some particular cases. The only male speaker who shows statistically significant differences when comparing his samples in MT1 and MT2 is *InSit*_m_4, who produces a tap 43.65% of the times in MT1 whereas this proportion increases to 57.42% in MT2. As regards the female speakers, *InSit*_f_4 also increases this proportion from 17.65% to 25.55%, and *LanCon*_f_1 goes from 27.40% to 50%, a difference that is significant in both cases. The rest of the male and female speakers show quite a stable use of this variant over time. Therefore, since only 3 out of the 13 speakers show significant intra-speaker differences, we could say that intra-speaker variation of t-tapping over time is generally quite low in this context.

Conversely, inter-speaker variation seems to be quite high. As regards female speakers, *InSit*_f_2, for example, does not produce this variant very often, only 15% and 8% of the times, whereas *InSit*_f_3 produces it around half of the times (54% and 45% in MT1 and MT2), and other speakers such as *InSit*_f_1 and *InSit*_f_5 produce it around 20-30%. This is also the case with the *LanCon* female subjects, since *LanCon*_f_1 produces this variant 27% and 50% of the times, whereas *LanCon*_f_2 only 14% of the times. If we look at comparisons between different female speakers by means of the Chi-square test, 18 out of 36 comparisons (which represent 50%) show statistically significant differences. Men show even a higher inter-speaker variation, since 42 out of the 57 (74%) comparisons between each other exhibit significant differences. Apart from this, the fact that 85 out of 105 comparisons between men and women show significant differences, which represents 81%, indicates that this variable correlates significantly with gender, in that men and women show a different use.

These results, which are summarised in Table 34, indicate that variable 10, which considers t-tapping in context 1, seems to be a suitable variable for forensic purposes, since it shows low intra-speaker variation and quite high inter-speaker variation, both for women and men, but specially for men. In addition to this, this variable also shows quite a high frequency of occurrence, since it appears 108 times on average in the samples that have been studied, which makes it even a better variable in forensic terms.

Table 34: Summary of discriminatory potential of variable 10.

Intra-speaker variation (% of comparisons that show statistically significant differences (χ^2 test)	Women: 2 out of 6 (33%)	Low, especially for men
	Men: 1 out of 7 (14%)	
Inter-speaker variation (% of comparisons that show statistically significant differences (χ^2 test)	Women: 18 out of 36 (50%)	Very high, especially for men
	Men: 42 out of 57 (74%)	
Frequency of occurrence	Range = 33-178 Mean = 108	High
Forensic implications: high discriminatory potential for comparisons between women and between men, but even better for comparisons between men. Subcorpus does not seem to have an effect on speakers.		

Frication of /t/

Despite the fact that frication in this context is not an IIS variable, it might also be interesting to look at the behaviour of this process from a qualitative perspective with the data available. Firstly, if we look at the percentage of use of each speaker, it is evident that women produce this variant much more often than men, which confirms previous studies which stated that this variant was much more preferred by women than by men (see section 6.2.2.5), in that it is a rather prestigious variant. In fact, the majority of men do not use this variant at all, and the men that do, do so in very low percentages. Although we do not have data on the statistical significance, since frication of /t/ is not an IIS variable and Chi-square tests were not performed, we can infer some descriptive observations regarding the percentage of production of this variant. Frication in this context seems to show high intra-speaker variation throughout time, which would appear to be related to a decrease of their percentage of occurrence from MT1 to MT2. For all the women both in the *InSit* and *LanCon* subcorpus there is a considerable decrease in the percentage of realisation of [ț], except for speaker *InSit*_f_5, who shows a slight increase. It could be a possibility that this decrease in fricated /t/s is linked to the increase in t-glottalling that has been commented on before. In fact, if we separate [ɾ] and [ʔ] on one hand (the less prestigious variants) and [ț] and [t] on the other (the more prestigious ones), we can see that all the female subjects regardless of their subcorpus exhibit a decrease in the proportion of prestigious variants, and an increase in the proportion of less prestigious variants, either [ɾ] or [ʔ]. The only exception to this pattern would be *InSit*_f_5, whose proportion seems to stay relatively stable. It is noticeable that women, who have traditionally been considered to prefer more prestigious variants than men by sociolinguistic research,[33] exhibit here a decrease in the percentage of prestigious variants of /t/. This fact might also be an important point to take into account in a forensic context where non-contemporary samples produced by women are being considered.

8.1.2. Context 2: Intervocalically within a word in highly frequent words (variable 11)

Percentages of realisations of the three allophonic process of /t/ in this context are shown in Figure 27 and Figure 28 for the subjects in the *InSit* and *LanCon* subcorpora respectively.

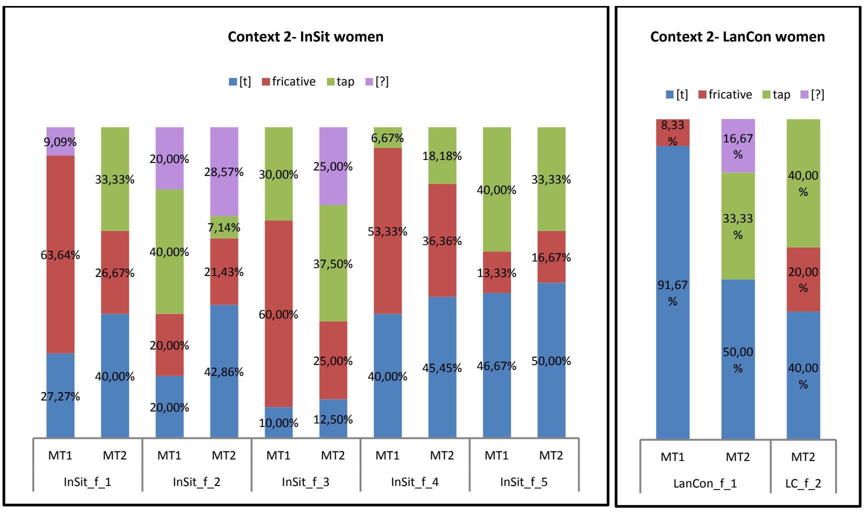


Figure 27: Allophonic realizations (%) of /t/ intervocalically and word internally V_V in highly frequent words (variable 11) for female speakers (*InSit* on the left and *LanCon* on the right).

[33] See for example Wolfram and Fasold (1974: 243), Trudgill (1983: 161), Cameron and Coates (1988: 13) and Fasold (1990: 92).

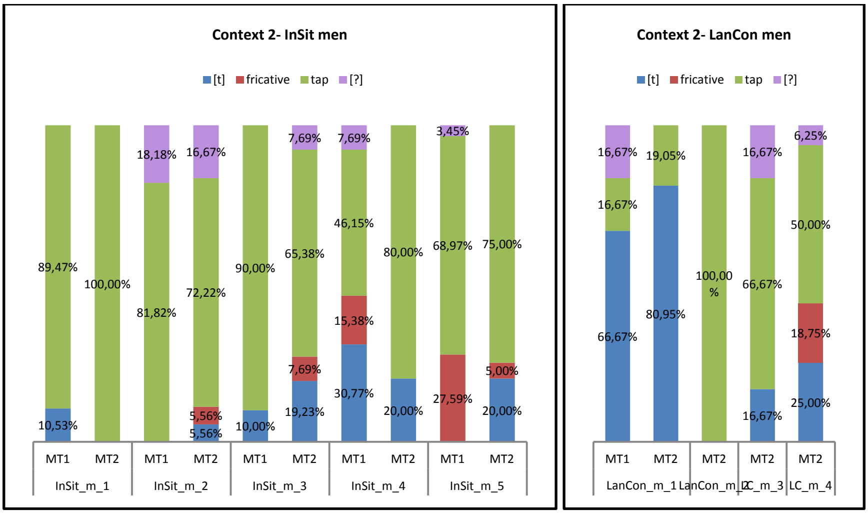


Figure 28: Allophonic realizations (%) of /t/ intervocalically and word internally V_V in highly frequent words (variable 11) for male speakers (*InSit* on the left and *LanCon* on the right).

Variable 11: /t/-tapping between vowels word internally in highly frequent words.

Similarly to the previous context, the gender difference as regards t-tapping is quite considerable, since there is a clear preference by men in both corpora (except *LanCon*_m_1, whose production of t-tapping is quite low) to produce this variant much more often than women.

Intra-speaker variation also seems to be very low in this context, since none of the 12 intra-speaker comparisons shows significant differences (as inferred by the Chi-square tests), so both men and women seem to remain quite stable in their use of this variant over time. The inter-speaker differences that arise also seem to be quite low when we compare women with women and men with men. Only 1 out of 35 (2.68%) comparisons in MT1 and MT2 between women independently of their subcorpora shows significant differences, so inter-speaker variation for women is very low. In the case of men, 8 out of 50 (16%) total comparisons in MT1 and MT2 regardless of their subcorpora show significant differences. When we compare men with women, this percentage is quite higher, since 45 out of 99 (45%) comparisons between men and women show significant differences. What we can infer from these figures is that t-tapping in highly frequent words such as *better* or *getting* is a process highly correlated with gender, since, similarly to the previous context, men produce t-tapping much more often than women. Regarding its forensic potential, this variable, despite showing low intra-speaker variation, also shows quite low inter-speaker variation, especially with comparisons between women, a fact that indicates that it might not be a good candidate to bear in mind in forensic contexts. Moreover, another negative aspect about this variable is its low frequency of occurrence, due to its being limited to a fixed set of lexical items, and the fact that it did not occur in some of the samples (e.g. *LanCon*_m_2 in MT1) made some comparisons impossible. Consequently, this variable might need to be reconsidered in future analyses for the calculation of the IIS. Table 35 shows a summary of the discriminatory potential of variable 11.

Table 35: Summary of discriminatory potential of variable 11.

Intra-speaker variation (% of comparisons that show statistically significant differences)	Both men and women: 0%	Very low for both men and women
Inter-speaker variation (% of comparisons that show statistically significant differences)	Women: 1 out of 35 (2.68%)	Low
	Men: 8 out of 50 (16%)	
Frequency of occurrence	Range = 0-29 Mean = 12.5	Low
Forensic implications: low discriminatory potential for both women and men due to its low inter-speaker variation and its low frequency of occurrence.		

Frication of /t/

The process of frication of /t/, which is mostly present in the oral production of *InSit* women, seems to show high inter-speaker variation from a qualitative inference, since they produce this variant in very different percentages. *InSit*_f_1 and *InSit*_f_3 produce fricated /t/s around 60% of the times in MT1, whereas it is only 20% for *InSit*_f_2, and even less, 13%, for *InSit*_f_5 also in MT1. However, the percentage of occurrence of this variant seems to have a tendency to be reduced considerably in MT2 for three of the female speakers (*InSit*_f_1, *InSit*_f_3 and *InSit*_f_4), whereas it stays quite stable in the other two *InSit* female speakers. At the same time, there seems to be a slight increase in the production of the most prestigious variant [t] for all the *InSit* female speakers. As regards *LanCon* women, *LanCon*_f_1 produces very few instances of this variant in MT1 and none in MT2, and *LanCon*_f_2 does not produce it very often either, but their pattern is quite similar to her *InSit* peer *InSit*_f_2, so this low production of frication of /t/s cannot be said to be a consequence of their situation of language contact without further research.

Although frication in this context has not been regarded as an IIS variable in the present dissertation, it might be interesting to look at it in future research for forensic purposes when comparing female speakers, since it seems to exhibit quite a high inter-speaker variation. However, its low frequency of occurrence might be a problem, so future studies might need to consider combining this context with other contexts that show a similar behaviour in order to formulate a more robust variable.

8.1.3. Context 3: Word finally before pause (variable 9)

Only two variants have been examined in this context, which coincide with the binary formulation of this variable for the calculation of the IIS. On the one hand there is [ʔ] and on the other, instances of both [t] and [t̪] were considered together. Unfortunately, contrary to what happened in the other contexts, at the time of the analysis, [t] and [t̪] were regarded together in the same variant for the purpose of the formulation of the IIS variable, so no data regarding the production of [t̪], and [t] are available separately.

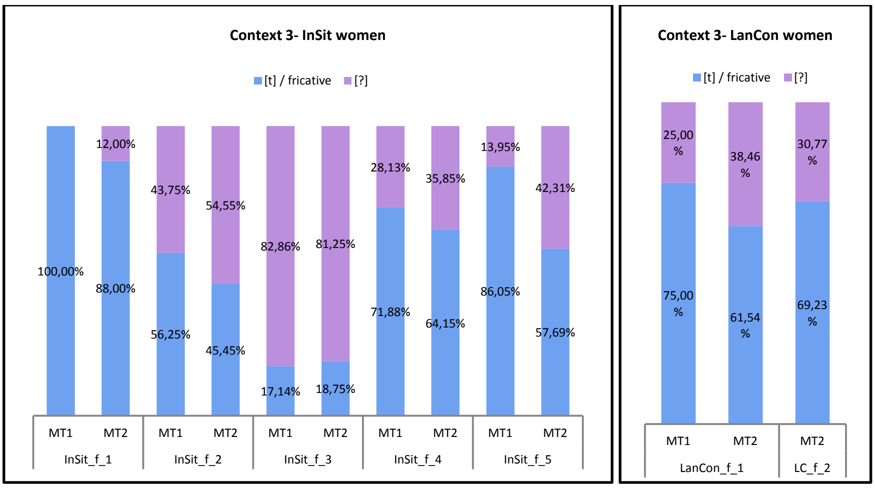


Figure 29: Allophonic realisations (%) of /t/ word finally before pause (variable 9) for female speakers (*InSit* on the left and *LanCon* on the right).

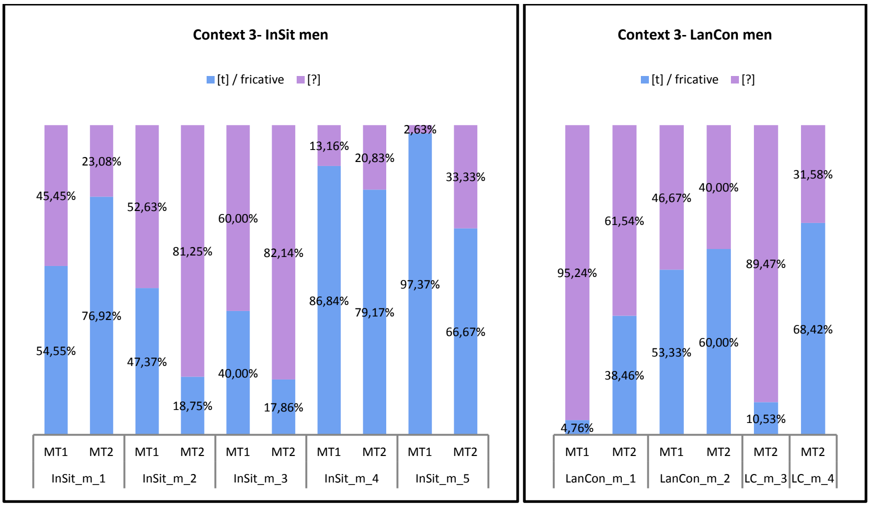


Figure 30: Allophonic realisations (%) of /t/ word finally before pause (variable 9) for male speakers (*InSit* on the left and *LanCon* on the right).

Figure 29 and Figure 30 show the percentage of realisations of both variants in the subjects under study. These figures show an increase from MT1 to MT2 in the production of glottal stops in this context for almost all the female subjects (both *InSit* and *LanCon*), except *InSit*_f_3, whose production of [ʔ] stays very stable over time, which seems to be parallel to the increase of [ʔ] in context 1. Despite this slight increase, only one woman out of the 6 for whom there are longitudinal data (*InSit*_f_5) exhibits a significant change over time. About men, all *InSit* speakers, except *InSit*_m_1, also show an increase in the production of this variant in MT2. Conversely, the two *LanCon* men for whom there are data in two measurement times both show an interesting decrease in the production of glottal stops, parallel to an increase in the production of the more prestigious variants ([t] and [t̪]). As a matter of fact, if we look at the behaviour of these speakers in contexts 1 and 2, they also show a general increase of the most prestigious variants, which could be interpreted as a consequence of being away from their community. In fact, politeness has been reported as a factor that can influence the migrant to adopt a more standard version of their L1, so that people in their L2 community understand them better when they speak their L1 (see factors influencing language contact phenomena in section 3.2.3). Findings regarding the increase of the most prestigious variants ([t] and [t̪]) experienced by *LanCon* men over time may be an example of a change prompted by politeness in a migratory context. As regards statistical significance, only *InSit*_m_5 and *LanCon*_m_1 exhibit significant intra-speaker differences across their lifespan in the use of glottal stops. Therefore, it could be said that intra-speaker variation appears to be quite low both for men and women in the production of this variant in context 3.

Inter-speaker variation seems to be quite high for all comparisons, irrespective of gender and subcorpora. 18 out of 36 possible comparisons between women show significant differences, which constitutes 50% of the comparisons. As for men, this percentage is a bit higher, since 34 out of 57 comparisons (60%) exhibit significant differences.

The forensic implications of these results, which are summarised in Table 36, are that variable 9, which considers t-glottalling in context 3, seems to be quite a suitable variable to take into consideration in forensic analyses, since it shows pretty low intra-speaker variation and high inter-speaker variation. However, despite the fact that most intra-speaker differences are not statistically significant, when dealing with non-contemporary samples, the possibility that speakers might show a slight increase in their production of glottal stops in this context over time should be born in mind. In addition to this, this variable does not appear as frequently as some of the previous variables we have seen, since the average of occurrence in the samples studied is 26 times. But if present in the samples, it may be an interesting variable to examine.

Table 36: Summary of discriminatory potential of variable 9.

Intra-speaker variation (% of comparisons that show statistically significant differences)	Women: 1 out of 6 (17%)	Low, especially for women
	Men: 2 out of 7 (29%)	
Inter-speaker variation (% of comparisons that show statistically significant differences)	Women: 18 out of 36 (50%)	High
	Men: 34 out of 57 (60%)	
Frequency of occurrence	Range = 5-53 Mean = 26	Medium high
Forensic implications: high discriminatory potential for comparisons both between women and between men. With non-contemporary samples bear in mind that both male and female speakers might show increase in the percentage of t-glottalling across their lifespans (lifespan change).		

8.1.4. Context 4: Intervocalically across word boundaries (variable 8)

Context 4 is related to variable 8, which regards the process of t-glottalling. The percentages of realisations of all the variants can be seen in Figure 31 and Figure 32. Intra-speaker variation seems to be pretty low both for female and male subjects. Only one out of 5 (20%) intra-speaker comparisons shows significant differences, that of *InSit*_f_4 who shows no production of [ʔ] in MT1 and 44% of production of this variant in MT2, a very considerable increase. The rest of speakers, both male and female, do not show significant intra-speaker variation.

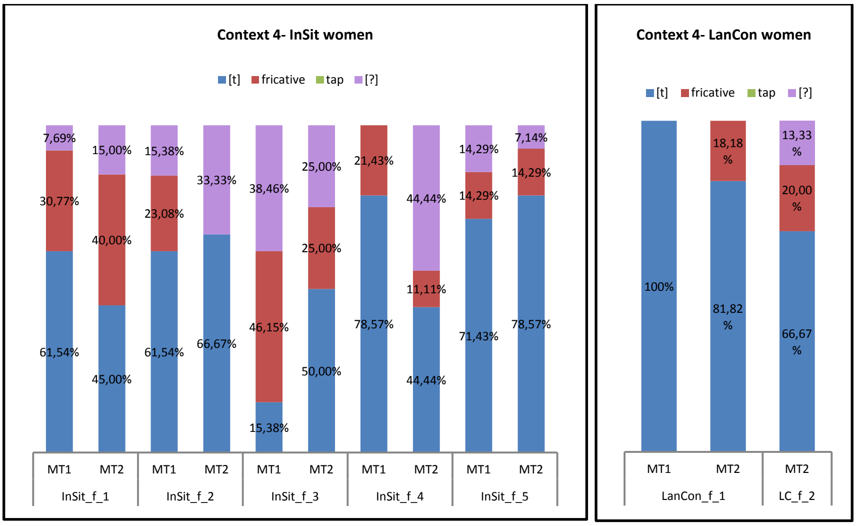


Figure 31: Allophonic realisations (%) of /t/ between vowels across word boundaries (V_#V) (variable 8) for female speakers (*InSit* on the left and *LanCon* on the right).

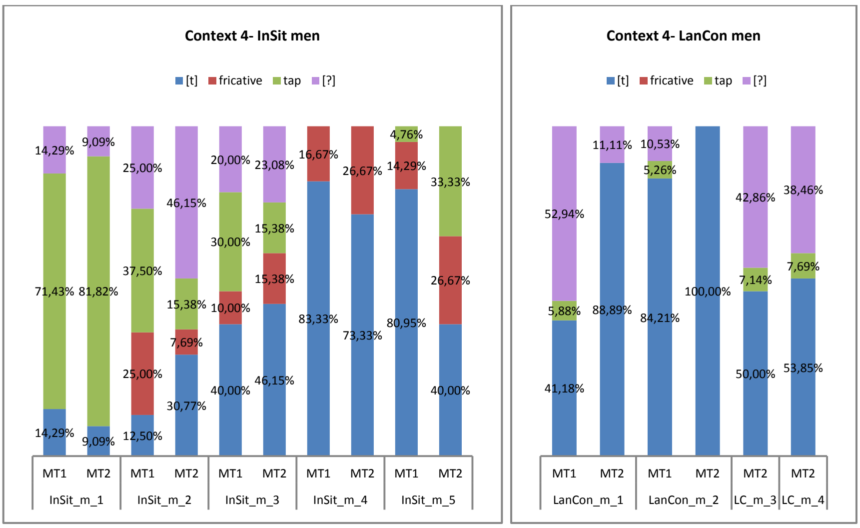


Figure 32: Allophonic realisations (%) of /t/ between vowels across word boundaries (V_#V) (variable 8) for male speakers (*InSit* on the left and *LanCon* on the right).

Similarly, inter-speaker variation is also quite low, since only 11 out of the total 53 possible comparisons between all men (which represent 21%) give statistically significant differences. As regards women, the comparisons which show significant differences are even less, only 4 out of 35 (11%) comparisons between all women. Moreover, as we have seen, both male and female subjects show a similar production of this variant, as confirmed by the Chi-square tests which show significant differences only in 14 out of 98 (14%) comparisons between men and women. Thus, t-glottalling in this context, besides showing low inter-speaker variation, does not seem to be correlated with gender either.

The forensic implications that we can infer from these results (summarised in Table 37) are that variable 8 does not seem to constitute a very robust variable to be considered in forensic contexts. Its capacity to discriminate between different speakers is quite low, since all speakers, independently of their gender and subcorpus seem to show a similar production of glottal stops. Moreover, its frequency of occurrence is considerably low, since the average in which this variable appears is 13 times in all the samples studied. Consequently, this variable might need to be reconsidered in future studies for forensic purposes.

Table 37: Summary of discriminatory potential of variable 8.

Intra-speaker variation (% of comparisons that show statistically significant differences)	Women: 1 out of 5 (20%)	Low, especially for men
	Men: 0 out of 7 (0%)	
Inter-speaker variation (% of comparisons that show statistically significant differences)	Women: 4 out of 35 (11%)	Low, especially for women
	Men: 11 out of 53 (21%)	
Frequency of occurrence	Range = 4-21 Mean = 13.7	Low
Forensic implications: Low discriminatory potential for both men and women and low frequency of occurrence.		

8.1.5. Context 5: Intervocalically word internally and across word boundaries (variables 12 and 13)

Context 5 is related to variable 12, which considers t-tapping, and variable 13, which is related to frication of /t/. Figure 33 and Figure 34 show the percentages of occurrence of all the variants for all speakers divided into subcorpora and gender.

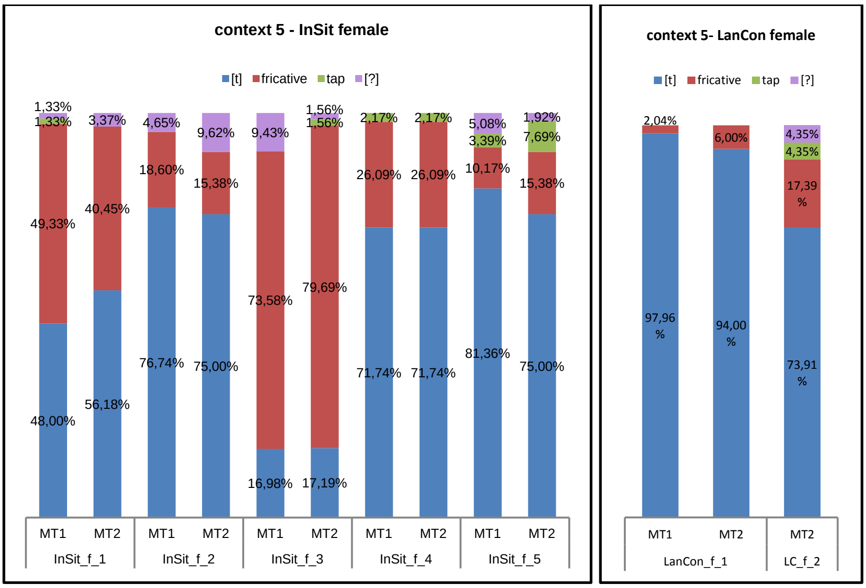


Figure 33: Allophonic realisations (%) of /t/ between vowels word internally and across word boundaries (V_(#)V) (variables 12 and 13) for female speakers (*InSit* on the left and *LanCon* on the right).

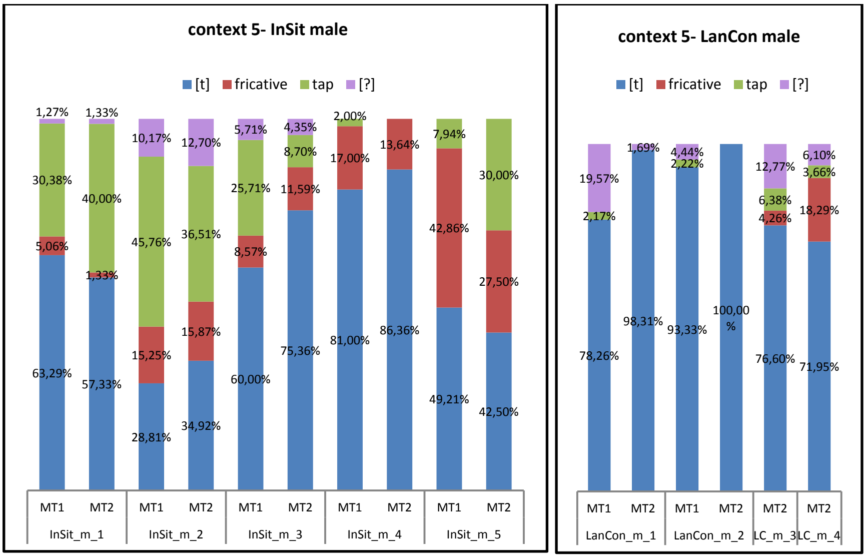


Figure 34: Allophonic realisations (%) of /t/ between vowels word internally and across word boundaries (V_(#)V) (variables 12 and 13) for male speakers (*InSit* on the left and *LanCon* on the right).

Variable 12: T-tapping intervocalically word internally and across word boundaries

Similarly to previous contexts, women hardly produce t-tapping in this context, so it is no surprise that none of the intra-speaker comparisons between women shows significant differences. If we look at men, 2 speakers out of 7 (*InSit*_m_3 reduces significantly the percentage of production of this variant, and *InSit*_m_5 increases it) show significant differences. Thus, intra-speaker variation is generally low.

Inter-speaker variation is very low for women, only 2 out of 27 comparisons between female speakers show significant differences, which, again, can be explained by the fact that they hardly produce taps in this context. On the contrary, inter-speaker variation in men is quite high, but only for *InSit* men. 12 out of 20 comparisons carried out between *InSit* men exhibit significant differences, which makes up 60%, whereas none of the 6 comparisons between *LanCon* men show significant differences. As a matter of fact, production of t-tapping by *LanCon* men is very scarce, so the difference between both subcorpora is considerable. If we compare men from both subcorpora, 19 out of 30 comparisons (63%) show significant differences, a figure that highlights the different behaviour that men exhibit across subcorpora. Results indicate that *LanCon* men seem to be affected by the fact that they have been away from their community, as they show much lower production of this variant than their *InSit* peers.

The forensic implications of variable 12, which are summarised in Table 38, are that this variable is suitable to be analysed in forensic contexts, but only when dealing with men, and only with men who have not been away from their community, since it generally shows low intra-speaker variation and high inter-speaker variation. The frequency of occurrence of this variable is quite high, which also makes it a good candidate to examine in forensic purposes.

Table 38: Summary of discriminatory potential of variable 12.

<table>
<tr><td rowspan="2">Intra-speaker variation
(% of comparisons that show statistically significant differences)</td><td>Women: 0 out of 4 (0%)</td><td rowspan="2">Low</td></tr>
<tr><td>Men: 2 out of 7 (29%)</td></tr>
<tr><td rowspan="4">Inter-speaker variation
(% of comparisons that show statistically significant differences)</td><td>Women: 2 out of 27 (7%)</td><td rowspan="4">Very low for women, high for InSit men and low for LanCon men</td></tr>
<tr><td>InSit men: 12 out of 20 (60%)</td></tr>
<tr><td>LanCon men: 0 out of 6 (0%)</td></tr>
<tr><td>InSit v. LanCon men: 19 out of 30 (63%)</td></tr>
<tr><td>Frequency of occurrence</td><td>Range = 35-100
Mean = 59</td><td>High</td></tr>
<tr><td colspan="3">Forensic implications: High discriminatory potential but only when looking at samples produced by men. In the case of men who have been away from their community, they might not show many instances of t-tapping in this context, and therefore, inter-speaker variation is expected to be low.</td></tr>
</table>

Variable 13: frication of /t/ intervocalically word internally and across word boundaries

Results indicate that women produce fricated /t/s much more often than men, which coincides with what has previously been commented on in contexts 1, 2 and 4. These observations confirm previous studies which report a higher use in the production of fricated /t/s by women (see section 6.2.2.5).

Intra-speaker variation seems to be very low both for women and men, since none of the 11 comparisons that have been carried out of the same speakers in MT1 and MT2 shows significant differences. On the other hand, inter-speaker variation seems to be generally high. Considering women, this process shows very high inter-speaker variation between women within the *InSit* subcorpus, since 12 out of 20 (60%) possible comparisons within this subcorpus show significant results. However, the only possible comparison within the *LanCon* subcorpus does not show such significant results. In fact, when we carry out comparisons between women from both subcorpora, inter-speaker variation is very high (9 out of 15, 60%), which may suggest that *LanCon* and *InSit* women differ significantly in the production of this variant, since the former produce this variant less often than the latter. Despite there are not enough data on LanCon female speakers to draw very robust conclusions, it seems that, similarly to what has been observed with *LanCon* men and t-tapping, *LanCon* women produce fricated /t/s at a lower proportion than their *InSit* peers as a result of their being away from their community, where this variant has increasingly been used by women in recent years.

Male speakers also show pretty high inter-speaker variation in fricated /t/s both within the *InSit* and the *LanCon* subcorpus, since 10 out of 20 (50%) comparisons within the *InSit* subcorpus, and 3 out of 5 (60%) comparisons within the *LanCon* subcorpus show significant differences. Besides, *LanCon* and *InSit* male speakers also seem to differ in their production of fricated /t/s. Figure 34 above shows that *LanCon* men produce this variant much less often than *InSit* men. Moreover, 16 out of 30 (53%) comparisons between men from both subcorpora exhibit significant differences, a figure that suggests that, similarly to female speakers, male speakers show a considerable difference in the production of this variant depending on whether they have been away from their community or not.

Results of context 5 and its influence in t-tapping and frication suggest that *LanCon* speakers may differ significantly with respect to their *InSit* peers in the production of these two variants in this context. Both processes have been described as recent innovations occurring in SSBE (see 6.2.2.4 for t-tapping and 6.2.2.5 for frication of /t/). Speakers who have been away from their community for more than twenty years as in the case of *LanCon* speakers have not been a direct part of these innovations and therefore they hardly present any instances of them. On the one hand, frication of /t/ is mostly used by women and in a lesser degree by men, but it is not much used by any of the *LanCon* speakers. On the other, t-tapping, which is a process that is mostly used by men, is not a common variant in the speech of *LanCon* men. These differences could be interpreted, not as a direct effect of the 2nd language on the 1st, but as an effect of being permanently away from their community of origin and not participating from the changes that are currently in progress.

From a forensic point of view, frication of /t/ in this context (variable 13) seems to have quite a high discriminatory potential for both male and female speakers. As shown in Table 39, it shows very low intra-speaker variation and pretty high inter-speaker variation, both for men and for women. Moreover, its frequency of occurrence is also quite high, which makes it even a better variable to be analysed in forensic contexts.

Table 39: Summary of discriminatory potential of variable 13.

<table>
<tr><td>Intra-speaker variation
(% of comparisons that show statistically significant differences)</td><td colspan="2">Both men and women: 0%</td><td>Very low</td></tr>
<tr><td rowspan="6">Inter-speaker variation
(% of comparisons that show statistically significant differences)</td><td>InSit women: 12 out of 20 (60%)</td><td rowspan="3">General comparisons between women: 23 out of 36 (64%)</td><td rowspan="6">Generally high</td></tr>
<tr><td>LanCon women: 0 out of 1 (0%)</td></tr>
<tr><td>InSit women v. LanCon women: 9 out of 15 (60%)</td></tr>
<tr><td>InSit men: 10 out of 20 (50%)</td><td rowspan="3">General comparisons between men: 29 out of 55 (53%)</td></tr>
<tr><td>LanCon men: 3 out of 5 (60%)</td></tr>
<tr><td>InSit men v. LanCon men: 16 out of 30 (53%)</td></tr>
<tr><td>Frequency of occurrence</td><td colspan="2">Range = 35-100
Mean = 59</td><td>High</td></tr>
<tr><td colspan="4">Forensic implications: High discriminatory potential both for male and female speakers. Low intra-speaker variation and generally high inter-speaker variation. Frequency of occurrence is also quite high.</td></tr>
</table>

8.1.6. *Correlation analyses of allophonic realisations of /t/*

Another interesting analysis that can shed some light on the behaviour of the variables related to allophonic processes of /t/ is to look at whether there is any relationship among these processes. On the one hand, the relationship between the variables concerned with the same process will be examined, in order to see, for example, whether a high production of glottal stops in variable 7 implies a high production of the same variant in variable 9 and so on. On the other hand, it is also interesting to test whether the different processes (glottalling, tapping and frication) are somehow related to each other in any particular way.

Since t-tapping is relevant mostly in analyses regarding male speakers, only the production of this process by male speakers will be considered. Figure 35 shows the individual percentages of production of this variant for the three relevant variables (IIS variables 10, 11 and 12). As can be seen, the production of taps in the three variables seems to be somehow related to each other. For example, speakers *InSit*_m_1 and *InSit*_m_2 show the highest percentages of occurrence of t-tapping in all the three variables, both in MT1 and MT2, whereas speakers such as *LanCon*_m_1, *InSit*_m_4 (especially in MT1) and *LanCon*_m_3 show much lower production of taps in the three variables.

In order to test whether there actually exists a linear relationship between these three variables for male speakers, a correlation analysis was performed using Pearson's correlation coefficient, and Spearman's whenever the Kolmogorov-Smirnov and Shapiro-Wilk normality tests showed that any of the variables did not have a normal distribution. Table 40 shows the matrix of correlation coefficients for variables related to allophonic processes of /t/ for male speakers (highlighted in green) and Figure 36 shows the respective scatterplot matrix. As can be seen, correlation coefficient results among the three variables dealing with t-tapping (shown in green) produced by male speakers are statistically significant. The relationship between variables 10 and 11 is significant at the level 0.05 [ρ=.552; *p*=.033], the relationship between variables 10 and 12 is significant at the level 0.01 [ρ=.894; *p*=<.001] and the relationship between variables 11 and 12 is significant at the level 0.001 [r=.764; *p*=.004]. From these results we can infer that a high production of t-tapping by male speakers in one variable may imply a high production of this variant in the other variables that consider the process of t-tapping.

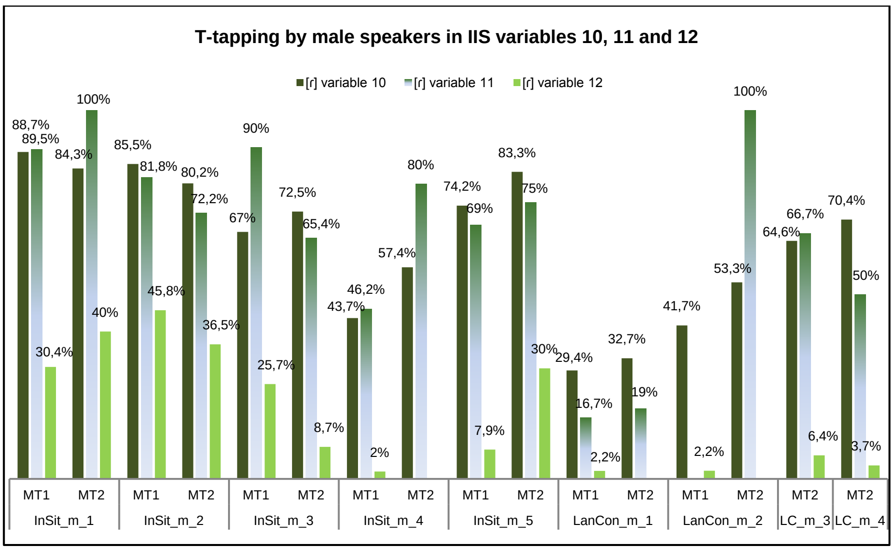


Figure 35: T-tapping (%) by male speakers in IIS variables 10 (V_#V in frequent words and lexical items with syntactic linkage, variable 11 (V_V in highly frequent words) and variable 12 (V_(#)V).

Table 40: Matrix of Correlation Coefficients for variables related to allophonic processes of /t/ for male speakers: glottalling (variables 7, 8 and 9), tapping (variables 10, 11 and 12) and frication (variable 13).

		Glott_7	Glott_ 8	Glott_9	Tap_10	Tap_11	Tap_12
Glott_ 8	Correlation Coefficient	Pearson 0.608					
	Sig. (bilateral)	0.47					
	N	11					
Glott_9	Correlation Coefficient	Pearson 0.700	Pearson 0.652				
	Sig. (bilateral)	0.004	0.30				
	N	15	11				
Tap_10	Correlation Coefficient	Spearman -0.606	Spearman -0.169	Spearman -0.209			
	Sig. (bilateral)	0.017	0.62	0.438			
	N	15	11	16			
Tap_11	Correlation Coefficient	Pearson -0.319	Pearson -0.410	Pearson -0.318	Spearman 0.552		
	Sig. (bilateral)	0.267	0.239	0.247	0.033		
	N	14	10	15	15		
Tap_12	Correlation Coefficient	Pearson -0.439	Pearson -0.325	Pearson 0.038	Spearman 0.894	Pearson 0.764	
	Sig. (bilateral)	0.133	0.659	0.902	0.000	0.004	
	N	13	10	13	13	12	
Fric_13	Correlation Coefficient	Pearson -0.485	Pearson 0.336	Pearson -0.503	Spearman 0.496	Pearson 0.062	Pearson 0.000
	Sig. (bilateral)	0.67	0.312	0.47	0.051	0.826	0.999
	N	15	11	16	16	15	13

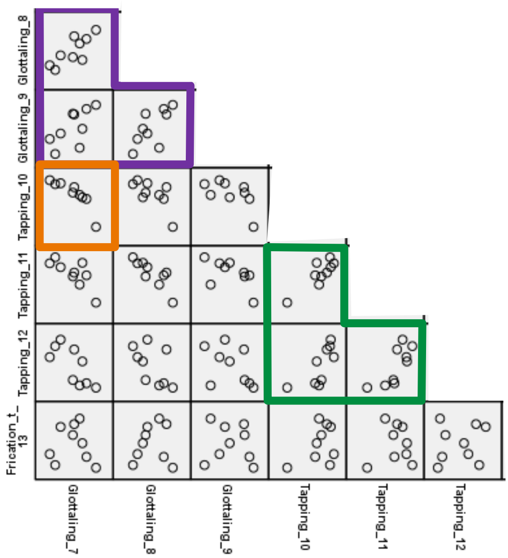


Figure 36: Scatterplot matrix for variables related to allophonic processes of /t/ for male speakers: glottalling (variables 7. 8 and 9), tapping (variables 10, 11 and 12) and frication (variable 13).

Let us now observe the variables dealing with t-glottalling (variables 7, 8 and 9). Figure 37 shows the percentages of production of glottal stops in the three variables by male speakers. The relationship between these three variables by male speakers also seems to be quite close, though perhaps not so straightforward as in the case of t-tapping. Speaker *LanCon*_m_1 in MT1, for example, who shows the highest percentage of t-glottalling in variable 9 (95%), also shows the highest percentage of t-glottalling in variable 7 (36%) and one of the highest percentages of glottalling in variable 8 (36%). Other speakers, such as *LanCon*_m_3 and *InSit*_m_2 in MT2 also show high percentages of production of glottal stops in the three variables. On the other hand, speakers such as *InSit*_m_4 and *InSit*_m_5, both in MT1 and MT2 show a very low production of glottal stops in the three variables. As seen in Table 40 and Figure 36 above, correlation coefficients show that the three variables that deal with t-glottalling (highlighted in purple) also show a positive linear correlation between each other for male speakers. This relationship is stronger in the case of variables 7 and 9, since the correlation is significant at the level 0.01 [r =.764; *p*=.004], whereas it is not as strong between variables 8 and 9 [r=.652; *p*=.030] and even less between 7 and 8 [r=.608; *p*=.047], practically non-significant at the level 0.05.

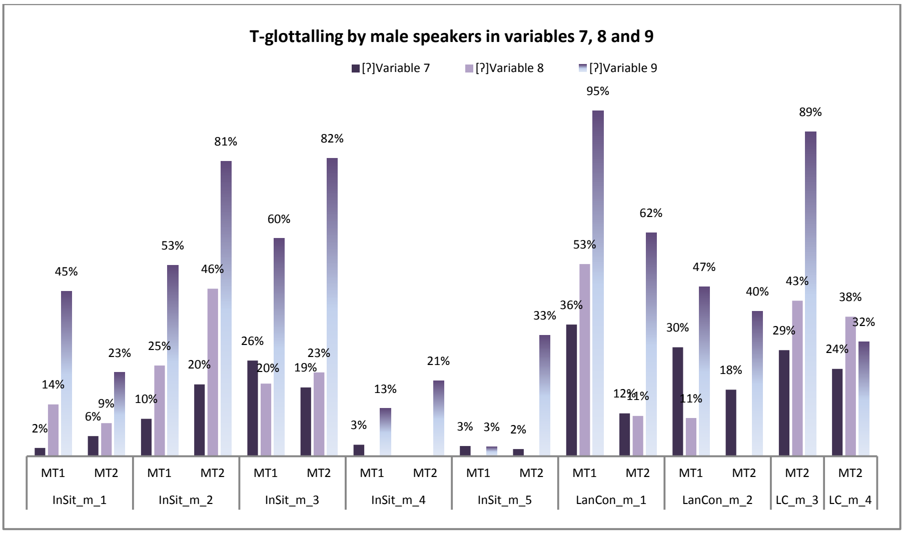


Figure 37: T-glottalling (%) by male speakers in IIS variables 7 (V_#V in lexical items with syntactic linkage), 8 (V_#V) and 9 (before pause)

Table 40 above, and the respective scatterplot (Figure 36) shows that there seems to be a negative relationship between variables 7 and 10 (highlighted in orange) since Spearman's correlation results are [ρ= -.606; *p*=.017]. These two variables consider glottalling and tapping in the same environment (intervocalically in highly frequent words and lexical items with syntactic linkage – context 1). In 8.1.1 we saw that, in general, male speakers for whom there were data in MT1 and MT2 showed an increase in the production of taps in MT2, which seemed to be parallel to a decrease in glottal stops. If we look back at Figure 26 in that section, we can observe that, for example, speakers *InSit*_m_1, *InSit*_m_2, and *InSit*_m_5 produce a very low proportion of glottal stops and a very high percentage of taps, whereas speakers *InSit*_m_3, *LanCon*_m_1 and *LanCon*_m_2 produce a low percentage of taps and a high percentage of glottal stops. The only exception to this linear relationship is *InSit*_m_4, who produces both variants in a low proportion, whereas he makes use of the prestige variant [t] much more often. Therefore, there seems to be a negative correlation between t-tapping and t-glottalling in this context for male speakers, which implies that the more taps a speaker produces, the less glottal stops he might produce and vice versa.

In the case of female speakers, there does not seem to be a linear relationship between the three variables related to t-glottalling as was observed for male speakers, as can be seen in Figure 38, which shows their percentage of production of these three variables. Speaker *InSit*_f_4, for example, shows the highest proportion of glottalisation in variable 8, whereas her glottalisation in variable 9 is pretty low in comparison with other speakers. On the other hand, speaker *InSit*_f_3 both in MT1 and MT2 shows a very high percentage of glottalisation in variable 9 and a pretty low percentage of production of glottal stops in the other two variables. On the other hand, speaker *LanCon*_f_1 produces 25% (MT1) and 38% (MT2) of glottal stops in variable 9 and does not produce any instance of glottal stop in variable 8. Correlation analyses confirm that the relationship between the three variables is non-linear, as can be seen in the matrix of correlation coefficients in Table 41 (shown in purple) and the respective scatterplots in Figure 39. From these results we can infer that the fact that a female speaker produces glottal stops at a high percentage in one variable does not imply that the same behaviour will be found in another variable that considers t-glottalling.

Finally, the variable related to frication of /t/ does not seem to be related in any particular way to the rest of variables concerned with allophonic processes of /t/ in female speakers as inferred from the correlation coefficients highlighted in red (see Table 41 and Figure 39, highlighted in red)

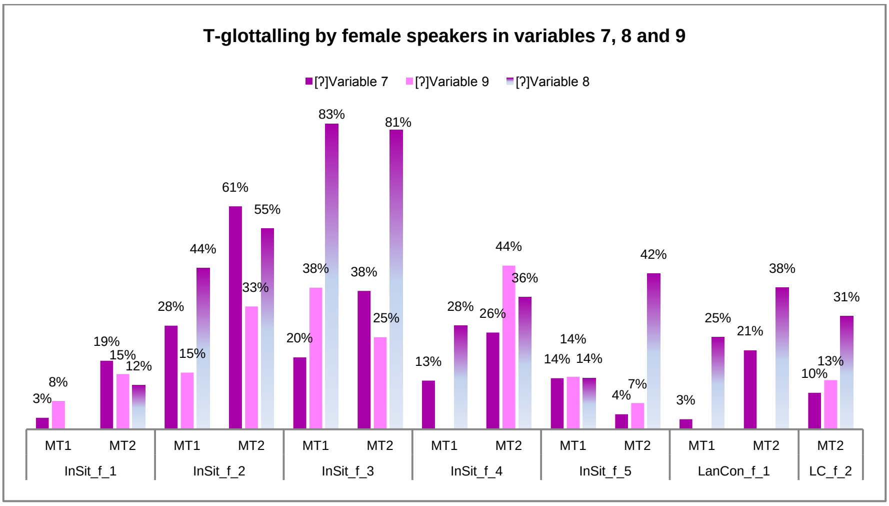


Figure 38: T-glottalling (%) by female speakers in IIS variables 7 (V_#V in highly frequent words and lexical items with syntactic linkage), 8 (V_#V) and 9 (before pause).

All these findings regarding the relationship between the variables related to allophonic variants of /t/ have implications for future research on the IIS and for the analysis of these variables for forensic purposes. In the case of men, the three variables related to t-tapping and the three variables related to t-glottalling seem to have a relationship among each other, a fact that needs to be considered in future formulations of these variables. In other words, it might be suitable to consider all the variables jointly (i.e. all the variables involving t-glottalling on the one hand, and all the variables related to t-tapping on the other) in order to obtain a single, but more robust variable. In the case of women, however, this does not seem to be the case, and future analyses involving female speakers might need to keep these variables independently.

Table 41: Matrix of Correlation Coefficients for variables related to allophonic processes of /t/ for female speakers: glottalling (variables 7. 8 and 9), tapping (variables 10, 11 and 12) and frication (variable 13).

		Glott_7	Glott_ 8	Glott_9	Tap_10	Tap_11	Tap_12
Glott_ 8	Correlation Coefficient	Pearson 0.598					
	Sig. (bilateral)	0.068					
	N	10					
Glott_9	Correlation Coefficient	Pearson 0.481	Pearson 0.491				
	Sig. (bilateral)	0.113	0.180				
	N	12	9				
Tap_1 0	Correlation Coefficient	Pearson -0.099	Pearson 0.279	Pearson 0.458			
	Sig. (bilateral)	0.747	0.436	0.135			
	N	13	10	12			
Tap_11	Correlation Coefficient	Pearson -0.409	Pearson -0.681	Pearson -0.021	Pearson 0.332		
	Sig. (bilateral)	0.212	0.43	0.950	0.319		
	N	11	9	11	11		
Tap_12	Correlation Coefficient	Spearman -0.333	Spearman -0.541	Spearman -0.158	Spearman -0.189	Spearman 0.295	
	Sig. (bilateral)	0.266	0.106	0.624	0.536	0.378	
	N	13	10	12	13	11	
Fric_13	Correlation Coefficient	Spearman 0.218	Spearman 0.354	Spearman 0.344	Spearman 0.212	Spearman -0.168	Spearman 0.007
	Sig. (bilateral)	0.474	0.316	0.274	0.487	0.622	0.981
	N	13	10	12	13		13

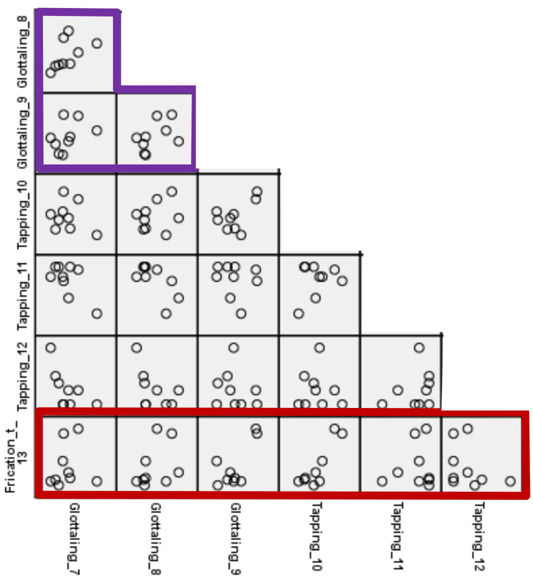


Figure 39: Scatterplot matrix for variables related to allophonic processes of /t/ for female speakers: glottalling (variables 7. 8 and 9), tapping (variables 10, 11 and 12) and frication (variable 13).

8.2. Alternation of [ə] and [ɪ] (variables 1 and 2)

Variables 1 and 2 formulated for the calculation of the IIS deal with a process of vowel alternation by which both vowels [ɪ] and [ə] can occur in certain unstressed positions. Variable 1 deals with this process in weakened beginnings *be*-, *de*-, *pre*-, *re*- and *e*- in words such as *enough, begin, depend* and variable 2 regards this process in terminations such as *-ible, -ily* and *-ity* in words like *possible, happily and delicate*.

Variable 1: vowel alternation in "weakened" *be–*, *de–*, *pre–*, *re– and e–* (*enough, begin, depend)*

As stated in section 6.2.1, the literature describes some variation between [ɪ] and [ə] in unstressed beginnings such as *be*-, *de*-, *pre*-, *re*- and *e*- in words like *begin*, *enough* or *depend*. The preferred variant, though, is reported to be [ɪ], so this is the variant that would be expected to be most recurrent. Figure 40 and Figure 41 show the percentages of realisation of each variant of variable 1 by all the speakers in this study separated into groups according to subcorpora and gender. As can be seen, there is a general tendency for men to use both variants in similar proportions, whereas women show a near-categorical use of [ɪ] independently of the subcorpus.

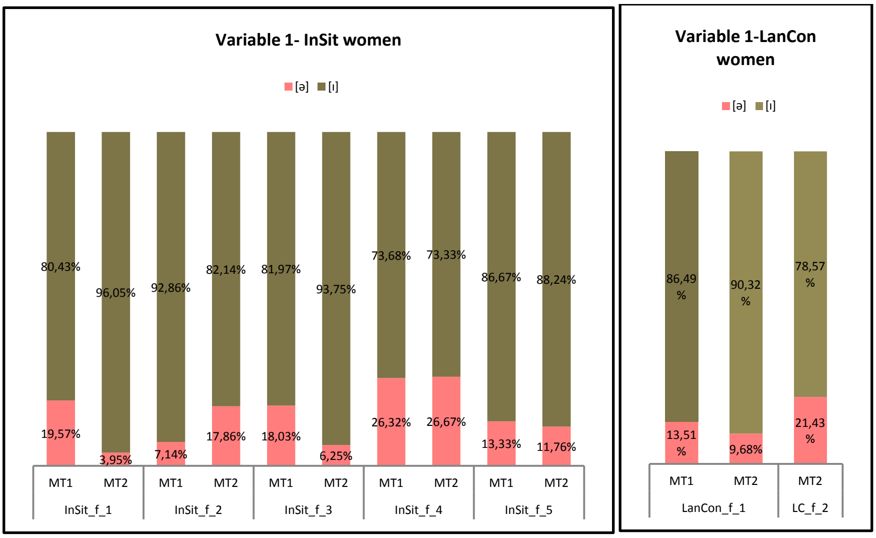


Figure 40: Vowel alternation (%) [ə] [ɪ] in weakened beginnings (variable 1) for female speakers (*InSit* on the left and *LanCon* on the right).

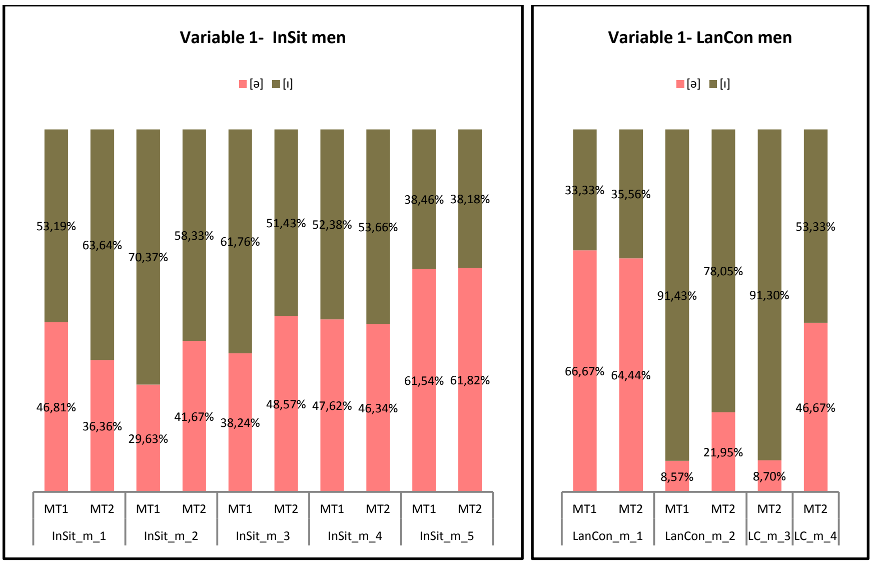


Figure 41: Vowel alternation (%) [ə] [ɪ] in weakened beginnings (variable 1) for male speakers (*InSit* on the left and *LanCon* on the right).

Intra-speaker variation seems to be very low since the majority of speakers produce the variants in similar proportions in MT1 and MT2. Only one women out of 6 (17%), *InSit*_f_1, shows statistically significant lifespan differences, since she reduces her production of [ɪ] from 20% to 4%, which is a considerable increase. None of the men show significant intra-speaker differences.

Inter-speaker differences are higher for men than for women, since, as we have seen, all women mostly produce the most conservative variant [ɪ]. In fact, only 3 out of all the 36 possible comparisons between all the women in the corpus both in MT1 and MT2 (which make up 8%) exhibit significant differences. Conversely, inter-speaker differences between men seem to depend on the subcorpora they belong to. Variation between *InSit* men seem to be low, since only 3 out of 20 possible comparisons show significant differences, which represent 15%. On the other hand, *LanCon* male speakers show much higher inter-speaker variation, since 5 out of 7 comparisons (71%) show significant differences. In fact, we only need to look at the data to see that variation is much higher between *LanCon* men than between *InSit* men, since *LanCon*_m_1 and *LanCon*_m_4 show a high production of the variant [ə], whereas *LanCon*_m_2 and *LanCon*_m_3 show a very low use of [ə]. If we compare speakers from both subcorpora, 18 out of 30 comparisons (60%) reveal significant differences, a figure that indicates that variation across subcorpora is substantial. The inter-speaker differences between *LanCon* men could be due to their particular situation, but they could also be due to idiolectal differences. If we consider all men together, 26 out of 57 possible comparisons (46%) show significant differences, which can be considered pretty high inter-speaker variation.

Thus, from a forensic point of view, this variable may be an interesting variable to analyse but only when dealing with men, since they show much more inter-speaker variation than female speakers. Moreover, as seen in Table 42, the frequency of occurrence of this variable is quite high, as it appears 42 times on average in all the samples considered.

Table 42: Summary of discriminatory potential of variable 1.

<table>
<tr><td rowspan="2">Intra-speaker variation
(% of comparisons that show statistically significant differences)</td><td colspan="2">Women: 1 out of 6 (17%)</td><td rowspan="2">Low, especially for men</td></tr>
<tr><td colspan="2">Men: 0 out of 7 (0%)</td></tr>
<tr><td rowspan="4">Inter-speaker variation
(% of comparisons that show statistically significant differences)</td><td colspan="2">Women: 3 out of 36 (8%)</td><td rowspan="4">Low for women, and pretty high for men</td></tr>
<tr><td>InSit men: 3 out of 20 (15%)</td><td rowspan="3">General comparisons between men: 26 out of 57 (46%)</td></tr>
<tr><td>LanCon men: 5 out of 7 (71%)</td></tr>
<tr><td>InSit men v. LanCon men:
18 out of 30 (60%)</td></tr>
<tr><td>Frequency of occurrence</td><td colspan="2">Range = 14-76
Mean = 42</td><td>Quite high</td></tr>
<tr><td colspan="4">Forensic implications: quite high discriminatory potential for men, not for women.</td></tr>
</table>

Variable 2: Vowel reduction in terminations: *-ible, -ily, -ity, -less, -let/-ret, -ate, -ace* (*possible, happily, delicate*)

Speakers of SSBE have been described by the literature as producing [ə] more often in this context than [ɪ] (see section 6.2.1). This also seems to be the general tendency of the subjects in this study, as seen in Figure 42 and Figure 43, which show a summary of percentages of occurrence of each variant for men and women in the two different subcorpora. Although [ə] is the general preference for both men and women, women seem to produce a greater deal of [ɪ] variants than male speakers, thus showing more variation in the production of both variants, whereas men show a near-categorical tendency towards the use of [ə].

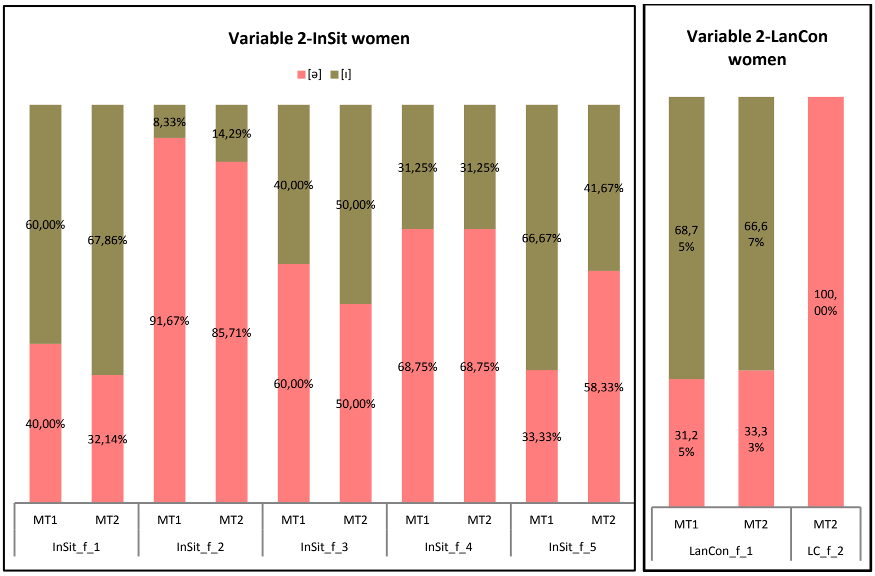


Figure 42: Vowel alternation (%) [ə]-[ɪ] in terminations (variable 2) for female speakers (*InSit* on the left and *LanCon* on the right).

Figure 43: Vowel alternation (%) [ə]- [ɪ] in terminations (variable 2) for male speakers (*InSit* on the left and *LanCon* on the right).

Intra-speaker variation is very low for both men and women, since none of the comparisons carried out of the same speaker in MT1 and MT2 show significant differences. On the other hand, inter-speaker variation in this variable shows a contrary pattern to what was observed in variable 1. In this case, none of the comparisons carried out between men shows significant differences, which is expected since they all mainly produce the variant [ə]. As for women, inter-speaker variation is not very high either, since out of 36 comparisons between all women, only 6 show significant differences, which makes up 17%. Moreover, the frequency of occurrence of this variant, as seen in Table 43, is quite low. Therefore, from a forensic perspective, this may not be a very suitable variable to bear in mind on its own in a forensic comparison. And if looked at, it might be more useful when comparing women, but not men, since inter-speaker variation appears to be slightly higher between women.

Table 43: Summary of discriminatory potential of variable 2.

Intra-speaker variation (% of comparisons that show statistically significant differences)	Both men and women: 0%	Very low for both men and women
Inter-speaker variation (% of comparisons that show statistically significant differences)	Women: 6 out of 36 (17%)	Very low for both men and women
	Men: 0 out of 56 (0%)	
Frequency of occurrence	Range = 3-29 Mean = 13	Low
Forensic implications: low discriminatory potential for both women and men and low frequency of occurrence.		

Figure 44 and Figure 45 compare the individual production of the variant [ə] in variable 1 and 2 respectively in order to see whether there exists any relationship between these two variables. As regards male speakers (Figure 44), we can observe that a higher production of the variant [ə] in one variable does not necessarily imply a high production of the same variant in the other variable. Speakers *LanCon*_m_2 (both in MT1 and MT2) and *LanCon*_m_3 both exhibit a very high production of [ə] in variable 2 and the lowest productions of the same variant in variable 1. On the contrary, speakers *InSit*_m_5 and *LanCon*_m_1 show a pretty high production of [ə] in both variables, since they produce [ə] around 65% of the times in variable 1 and around 80-90% in variable 2. Other speakers such as *InSit*_m_1 (especially in MT1), *InSit*_m_2 and *LanCon*_m_4 produce [ə] around 40% of the times in variable 1 and around 90% in variable 2.

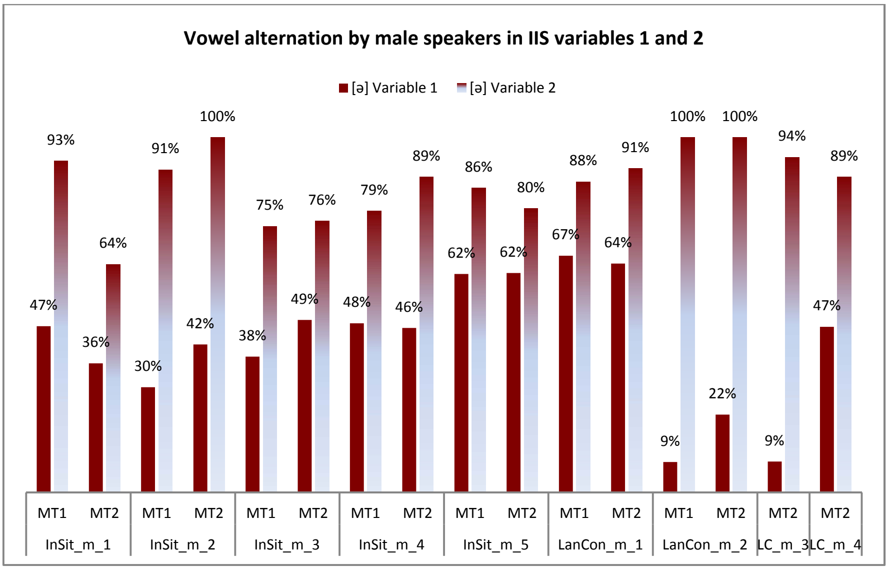


Figure 44: Vowel alternation by male speakers in IIS variables 1 and 2 (only % of [ə] is shown).

If we look at the production of these variables by female speakers (Figure 45) we can observe that, similarly to the case of male speakers, there does not seem to be any linear relationship between the production of [ə] in the two variables. The percentage of [ə] in variable 1 is generally low by all female speakers, as it was previously shown, since its range of production is between 4% and 27%. On the contrary, the production of [ə] varies quite a lot depending on the speaker, since some of them, e.g. *InSit*_f_1 (both in MT1 and MT2) or *LanCon*_f_1 show a low production of [ə] in variable 2 (around 30-40%), whereas other speakers such as *InSit*_f_2 or *LanCon*_f_2 show a very high production of this variant (around 90%). Moreover, these last speakers who show a high occurrence of [ə] in variable 2 do not precisely show the highest percentages of occurrence of this variant in variable 1.

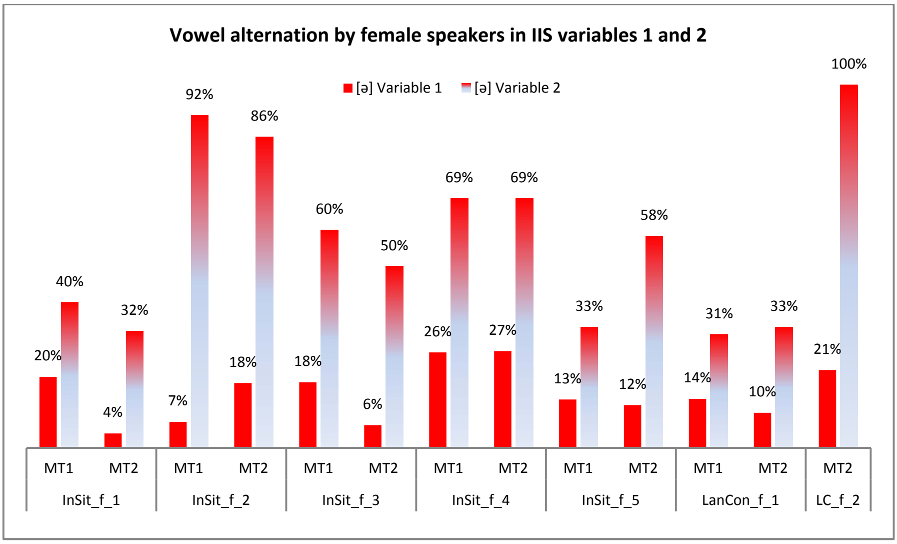


Figure 45: Vowel alternation by female speakers in IIS variables 1 and 2 (only % of [ə] is shown).

In conclusion, the descriptive analysis of the relationship between variable 1 and 2 shows that there does not seem to be any relationship between them. Correlation analyses using Pearson's coefficient confirm that there is no statistically significant linear relationship between these two variables either for male [r= -.333; *p*=.208] or female subjects [r=.372; *p*=.210]. Thus, from these results, which can be seen in Table 44 and Table 45, it is possible to confirm that these two variables should be analysed independently, i.e. the two contexts need to be considered separately, since the production of one variant in one variable does not imply a preference towards the same variant in the other variable.

Table 44: Matrix of Correlation Coefficients for variables related to vowel alternation between [ə]-[ɪ] (variables 1 and 2) for male speakers.

		Vowel_alt_2
Vowel_alt_1	Pearson's Correlation	-.333
	Sig. (bilateral)	.208
	N	16

Table 45: Matrix of Correlation Coefficients for variables related to vowel alternation between [ə]-[ɪ] (variables 1 and 2) for female speakers.

		Vowel_alt_2
Vowel_alt_1	Pearson's Correlation	.372
	Sig. (bilateral)	.210
	N	13

8.3. Yod coalescence (variables 3 and 4)

Variable 3: Yod coalescence across word-boundaries (e.g. *this year, as you*)

Figure 46 and Figure 47 show the percentages of realisation of this variable for the subjects analysed separated into groups depending on subcorpora and gender. The first impression when looking at these figures is that neither subcorpora nor gender appear to have an influence on the patterns that the speakers present, since all the speakers show different patterns of realisations of the two variants.

If we look at intra-speaker variation, no comparison between samples in MT1 and MT2 for women shows significant differences, whereas 2 out of 7 (29%) comparisons between men (*InSit*_m_2 and *InSit*_m_3) do.

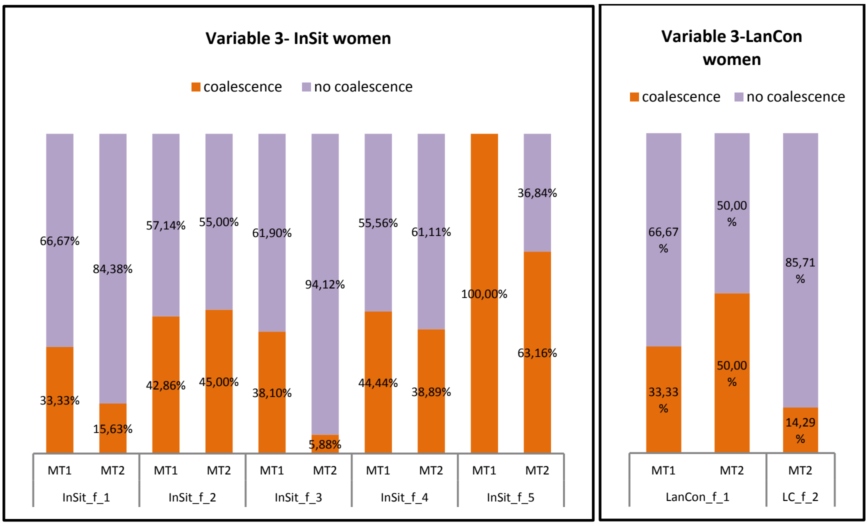


Figure 46: Yod coalescence across word boundaries (%) (variable 3) for female speakers (*InSit* on the left and *LanCon* on the right).

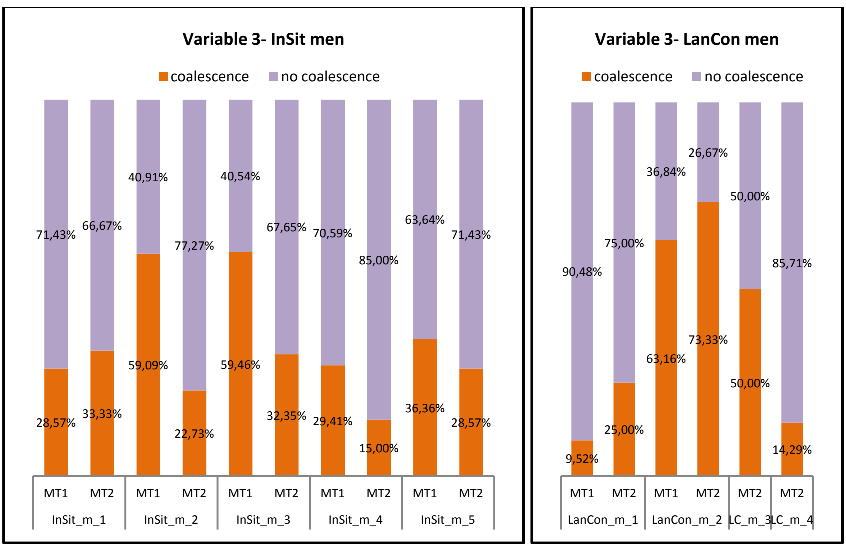


Figure 47: Yod coalescence across word boundaries (%) (variable 3) for male speakers (*InSit* on the left and *LanCon* on the right).

On the other hand, inter-speaker differences are a bit higher, though not very high. When comparing samples between female speakers, 10 out of 36 (28%) differ significantly, whereas 11 out of 57 (19%) comparisons between male speakers show significant differences. This last observation means that in fact, in the case of men, intra-speaker variation is higher than inter-speaker variation, which would make this variable unsuitable to analyse on its own for forensic purposes. In the case of women, intra-speaker variation is very low and differences between different women are a bit higher, since it is able to discriminate that the samples belong to different speakers 29% of the times. However, the frequency of occurrence of the variable is quite low, since it only appears 17 times on average in the samples studied. Consequently, this variable seems not to have a high potential to discriminate between speakers, especially between male speakers. So in future research this variable might need to be reconsidered. Table 46 summarises the little discriminatory potential of this variable.

Table 46: Summary of discriminatory potential of variable 3.

Intra-speaker variation (% of comparisons that show statistically significant differences)	Women: 0 out of 6 (0%)	Quite low, especially for women
	Men: 2 out of 7 (29%)	
Inter-speaker variation (% of comparisons that show statistically significant differences)	Women: 10 out of 36 (28%)	Low, especially for men
	Men: 11 out of 57 (19%)	
Frequency of occurrence	Range = 6-37 Mean = 17	Low
Forensic implications: Quite low discriminatory potential, especially for men. Frequency of occurrence is also low. Not a very robust variable.		

Variable 4: Yod-coalescence word-internally (e.g. *student, duty*)

As can be seen in Figure 48 and Figure 49, the different patterns in the production of the variants in comparison with the previous variable are evident. Speakers generally vary between both forms when yod coalescence can occur across word boundaries (variable 3), whereas they show a general tendency towards coalesced forms word internally (variable 4), which supports the separation of these two contexts into different variables, since if the two contexts had been taken into consideration jointly, these different patterns would have been neutralised. Besides, men and women generally differ in their production of variable 4, as most women have a near-categorical tendency towards the coalesced forms, whereas some of the men exhibit some variation between both forms. In fact, this is obvious in the fact that none of the comparisons carried out between different women (out of 30) show significant difference, so inter-speaker variation for women is obviously low. As regards men, it is a bit higher, since 16 out of the 57 possible comparisons between all the men exhibit significant differences, which make up 28%.

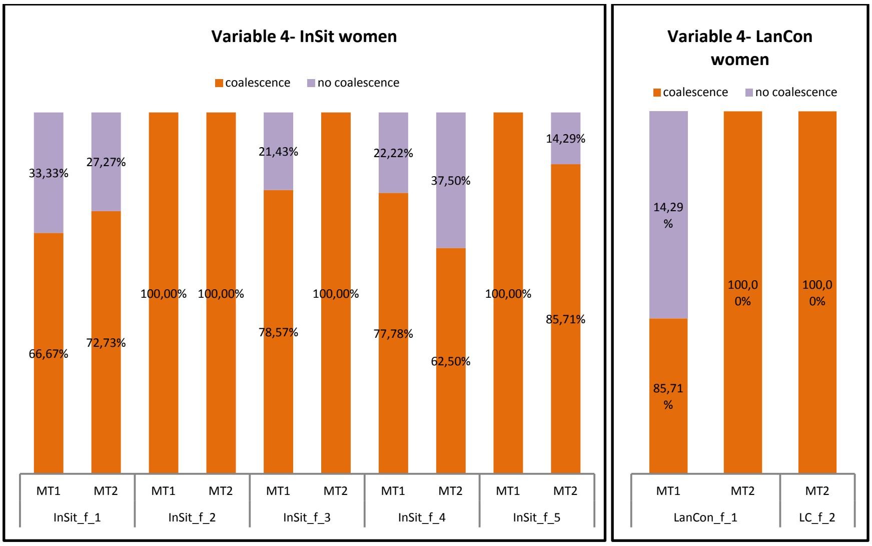


Figure 48: Yod coalescence word-internally (%) (variable 4) for female speakers (*InSit* on the left and *LanCon* on the right).

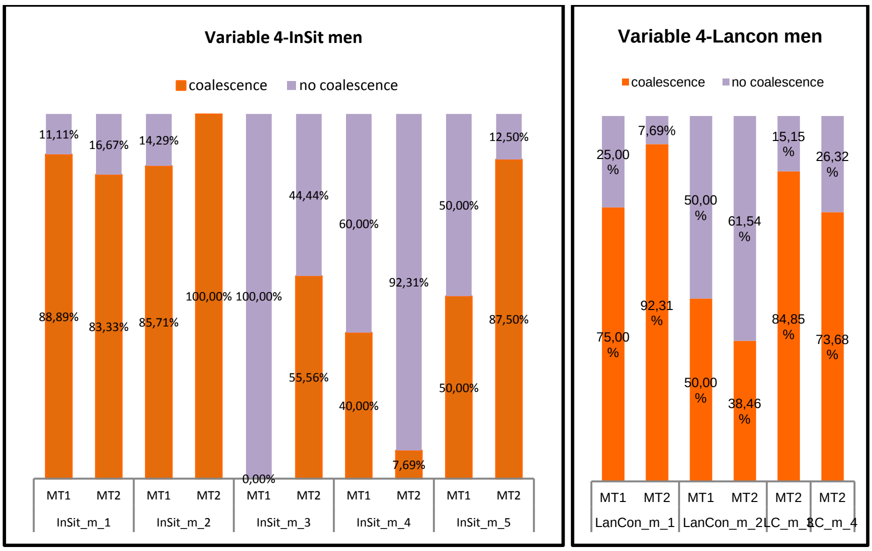


Figure 49: Yod coalescence word-internally (%) (variable 4) for male speakers (*InSit* on the left and *LanCon* on the right).

The forensic implications of these results, which are summarised in Table 47, are that this variable is not a suitable variable when comparing women, since the inter-speaker variation they show is extremely low due to their near-categorical production of coalesced forms. It may be interesting to analyse when comparing men, though the frequency of occurrence of this variable is in fact very low. From all these observations we can infer that the discriminatory potential of variable 4 is generally quite low.

Table 47: Summary of discriminatory potential of variable 4.

Intra-speaker variation (% of comparisons that show statistically significant differences)	Women: 0 out of 7 (0%)	Low, especially for women
	Men: 1 out of 7 (14%)	
Inter-speaker variation (% of comparisons that show statistically significant differences)	Women: 0 out of 30 (0%)	Low, especially for women
	Men: 16 out of 57 (28%)	
Frequency of occurrence	Range = 2-33 Mean = 11	Low
Forensic implications: Quite low discriminatory potential, especially for women. Frequency of occurrence is low. Not a very robust variable.		

Figure 50 and Figure 51 show the individual realisations of the coalesced variants in variable 3 and variable 4 for male and female speakers respectively, which will allow us to infer some conclusions regarding the relationship between the two variables related to yod coalescence. The percentage of production of coalesced forms for some speakers such as *InSit*_m_1 and *LanCon*_m_1 is pretty low for variable 3 and pretty high for variable 4, whereas other speakers such as *InSit*_m_3 (in MT2) and *InSit*_m_4 (both in MT1 and MT2) show pretty similar proportions of yod coalescence in the two variables. On the other hand, speaker *LanCon*_m_2 actually shows more yod-coalescence in variable 3 than in variable 4. A similar pattern can also be observed in Figure 51 for female speakers.

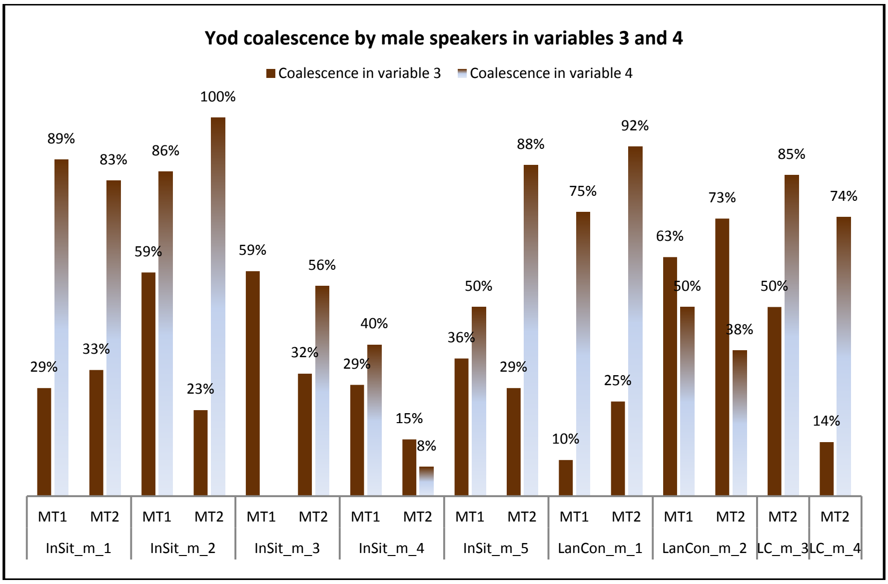


Figure 50: Yod coalescence by male speakers in IIS variables 3 and 4 (only % of coalesced forms is shown).

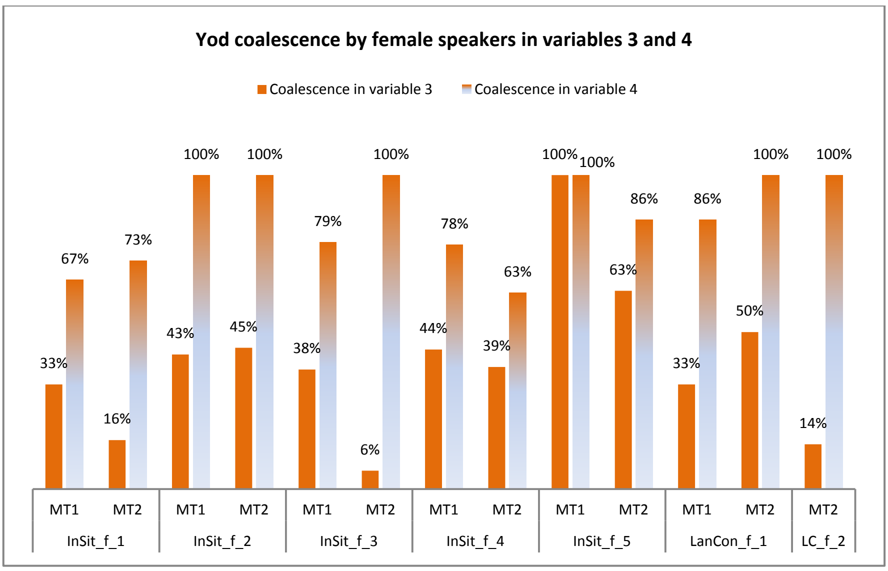


Figure 51: Yod coalescence by female speakers in IIS variables 3 and 4 (only % of coalesced forms is shown).

Correlation analyses using Spearman's coefficient confirm that the relationship between these two variables is not a linear one either for men or for women, as it is shown in Table 48 and Table 49. Consequently, preference (or not) towards coalescence in one variable by one speaker does not imply the same preference towards the same variant in the other variable.

Table 48: Matrix of Correlation Coefficients for variables related to yod coalescence (variables 3 and 4) for male speakers

			Yod_coal_4
Spearman's rho	Yod_coal_3	Correlation coefficient	-.318
		Sig. (bilateral)	.231
		N	16

Table 49: Matrix of Correlation Coefficients for variables related to yod coalescence (variables 3 and 4) for female speakers.

			Yod_coal_4
Spearman's rho	Yod_coal_3	Correlation coefficient	.196
		Sig. (bilateral)	.522
		N	13

8.4. Insertion of [t] between [n] and [s] (variable 5)

Figure 52 and Figure 53 show the percentages of occurrence of the two variants considered by variable 5. Intra-speaker variation is quite low for all speakers, since none of the 6 comparisons between women and only 2 out of 7 comparisons between men exhibit significant differences as inferred by the Chi-square tests (*InSit*_m_5 and *LanCon*_m_1, who show a considerable decrease and increase of insertion of [t] respectively). On the other hand, inter-speaker variation seems to depend greatly on the subcorpora. Within the *InSit* subcorpus, 7 out of 20 comparisons between women (35%) and 10 out of 20 (50%) comparisons between men show significant differences. Within the *LanCon* subcorpus, the only possible comparison between women does not show significant differences, and only 1 out of 7 comparisons between men (14%) does so. Moreover, if we compare men and women within the same subcorpus, within the *InSit* subcorpus we obtain 11 out of 50 (20%) comparisons with significant differences whereas none of the 10 comparisons between men and women in the *LanCon* subcorpora is significant. If we look at general inter-speaker differences, comparing speakers from both corpora, we get 9 out of 36 comparisons between women (25%) and 19 out of 57 (33%) comparisons with significant results. Therefore, general inter-speaker differences are a bit high, especially if we look at differences between *InSit* men and women. On the contrary, *LanCon* speakers seem to have acquired a very similar pattern after being away from the community, which makes differences between them very low, a phenomenon that has also been observed in other processes such as t-tapping and frication of /t/.

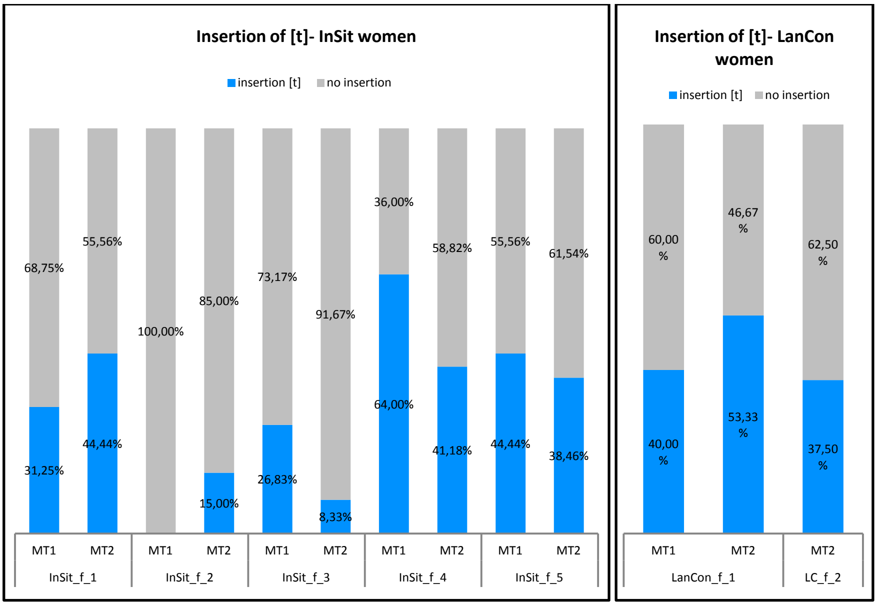


Figure 52: Insertion of [t] between [n] and [s] (%) (variable 5) for female speakers (*InSit* on the left and *LanCon* on the right).

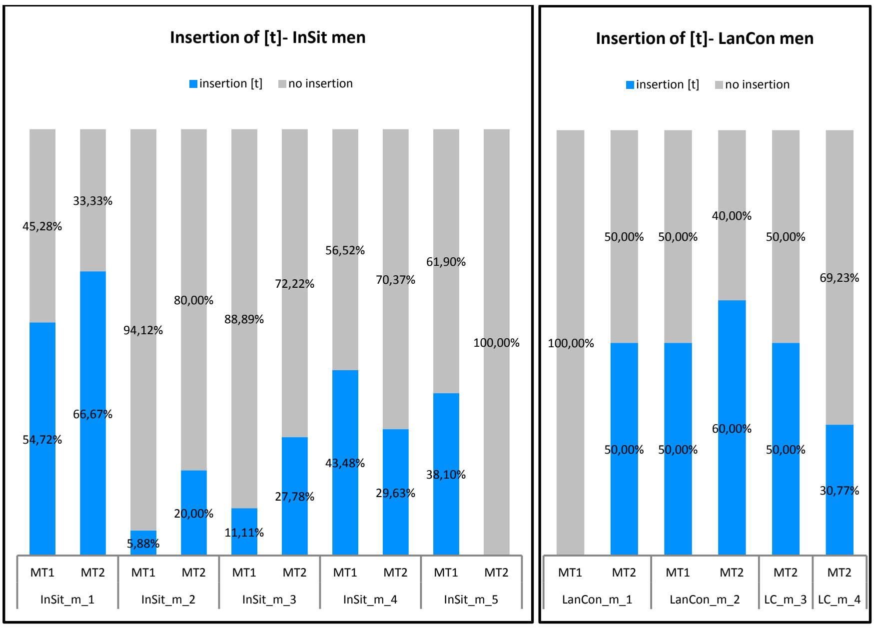


Figure 53: Insertion of [t] between [n] and [s] (%) (variable 5) for male speakers (*InSit* on the left and *LanCon* on the right).

The forensic implications of such results, which are summarised in Table 50, would be that this variable would only be an interesting parameter to look at in a context where speakers have not been away from their community of origin. However, the fact the frequency of occurrence of this variable is quite low, and the inter-speaker differences are not very high, should not make the investigator expect to find very definitive results.

Table 50: Summary of discriminatory potential of variable 5.

<table>
<tr><td rowspan="2">Intra-speaker variation
(% of comparisons that show statistically significant differences)</td><td colspan="2">Women: 0 out of 6 (0%)</td><td rowspan="2">Low, especially for women</td></tr>
<tr><td colspan="2">Men: 2 out of 7 (29%)</td></tr>
<tr><td rowspan="4">Inter-speaker variation
(% of comparisons that show statistically significant differences)</td><td>InSit women: 7 out of 20 (35%)</td><td rowspan="2">General comparisons between women: 9 out of 36 (25%)</td><td rowspan="4">A bit high, especially for InSit men and women</td></tr>
<tr><td>LanCon women: 0 out of 1 (0%)</td></tr>
<tr><td>InSit men: 10 out of 20 (50%)</td><td rowspan="2">General comparisons between men: 19 out of 57 (33%)</td></tr>
<tr><td>LanCon men: 1 out of 7 (14%)</td></tr>
<tr><td>Frequency of occurrence</td><td colspan="2">Range = 6-53
Mean = 20</td><td>Low</td></tr>
<tr><td colspan="4">Forensic implications: discriminatory potential only for InSit speakers. Frequency of occurrence is quite low. Interesting to look at but results may not be definitive.</td></tr>
</table>

8.5. Linking /r/ (variable 6)

Figure 54 and Figure 55 show the percentages of production of linking /r/ in the speakers analysed. The most striking feature about the distribution of the two variants is that both male and female speakers show a near-categorical production of linking /r/, which will obviously affect inter-speaker variation, since they all show a very similar production of this variable. By looking at intra-speaker differences by means of the chi-square test, it can be inferred that only one of the men (out of 7), *InSit*_m_2, shows significant intra-speaker differences. As regards differences between speakers, men seem to show more variation, since 17 out of 47 total comparisons between all men (36%) reveal significant differences, whereas only 7 out of 36 comparisons between all women (19%) do so. However, as summarised in Table 51, inter-speaker variation does not seem to be very high for any of the speakers precisely to the near-categorical behaviour they all show, so the discriminatory potential of this variable in isolation is low.

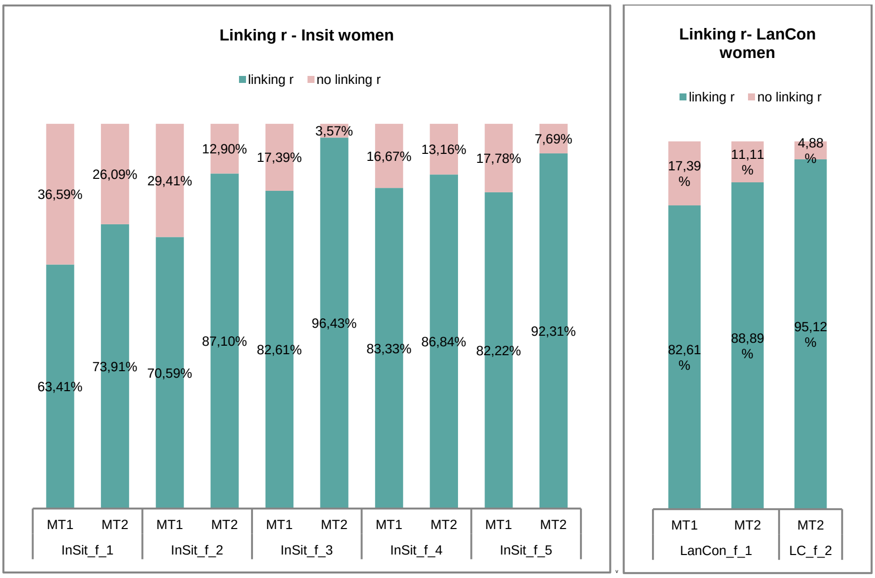


Figure 54: Linking /r/ (%) (variable 6) for female speakers (*InSit* on the left and *LanCon* on the right).

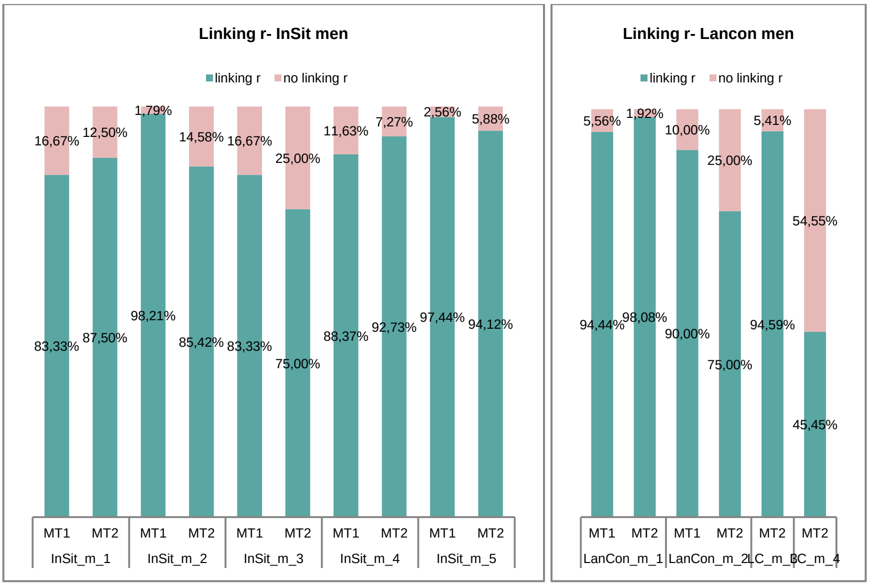


Figure 55: Linking /r/ (%) (variable 6) for male speakers (*InSit* on the left and *LanCon* on the right).

Table 51: Summary of discriminatory potential of variable 6.

Intra-speaker variation (% of comparisons that show statistically significant differences)	Women: 0 out of (0%) Men: 1 out of 7 (14%)	Low, especially for women
Inter-speaker variation (% of comparisons that show statistically significant differences)	Women: 7 out of 36 (19%) Men: 17 out of 47 (36%)	Low, especially for women
Frequency of occurrence	Range = 20-69 Mean = 43	Quite high
Forensic implications: Quite low discriminatory potential, near-categorical behaviour.		

8.6. Frication of /k/ between vowels V_(#)V (variable14)

As seen in Figure 56 and Figure 57, all the speakers, both male and female, produce both variants in quite different proportions. An interesting observation about subcorpora is that *LanCon* women seem to produce fricated /k/s less often than their *InSit* peers, a parallel situation to what we saw earlier with frication of /t/.

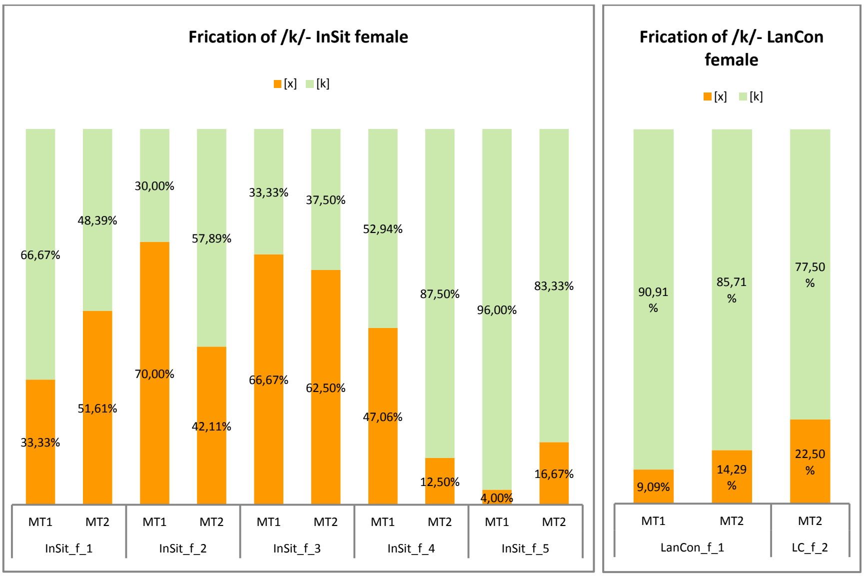


Figure 56: Frication of /k/ between vowels V_(#)V (%) (variable 14) for female speakers (*InSit* on the left and *LanCon* on the right).

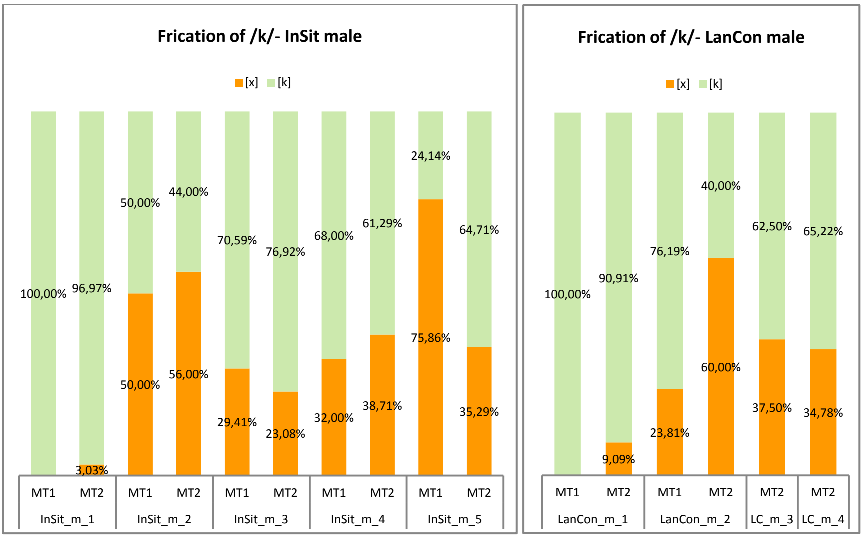


Figure 57: Frication of /k/ between vowels V_(#)V (%) (variable 14) for male speakers (*InSit* on the left and *LanCon* on the right).

Intra-speaker variation seems to be quite low, since only 1 woman out of 6 (*InSit*_f_4) shows significant differences in her production in MT1 and MT2. As for men, 2 out of 7 (*InSit*_m_5 and *LanCon*_m_1) exhibit significant differences. On the contrary, when carrying out comparisons between all the women, 16 out of 36 show significant differences, which constitutes a 44%, whereas when comparing men, 19 out of 56 (34%) comparisons exhibit significant differences. Thus, we can say that inter-speaker variation is quite high, especially when comparing women.

The forensic implications of these results are summarised in Table 52. We can infer that variable 14 seems to be quite a good variable to analyse for forensic purposes, since inter-speaker variation is quite high, especially in the case of comparisons between women. Moreover, intra-speaker variation is quite low, again, especially for women. However, its frequency of occurrence is also quite low, since it only appears 22 times on average in the samples studied. In any case, if the variable appears in the samples to be compared, it may be a very interesting parameter to look at.

Table 52: Summary of discriminatory potential of variable 14.

Intra-speaker variation (% of comparisons that show statistically significant differences)	Women: 1 out of 6 (17%)	Quite low, especially for women
	Men: 2 out of 7 (29%)	
Inter-speaker variation (% of comparisons that show statistically significant differences)	Women: 16 out of 36 (44%)	Quite high, especially for women
	Men: 19 out of 56 (34%)	
Frequency of occurrence	Range = 10-40 Mean = 22	Quite Low
Forensic implications: Quite high discriminatory potential, especially for women.		

Figure 58 and Figure 59 show the percentages of production of frication of /k/ compared to the percentage of production of frication of /t/ by male and female speakers respectively, in order to infer conclusions on whether there exists a linear relationship between the frication of the two plosives. Correlation analyses show that these two variables actually exhibit a significant linear relationship at the level 0.01 both for men and for women. As shown in Table 53 and Table 54, Pearson's coefficient between these variables for men is [r =.640; *p* =.008], and Spearman's coefficient (variable 13 shows a non-normal distribution in women) is [ρ=.702; *p*=.007] for female speakers. This linear relationship can be more clearly seen in the respective scatterplots shown in Figure 60 and Figure 61. From a qualitative perspective, if we look at Figure 58 and Figure 59 we can also observe this relationship from a more qualitative perspective, especially when looking at the distributions in female speakers. Speaker *InSit*_f_2, for example, shows around 65% of fricated /k/s both in MT1 and MT2 and between 74-80% of fricated /t/s, while speaker *InSit*_f_1 shows between 35-50% of frication of both plosives. Other speakers such as *InSit*_f_5 and *LanCon*_f_1 show low percentages of frication of both plosives. As regards men, Speaker *InSit*_m_2 and *InSit*_m_5, for example, show the lowest percentage of frication of both plosives, whereas *InSit*_m_3, *InSit*_m_4 and *LanCon*_m_4 show lower percentages of both processes. Male speakers, however, show more exceptional cases than female speakers, since both *LanCon*_m_2 (in MT2) and *LanCon*_m_3, for example, show a high percentage of fricated /k/s and a low proportion (or no production) of fricated /t/s.

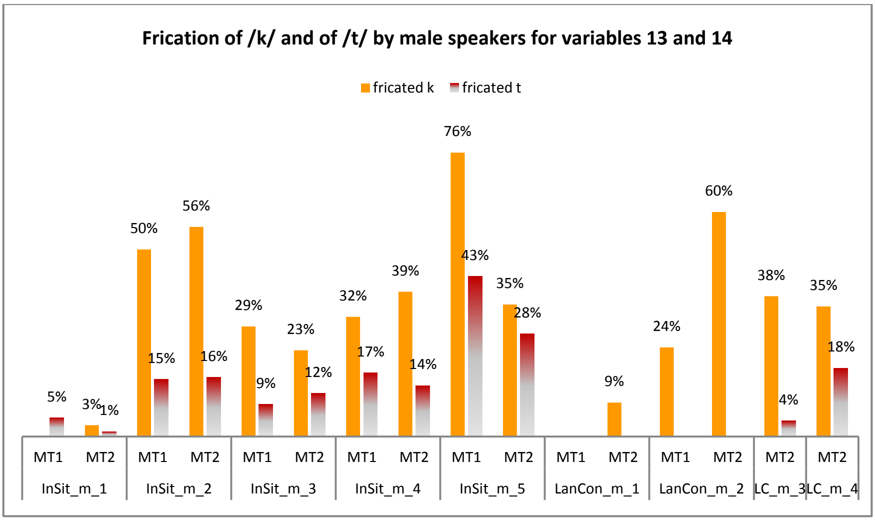


Figure 58: Frication of /k/ and /t/ by male speakers in IIS variables 13 and 14 (only % of fricated forms is shown).

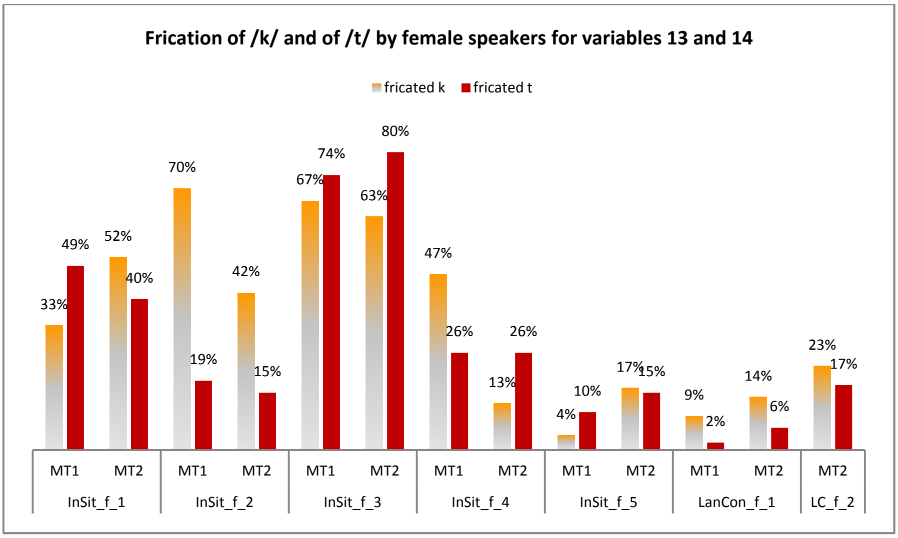


Figure 59: Frication of /k/ and /t/ by female speakers in IIS variables 13 and 14 (only % of fricated forms is shown).

This positive linear relationship, which is significant both for male and female speakers, implies that if a speaker shows a high degree of frication of one of the plosives, s/he will likely show a high production of fricated realisations of the other plosive. Therefore, what we are dealing with here is not two independent processes, but a single process of frication of plosives that affects both the alveolar and the velar voiceless plosives, and this fact should be considered in future analyses regarding these two variables.

Table 53: Matrix of Correlation Coefficients for variables related to frication of plosives (variables 13 and 14) for male speakers.

Frication_k	Pearson's Correlation	,640**
	Sig. (bilateral)	,008
	N	16

**. Correlation is significant at the level 0.01 (bilateral).

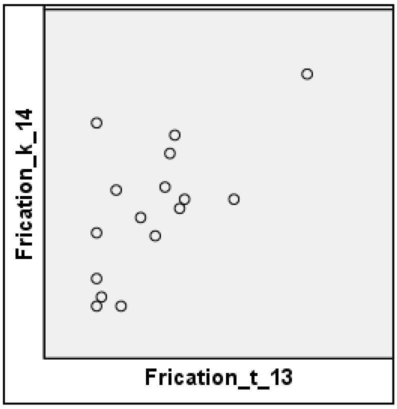


Figure 60: Scatterplot for variables related to frication of plosives (variables 13 and 14) for male speakers.

Table 54: Matrix of Correlation Coefficients for variables related to frication of plosives (variables 13 and 14) for female speakers.

			Frication_k
Spearman's Rho	Frication_t	Correlation coefficient	,702**
		Sig. (bilateral)	,007
		N	13

**. Correlation is significant at the level 0.01 (bilateral).

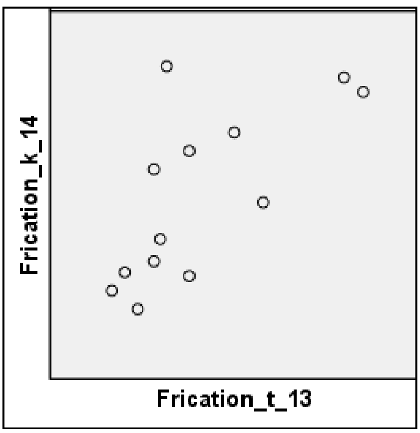


Figure 61: Scatterplot for variables related to frication of plosives (variables 13 and 14) for female speakers.

Chapter 8 has shown the results of the discriminatory potential of each variable. The analysis has been carried out from a qualitative perspective, through a description of the percentage of realisation of each variant, and also from a quantitative perspective, by means of the chi-square test, which shed light on the statistical significance shown by each comparison between two samples (both intra- and inter-individual). Many of the variables studied have turned out to have a pretty high discriminatory potential, namely variables 1, 5, 7, 9, 10, 13 and 14 due to their low intra-speaker variation, their high inter-speaker variation and their high frequency of occurrence. The rest of the variables, variables 2, 3, 4, 6, 8 and 11 have shown a low discriminatory potential since, despite showing low intra-individual variation, they also showed low inter-speaker variation and a low frequency of occurrence in the samples analysed. The next chapter, Chapter 9, will discuss in detail all the results found for the IIS protocol as well as those shown after the analysis of each variable in isolation.

Chapter 9
Discussion

The results for the analyses carried out with the IIS protocol were presented in Chapter 7. The IIS was presented as an index that combines the variation present in the fourteen variables under study, with the aim to determine whether two samples show variation that could be attributed to one person –intra-speaker variation– or that should be attributed to two different individuals –inter-speaker variation. By means of the method for the calculation of the IIS proposed in the present PhD dissertation, which is based on the Chi-square test and the Phi coefficient, experiments were carried out comparing samples from the same speaker in two measurement times and samples from different speakers. In addition to this, outside the IIS protocol, the present PhD dissertation also wanted to provide an individual analysis of each of the variables, in order to determine their discriminatory potential when regarded separately and outside the IIS protocol. This individual analysis will also provide the IIS protocol with more information regarding the variables it includes, so that future experiments with this tool centre specifically on the variables that show higher discriminatory value. This individual analysis was carried out in Chapter 8. The present chapter builds on the previous two chapters and discusses the results obtained in relation to the research questions that were presented in section 5.2. The discussion is organised around each individual question in the order they were posed.

Linguists must always approach linguistic evidence taking into account that language is always variable. In this sense, Nolan (1997) introduces the concept of ‘speaker space’ and explains that each speaker occupies a space, which implies that each speaker can be distinguished from each other, and at the same time, each space comprises certain linguistic dimensions along which speakers vary. In order to apply this concept to forensic linguistics, it is important to demonstrate that variation between speakers –the space that each speaker occupies- is higher than the variation found within the same speaker –the different dimensions within the space along which the same speaker varies. In this sense, the first research question was formulated as follows:

> ***RQ1: Is inter-speaker variation higher than intra-speaker variation?***

The hypothesis that was posed around this question (hypothesis 1) stated that inter-speaker variation would be higher than intra-speaker variation, and thus, IIS values when comparing samples from the same speaker would be closer to the 1 end of the IIS continuum, which indicates high similarity, whereas the IIS values when comparing different speakers would be closer to the 0 end of the IIS continuum. Results obtained in Chapter 7 show that comparisons between samples from the same speakers in two measurement times obtained IIS values between 0.77 and 0.90. On the other hand, the majority of the comparisons between samples from different speakers obtained results from 0.55 to 0.77, showing less similarity. Thus, it is possible to conclude that inter-speaker variation is most generally higher than intra-speaker variation, and that the IIS is able to determine whether two samples show intra- or inter-speaker variation most of the times. Yet, there is some overlap between both types of variation, in the sense that some inter-speaker comparisons obtain IIS values within the range of intra-speaker variation. Taking 0.77 (the intra-speaker comparison that shows most variation) as the boundary that should indicate whether two samples show intra-speaker variation (≥0.77) or inter-speaker variation (<0.77), considering the corpus under analysis, we observed that 40 comparisons between samples from different speakers out of 198 showed IIS values higher than 0.77. In other words, despite the fact that the IIS is able to distinguish between samples from different speakers 80% of the times that it was applied (158 out of a total of 198 inter-speaker comparisons), it was not able to do so 20% of the times, in which cases the IIS indicated variation that could wrongly be identified as intra-speaker. This figure required a further exploration of the factors that may influence the inter-speaker variation present in the participants under study, namely language contact and gender, which are discussed in relation to research questions 4 and 5.

The results that confirm hypothesis 1 also provide an answer to the second research question, which focuses on intra-speaker variation:

> ***RQ2: To what extent is a speaker's idiolectal style stable over time?***

Variationist sociolinguistics introduced the apparent-time construct (Labov 1966, 1972a among others), which maintains that individuals retain their childhood linguistic patterns and remain stable over time. According to this hypothesis, changes in the community would occur over different generations. The methodology for the observation of change in progress over time that results from this hypothesis is the apparent time study, which involves sampling and comparing different age groups as representatives of different generations comprised of stable individuals. Apparent time studies have proved to be a very reliable tool to study linguistic processes, studies such as Trudgill (1988), Labov (1994), and Sankoff *et al.* (2001), report results that confirm this stability. However, the stability of individuals over time may sometimes be affected by changes undergone by the community. Labov (1994) introduced the concept of age-grading as a process by which individuals change some linguistic habits to adjust to certain patterns associated with particular generations. In addition to this, Sankoff and Blondeau (2007) introduced a further process by which individuals may suffer change, lifespan change, which implies that individual speakers change over time in the same direction of a change in progress that is going on in the community.

The only way to study age grading and lifespan change is by means of a real time study, which monitors changes undergone by the same individuals over the years. In this light, Harrington (2007) reports changes in some of the Queen's phonological features, such as tensing of the HAPPY vowel /i/, fronting of the GOOSE vowel /uː/ and lowering and backing of the TRAP vowel /æ/, which indicates a change towards a "less aristocratic form of RP" (2007:128). Similarly, Bowie (2005) also reports evidence of lifespan change in the fill-fell merger, raising of /æ/ before nasals and /u/-fronting in speakers from Utah by means of the analysis of their religious speeches.

These kinds of changes are of utmost importance for forensic linguistics since in many forensic contexts, the expert witness has to deal with non-contemporary samples (Künzel 2007), so it is essential to investigate the stability of an individual's linguistic patterns over time. In this sense, the present dissertation carried out a study in real time, which implies the collection of samples from the same individual separated by a considerable time lapse. In our study, the time difference between both samples from the same speaker was between 10 and 25 years.

The hypothesis that addresses RQ2 is based on the apparent time construct and stated that, despite there may be certain linguistic –in this case phonological- patterns that may undergo age-grading or lifespan change, a speaker's idiolectal style would remain relatively stable over time. In this sense, all the intra-speaker IIS values were expected to be near the 1 end of the continuum. As stated in relation to the previous research question, all the thirteen intra-speaker comparisons that were carried out with samples from the same speakers separated in time by 10-25 years obtained IIS values that were close to 1, indicating high similarity –i.e. low variation. In this sense, hypothesis 2 was confirmed, providing the answer to RQ2 that a speaker's idiolectal style, as represented by the fourteen phonological variables under analysis, is generally stable over time. Moreover, the IIS has proved to be able to account for this low variation.

However, two processes in particular, t-glottalling and t-tapping, proved to show lifespan change. The change involving t-glottalling is particularly noticeable in context 1 (words such as *get up, but I* etc.), which corresponds to variable 7, and especially relevant for female speakers. All the six women exhibit significant differences between the samples in MT1 and MT2 as inferred by the Chi-square tests, and in most cases (5 out of 6) the change implies an increase of the glottal variant over time. The situation is a bit different for male speakers. Rather than a general increase in their production of glottal stops, only two of them show an increase in this variant, which seems to be related to a decrease in t-tapping, whereas the rest of them show an increase in t-tapping and a parallel decrease in t-glottalling over time. Despite these differences are mostly non-significant as inferred by the Chi-square tests, it is noticeable that men show a general increase in their production of t-tapping at the expense of a decrease in glottal stops. This fact is also observed in context 2 (words such as *pretty, getting*), where most of them also show an increase in their production of t-tapping. Context 3 (word finally before a pause) shows a different picture. Since the variant [ɾ] is not possible, in this case, both male and female speakers show a general increase in their production of glottal stops, with the clear exception of the two *LanCon* male speakers which will be commented on below. In addition to this, parallelly to the increase of glottal stops and taps, the majority of both male and female subjects seem to reduce their production of prestigious variants [t] and [t̹] from MT1 to MT2 in the four contexts under analysis. Despite the fact that female speakers still produce more prestigious variants than male speakers, it is noticeable that they exhibit a general decrease over time in [t] and [t̹], considering that sociolinguistic studies have traditionally report a preference by female subjects towards the use of prestigious variants (e.g. Wolfram & Fasold 1974; Trudgill 1983; Cameron & Coates 1988). From all these results we can infer that both female and male speakers are affected by a general increase in the production of the less prestigious variants [ʔ] and [ɾ] that is parallel to an increase in these variants in the SSBE community (as reported in studies such as Tollfree (1999), Fabricius (2000), Hannisdal (2006)). These results pointing towards lifespan change add further information to the real-time development of these processes by the members of the SSBE community, and are also important in relation to forensic applications, since they need to be born in mind in forensic analyses involving non-contemporary samples.

Yet, the two *LanCon* male speakers are a very clear exception to this lifespan change, as they show an increase in the most prestigious variants of /t/ in all the contexts under study that seems to be related to their particular sociolinguistic situation, which is discussed in relation to the following research question. Apart from change over time, intra-speaker variation was also investigated taking into account the factor of language change. Section 3.2.3 exposed some effects that a L2 can have on a L1. Several studies on L2→L1 effects and language attrition report that these effects are mostly noticeable in linguistic domains such as lexicon and that phonetics, and especially phonology, do not tend to be so influenced by a L2 (Schmid & Köpke 2007; Bond *et al.* 2006). Even so, effects on a L1 phonetics that are the result of interference of the phonetics of a L2 are indeed present in the literature, although these mainly regard phonetic changes in VOT values, changes in the quality of some vowels and consonants, changes in intonation, and the (phonological) merger of two vowel categories (Flege & Hillebrand 1984; Flege 1987 & Major 1992; Bullock & Gerfen 2004;

Mennen 2004; Bond *et al.* 2006; de Leeuw 2008; Sučková 2012). Thus, the present study aimed to investigate the consequences that a long-term situation of language contact would have on a speaker's idiolectal style:

> ***RQ3: How does a long-term situation of language contact affect a speaker's idiolectal style (intra-speaker variation)?***

Following the evidence of phonetic changes as a result of L2→L1 reported in the aforementioned literature, it was hypothesised (hypothesis 3) that speakers who have been in a long-term situation of language contact (within the *LanCon* subcorpus) would show higher intra-speaker variation than those speakers who have not (*InSit* subcorpus). At the same time, it was hypothesised that this difference would be shown by the IIS, in the sense that intra-speaker IIS values would be slightly lower in the IIS continuum for *LanCon* than for *InSit* subjects.

Intra-speaker comparisons within the *LanCon* subcorpus suggest only one pattern that seems to have changed slightly over time, which was introduced earlier. Results of the allophonic processes that affect /t/ in unstressed position (section 8.1) show that the two *LanCon* men for whom there are longitudinal data seem to adopt a higher percentage of prestigious variants [t] and [t̪] over the less prestigious variants [ʔ] and [ɾ] in MT2. As Seen in Figure 26 (context 1), Figure 28 (context 2), Figure 30 (context 3), Figure 32 (context 4) and Figure 34 (context 5), the two *LanCon* men show a slight increase of production of the most prestigious variants over the years, especially [t], whereas most of their *InSit* peers show a decrease in the production of these variants as explained in regard to the previous research question. This phenomenon is not shared by the only *LanCon* woman for whom there are data in two measurement times, since she shares with her *InSit* peers the decrease in the most prestigious variants that has been previously mentioned. Despite longitudinal data on *LanCon* speakers are very limited, it is noticeable that both men, especially *LanCon*_m_1, show an increase in the production of the most prestigious allophones of /t/ in MT2 in all the contexts under analysis, or what is the same, a decrease in the least prestigious allophones contrary to what is happening in the *in situ* community. This change may not be specifically due to the influence of a L2, in this case Spanish and/or Catalan, but it may be better understood as the result of these subjects being L1 speakers of English in a context where this language has a prestigious role and of which the members of the community of destination are potential learners. The factors that prompt this phenomenon may be the factor of politeness, and also their professional situation. Sučková (2012) shows that politeness is a factor that can influence the migrant to adopt a more standard version of their L1 so that people in their L2 community understand them better when they speak their L1. Moreover, both subjects work as teachers of English, which may be a further motivation to adopt more standard speech patterns. Despite the limited data, it is interesting to regard this matter in relation to the effects that being away from one's community of origin for a very long time may have in one's speech patterns, so future research could tackle this phenomenon by increasing analyses of real-time data in order to infer more robust conclusions on this matter.

Apart from this slight increase in the use of prestigious variants, no other conclusion can be drawn on possible effects of *LanCon* speakers' migrant situation in the phonological patterns under study with the existing data. Moreover, comparisons between samples from the same speakers within the *LanCon* subcorpus were not lower in the IIS continuum –did not show more variation– than comparisons between samples from the same speakers within the *InSit* subcorpus. Therefore, results obtained for intra-speaker comparisons show that a speaker's idiolectal style does not seem to be modified much after being in a long-term situation of language contact. These results confirm previous studies that affirmed that phonological patterns are not prone to suffer L2→L1 effects (e.g. Schmid & Köpke 2007; Bond *et al.* 2006). Consequently, the answer to RQ3 is that intra-speaker variation in phonological patterns –at least the ones that have been examined– does not seem to be affected by a situation of language contact. Despite the fact that the same speakers do show some effects in their lexicon as a result of language contact (Turell & Corcoll (2006) report some effects of code-switching in these and other members of the UK community in Spain), phonological patterns have shown to be less permeable.

Yet, both the IIS experiments carried out in Chapter 7 and the individual analysis of the variables conducted in Chapter 8 provide some indications that inter-speaker variation (i.e. if we contrast *LanCon* and *InSit* subjects) may actually be affected, not as a result of language transfer, but as a result of being away from their community of origin where some features are undergoing change.

These results are relevant for inter-speaker variation and research question 4:

> ***RQ4: How does a long-term situation of language contact affect inter-speaker variation?***

Considering that more variation was expected to be found in *LanCon* subjects, hypothesis 4 stated that inter-speaker variation would be higher –lower in the IIS continuum– when comparing subjects from different subcorpora than when comparing subjects from the same subcorpus. General results indicated in section 7.2.1 suggested that this hypothesis would not be validated, since IIS results from both groups (on the one hand within the same subcorpora and on the other crossing subcorpora) were within the same range (see Figure 17 and Figure 18 in section 7.2.1), a similarity that was confirmed through an ANOVA test. However, a deeper insight into the two different subcorpora showed some interesting differences. The contrast between inter-speaker IIS results corresponding to comparisons between different subjects within the *InSit* subcorpus on the one hand, and the *LanCon* subcorpus on the other in MT2 showed statistically significant differences, as inferred by the one-way ANOVA test. In fact, inter-speaker IIS values comparing subjects within the *LanCon* subcorpus were generally higher than those resulting from comparisons in MT2 between subjects within the *InSit* subcorpus. In other words, after being away from their community for more than twenty years, the six *LanCon* subjects for whom there are data seem to have become more alike each other, or what is the same, changed less than members of their community of origin, which is the contrary result that was expected. As a matter of fact, even comparisons between men and women within the *LanCon* subcorpus showed more general similarities between men and women as shown by the fact that out of 10 possible comparisons, 3 (30%) were within the IIS intra-speaker range (≥0.77) (see Table 30 in section 7.2.2). A parallel analysis in the *InSit* subcorpus shows that only 2 out of 50 (4%) comparisons between men and women show values that are within the intra-speaker range. Consequently, *LanCon* speakers, irrespective of their gender, show lower inter-speaker variation after years away from their community.

The individual analysis of the variables also shed some light on this phenomenon. As explained in sections 6.2.2.4 and 6.2.2.5, the processes of t-tapping and frication of /t/ have been described as current innovations being undergone by SSBE by recent literature. Hannisdal (2006: 113-114) states that t-voicing is a supra-regional feature and that it can be currently found in many areas of Britain, whereas Tollfree (1999), Ashby and Przedlacka (2010), and Buizza (2011) report an increase in frication of /t/ in SSBE. In relation to RQ2, we discussed a general increase over time in the less prestigious variants, of which *LanCon* speakers do not seem to be part. In other words, *LanCon* male speakers produce a higher percentage of prestigious variants, especially [t] and a lower percentage of less prestigious variants [ʔ] and [ɾ] whereas their *InSit* peers show an increase over time in the latter variants, especially t-tapping. At the same time, both *LanCon* men and women, though it is more noticeable in women, do not produce frication of /t/ as often as their *InSit* peers in all the contexts under study, but more clearly seen in context 5 (section 8.1.5). What we can infer from these conclusions is that *LanCon* subjects do not seem to be taking part of some of the ongoing changes happening in the community, namely the increase in frication of /t/ that affects mostly women and the increase in t-tapping that affects mostly men. However, both male and female subjects produce t-glottalling in a very similar proportion as their *InSit* peers. A possible explanation for this difference in the participation of ongoing changes is that speakers may be more aware of the process of t-glottalling in their speech or the speech of people around them due to the stigma that t-glottalling has suffered, and still does, in SSBE, especially when it occurs in intervocalic position. In this sense, the awareness of this process by *LanCon* speakers could have made them more participant of the sound change occurring in their community of origin in contrast with the other two processes, t-tapping and frication of /t/, of which members of their community, including themselves, do not seem to be as aware. Besides, t-glottalling has been included in current descriptions of SSBE and is a process widely studied in the literature (Altendorf 1999; Fabricius 2000; Altendorf & Watt 2004 among others). On the contrary, t-tapping and frication of /t/ are mostly associated with other accents of English rather than SSBE, and have only been studied in relation to this accent very recently by authors such as Hannisdal (2006), Ashby and Przedlacka (2010), and Buizza (2011). Another possible explanation, which may not necessarily be unrelated to the previous one, is that *LanCon* speakers who moved away from their community at a stage where t-glottalling was already showing variation (around the 1980's-1990's), whereas the processes of t-tapping and frication of /t/ are more recent innovations and may not have been much present at the time they left their community.

Thus, it may be reasonable to infer that people who have been away from their community of origin do not participate so much of sound changes that started after they left the community.

Consequently, the answer to RQ4 is that inter-speaker variation when comparing subjects who have been away from their community of origin (*LanCon*) is slightly lower than when comparing speakers who have remained in their community (*InSit*). In this sense, the IIS may be more likely to give results within the intra-speaker variation range (≥0.77) when comparing the first type of subjects than when comparing the second type. Besides, speakers who have been in a permanent migratory context may also show a different development of ongoing changes than speakers from their community of origin.

Another factor that has turned out to influence inter-speaker variation to a great extent is gender, which is related to the fifth research question:

RQ5: How does gender affect inter-speaker variation?

Gender is clearly a factor that can influence sociolinguistic variation and be the source for inter-speaker variation. Men and women have different ways of relating to the community and may choose different patterns of variation. Many of the variables that have been analysed in the present dissertation have been reported by the literature to be stratified by gender. Hannisdal (2006) finds significant differences between men and women in their use of t-tapping in SSBE, since this process is much more preferred by male speakers than by female speakers, a common phenomenon in other accents of English (cf. Watt & Milroy 1999; Holmes 1999).

Moreover, several studies (Haslerud 1995; Tollfree 2001; Jones & McDougall 2006, 2009; Loakes & McDougall 2010) show that frication of /t/ is much more favoured by female speakers in all the accents of English where frication of plosives takes place, an observation that is linked to the prestige that this variant seems to have over other allophonic processes of /t/ such as glottalling or tapping.

In view of these gender differences, hypothesis 5 stated that inter-speaker variation would be higher when comparing subjects of different gender (a man vs. a woman) than when comparing men with men and women with women. Results obtained for the IIS analyses confirm this hypothesis in that comparisons between subjects of the same gender obtained higher values in the IIS continuum (showing less variation) than comparisons between subjects of different gender (see Figure 20 and Figure 21 in section 7.2.2), a difference that is statistically significant as inferred from the ANOVA test. Also, an analysis of the inter-speaker comparisons that give IIS results within the intra-speaker variation range (≥0.77) shows that the IIS is able to discriminate between samples produced by speakers of different gender 89% of the times, whereas this percentage is reduced when comparing subjects of the same gender.

Yet, despite the fact that experiments of this kind have been performed in order to test the IIS, the situation of comparing a sample produced by one man and one woman in order to determine whether they have been produced by the same speaker or not would not be a usual situation in a forensic context (if not impossible). Other acoustic information (fundamentally F0) would discard the two samples as having been produced by the same speaker. Therefore, in a real forensic context, the IIS would only be applied to samples produced by speakers of the same gender. In this sense, IIS analyses have shown some very interesting results as regards different patterns in men and women. Comparisons between women are significantly higher in the IIS scale (showing less variation) than comparisons between men (see Figure 21 in section 7.2.2) as shown by the ANOVA test. Moreover, 44% of inter-speaker comparisons between women give IIS results higher than 0.77 whereas this proportion is 21% for samples produced by men. In other words, the IIS is able to discriminate between samples produced by different women only 56% of the times, whereas it discriminates between samples produced by different men 79% of the times (see Table 30 in section 7.2.2). From these results, the answer to RQ5 seems to be that women seem to show less inter-speaker variation than men in the variables included in the IIS. In turn, a conclusion about the IIS is that this tool would be more reliable when comparing samples from men than when comparing samples from women.

The individual analysis of the variables carried out in Chapter 8 also shed some light on some inter-speaker gender differences. Results for all the contexts under analysis show that male speakers use t-tapping much more often than female speakers, and that female speakers prefer the fricated variant [t̹] much more than men do. These results confirm previous studies that show these preferences in SSBE (Tollfree 2001; Hannisdal 2006) and in other accents of English (Watt & Milroy 1999; Holmes 1999; Haslerud 1995; Jones & McDougall 2006, 2009; Loakes & McDougall 2010).

The individual analysis of the variables also shows interesting results as regards the process of vowel alternation between [ɪ] and [ə]. According to studies such as Wells (1982) and Cruttenden (2001), words included in variable 1 (e.g. *begin* or *depend*) tend to be produced with the most conservative variant [ɪ] whereas words included in variable 2 tend to favour the most innovative variant [ə]. Results for the present study confirm these tendencies, and also shed some light on the correlation between this variation and gender. On the one hand, results for Variable 1 show a near-categorical production of variant [ɪ] by women, whereas men exhibit more variation between the two variants. As regards Variable 2, female speakers show variation between both variants, whereas men show a near-categorical use of [ə], i.e. the most innovative variant. Therefore, women show a clear preference for the most conservative variant in comparison with men, which is in line of the sociolinguistic studies that show that women tend to prefer more conservative and prestigious variants (e.g. Wolfram & Fasold 1974; Trudgill 1983; Cameron & Coates 1988). In this sense, men seem to be in a more forward stage than women as regards the sound change affecting vowel alternation between [ɪ] and [ə] in the two contexts, as shown by their more frequent use of the most innovative variant.

Let us now turn to the discussion on the discriminatory potential of each individual variable, in relation to research question 6:

> ***RQ6: How discriminatory will each variable be when considering them in isolation?***

The analysis conducted in Chapter 8 was divided into six major allophonic processes to which the fourteen IIS variables belong. These were:

1) Allophonic processes affecting /t/: t-glottalling, t-tapping and frication of /t/ (IIS variables 7-13).
2) Alternation of weak vowels [ə] and [ɪ] (IIS variables 1 and 2).
3) Yod-coalescence (IIS variables 3 and 4).
4) Insertion of [t] (IIS variable 5).
5) Linking /r/ (IIS variable 6).
6) Frication of /k/ (IIS variable 14).

The analysis consisted of 1) a descriptive observation regarding the percentage of production of each variant included in each variable; 2) a statistical significance inference by means of the chi-square test conducted for comparisons between pairs of samples; and 3) correlation analyses in order to examine the (non-)linearity behind the relationships between the variables.

Section 2.2 summarises the seven ideal characteristics that a forensic phonetic parameter needs to have. Of those seven, the present dissertation considers that the fundamental characteristics that are most relevant for the study of the discriminatory potential at hand are: 1) showing low intra-speaker variation; 2) showing high inter-speaker variation; and 3) showing a high frequency of occurrence. The other three characteristics established by Nolan (1983) (being resistant to disguise, being robust in transmission and being easy to extract and measure) are generally accomplished by phonological parameters. Firstly, any phonological variable such as the ones analysed here is very difficult (if not impossible) to imitate, since they deal with sociolinguistic variation that speakers produce unconsciously. Secondly, changes in transmission due to channels such as the telephone or tape recordings are mostly associated to acoustic properties such as vowel formants rather than to phonological processes (Cf. Künzel 2001, 2002; Nolan 2002b). Thirdly, although some of the variables are tricky to categorise, once the criteria to do so have been established and is systematically followed, their analysis is indeed possible (Chambers & Trudgill 1998). Finally, the last characteristic added by Rose (2002), that each parameter should be as independent as possible of other parameters, is one of the characteristics that has been tested by correlation analyses in the present dissertation and will be detailed in relation to each phonological process in the discussion that follows.

Table 55 shows a list of the fourteen variables arranged from more to less discriminatory in terms of inter- and intra-speaker variation and frequency of occurrence. Results show that the variables that are most discriminatory, and therefore would be better candidates to be considered in forensic contexts, are mostly related to allophonic processes of /t/ (glottalling, tapping and frication), with the exception of variable 1, which is related to vowel alternation, and variable 14, which considers frication of /k/.

Table 55: Summary of discriminatory potential of the 14 variables arranged from most to less discriminatory.

GENERAL CONCLUSIONS VARIABLE 13	Frication of /t/ between vowels word internally and across word boundaries (V_(#)V).	Intra-speaker variation	Very low
		Inter-speaker variation	High
		Frequency of occurrence	High
GENERAL CONCLUSIONS VARIABLE 7	T-glottalling (V_#V) in frequent words and lexical items with close syntactic linkage such as *get up, but I, what if, out of*…	Intra-speaker variation	Low for men (high for women–lifespan change)
		Inter-speaker variation	Very high
		Frequency of occurrence	High
GENERAL CONCLUSIONS VARIABLE 10	T-tapping (V_#V) in frequent words and lexical items with close syntactic linkage such as *get up, but I, what if, out of* …	Intra-speaker variation	Low
		Inter-speaker variation	High, esp. men
		Frequency of occurrence	High
GENERAL CONCLUSIONS VARIABLE 12	T-tapping between vowels word internally and across word boundaries (V_(#)V).	Intra-speaker variation	Low
		Inter-speaker variation	High (only for men)
		Frequency of occurrence	High
GENERAL CONCLUSIONS VARIABLE 9	T-glottalling word-finally before pause.	Intra-speaker variation	Low
		Inter-speaker variation	High
		Frequency of occurrence	Quite high
GENERAL CONCLUSIONS VARIABLE 1	Vowel alternation in 'weakened' be–, de–, pre–, re– and e– (*enough, begin, depend*).	Intra-speaker variation	Low
		Inter-speaker variation	High for men Low for women
		Frequency of occurrence	Quite high
GENERAL CONCLUSIONS VARIABLE 14	Frication of /k/ between vowels word internally and across word boundaries.	Intra-speaker variation	Low
		Inter-speaker variation	High
		Frequency of occurrence	Quite low
GENERAL CONCLUSIONS VARIABLE 5	Insertion of [t] in the context of [n]__[s]: (*since, once)*	Intra-speaker variation	Low
		Inter-speaker variation	Bit high for men only
		Frequency of occurrence	Low
GENERAL CONCLUSIONS VARIABLE 6	Linking /r/	Intra-speaker variation	Low
		Inter-speaker variation	Low
		Frequency of occurrence	Low
GENERAL CONCLUSIONS VARIABLE 4	Yod coalescence of [t, d, s, z] before [j] word-internally (*duty, student, studio*)	Intra-speaker variation	Low
		Inter-speaker variation	Low
		Frequency of occurrence	Low
GENERAL CONCLUSIONS VARIABLE 11	T-tapping between vowels (V_V) in highly frequent words: *pretty, whatever, getting, putting, British, Scottish, better, sitting, matter*.	Intra-speaker variation	Low
		Inter-speaker variation	Low
		Frequency of occurrence	Low
GENERAL CONCLUSIONS VARIABLE 8	T-glottalling intervocalically across word boundaries in lexical words (V_#V).	Intra-speaker variation	Low
		Inter-speaker variation	Low
		Frequency of occurrence	Low
GENERAL CONCLUSIONS VARIABLE 3	Yod coalescence of [t, d, s, z] before [j] across word-boundaries. (*this year*)	Intra-speaker variation	Low
		Inter-speaker variation	Low
		Frequency of occurrence	Low
GENERAL CONCLUSIONS VARIABLE 2	Vowel alternation in terminations: -ible, -ily, -ity, -less, -let/-ret, -ate, -ace (*possible, happily, delicate*).	Intra-speaker variation	Low
		Inter-speaker variation	Low
		Frequency of occurrence	Low

Variables 13 and 14 are related to the process of frication of plosives (/t/ and /k/ respectively) intervocalically both word internally and across word boundaries. Frication of plosives is a phenomenon mostly associated with accents of English such as Southern Irish English (Wells 1982; Hickey 1999; Jones & Llamas

2008), Liverpool English (Wells 1982; Marotta & Barth 2006; Watson 2007) and Australian English (Haslerud 1995; Jones & McDougall 2009), though several studies report that it is also a common feature of other English accents such as Middlesbrough English (Jones & Llamas 2008), Newcastle English (Foulkes & Docherty 2006), American English (Lavoie 2002) and also SSBE (Tollfree 1999; Cruttenden 2001; Shockey 2003; Ashby & Przedlacka 2010; Buizza 2010). The present results confirm these latter studies, as they show that frication of /t/ and /k/ is clearly present in the speech of SSBE, particularly in female speakers. From a forensic perspective, this process has only been studied in relation to Australian English (Loakes 2006; Loakes & McDougall 2004, 2007, 2010) but no information about the discriminatory potential of these processes is available for SSBE. The studies centred on Australian English reported that only frication of /k/ and /p/ are discriminatory, but they centred exclusively on male subjects, and frication of /t/ is mostly associated to female subjects. The present study does not consider frication of the plosive /p/ as a variable of study, because initial observations of the corpus under analysis did not show any instances of this process. Results show that frication of the plosives /t/ and /k/ are two useful processes to consider in forensic contexts also in SSBE since they exhibit low intra-speaker variation, high inter-speaker variation, and high frequency of occurrence. Moreover, correlation results show that there is a linear relationship between both processes of frication. This correlation implies that a high frication of one plosive may also imply a high frication of the other plosive. Findings by Loakes and McDougall (2010) also show a linear relationship between frication of /k/ and /p/ in Australian English, but not with /t/ since, again, their male subjects hardly produced frication of /t/. Findings from the present study add further information regarding the process of frication of /t/ and /k/ in SSBE, since these are two processes which have not been much explored in the literature with the exception of the aforementioned studies, as well new data on their discriminatory potential for forensic purposes.

The process of t-glottalling has also proved to be highly discriminatory. To my knowledge, this process has not been studied from a forensic perspective in any accent of English, so no previous studies can be mentioned in that regard. Results show that the two variables related to t-glottalling that show most discriminatory value are variable 7 ((V_#V) in frequent words and lexical items with close syntactic linkage such as *get up, but I, what if, out of*…) and variable 9 (word-finally before pause). These two contexts have shown most inter-speaker variation, and their frequency of occurrence is also quite high. On the contrary, variable 8 (glottalling intervocalically across word boundaries in lexical words) has proved not to show as much inter-speaker variation. A reason for this low inter-speaker variation is that speakers may not produce as many instances of [ʔ] in this context because it may be regarded as a more stigmatised context, whereas speakers may be less aware of the stigma present in glottalling in the same context with frequent words (variable 7) and before a pause (variable 9). Moreover, correlation analyses carried out in section 8.1.6 in relation to male speakers show that variables 7 and 9 exhibit a significant linear relationship between each other, whereas their relation with variable 10 is hardly significant. The implications of these relationships are that, only for male speakers, a high production of glottal stops in variable 7 may imply high production of this variant in variable 9 and vice versa, but not in variable 8. Several studies (Fabricius 2000; Altendorf & Watt 2004 among others) show that t-glottalling has lost its stigma to some extent in final position and in intervocalic position across word boundaries in SSBE, but the present study shows that the behaviour of this process in intervocalic position across word boundaries is different depending on the types of words involved. If the words are frequent and have some syntactic linkage (variable 7), speakers appear to be less aware of the stigma and they produce [ʔ] more often, which implies more inter-speaker variation (higher discriminatory potential). On the other hand, if the words involved are lexical and not related to each other (variable 8), attitude towards t-glottaling appears to be more similar to the same process in intervocalic position word-internally, which is considered to be a non-established feature in SSBE and shows a near-categorical behaviour towards a non-production of this variant. Consequently, future analyses may want to consider the contexts included in variables 7 and 9 in one single variable, because they both show a similar behaviour, but only for analyses involving male speakers. In contrast, women do not exhibit this linear relationship between variables 7 and 9, so these two contexts might still need to be considered separately when analysing samples produced by women. Another interesting finding regarding allophonic processes of /t/ is that male speakers also exhibit a significant linear relationship between variable 7 and variable 10, which consider the processes of t-glottaling and t-tapping in the same environment (intervocalically across word boundaries in words such as *out of, bit of, what if*). This time, the relationship is negative, which means that a higher production of one variant may imply a lower production of the other one and vice versa. This significant negative correlation reinforces what was commented on in relation to RQ1 as regards the fact that male speakers who showed an increase in their production of glottal stops exhibited a decrease in their production of taps and vice versa. This result provides further information regarding the relationship between t-glottalling and t-tapping in SSBE.

The process of t-tapping has traditionally been mostly associated with other accents of English, especially American, Canadian, Australian or New Zealand (Harris & Kaye 1990; Woods 1991; Holmes 1994), although more recent studies show that this process is also common in British accents of English such as Newcastle, Cardiff, Glasgow, Northern Ireland and SSBE (Watt & Milroy 1999; Mees & Collins 1999; Stuart-Smith 1999; McCafferty 1999; Tollfree 1999; Hannisdal 2006). The present study confirms these studies and shows that t-tapping is clearly present in SSBE speakers, especially in male speakers, since the percentage of t-tapping with respect to other allophones of /t/ in unstressed positions ([t], [t̡] and [ʔ]) is certainly high for some male speakers. In contexts 1 and 2 (corresponding to variables 10 and 11), many male speakers produce [ɾ] between 70-85% if the times. This percentage of production is considerably reduced in context 5 (variable 12), to only 30-40% at most, but it still is a very noticeable proportion. Therefore, it can be said that t-tapping is definitely part of the speech of SSBE male speakers and that it should be included in current descriptions of the accent, as Hannisdal (2006) argues.

Similarly to t-glottalling, the discriminatory potential of the process of t-tapping has not been previously investigated either, to my knowledge. However, results of the present study show that this process may actually be discriminatory in the contexts considered by variable 10 (V_#V in frequent words and lexical items with close syntactic linkage such as *get up, but I, what if, out of*…) and 12 (V_(#)V in lexical words), where it shows higher inter-speaker variation and higher frequency of occurrence. Moreover, as mentioned previously, t-tapping is only relevant in forensic contexts for samples produced by men, since women hardly ever produce this variant. The other variable that considers t-tapping, variable 11 ((V_V) in highly frequent words such as *pretty* or *whatever)* has proved not to be so discriminatory, maybe because of its low frequency of occurrence. The fact that this variable depends on a closed set of lexical items constitutes a considerable limit to its application. In spite of this, the three variables related to t-tapping show a linear relationship between each other in male speakers, as inferred by the correlation analyses. This relationship means that if a speaker tends to produce t-tapping in one variable very often, he may also show a tendency to produce a higher proportion of taps in the other variables. In the light of their similar behaviour, the three contexts under study could be considered in one single and more robust variable in future studies.

Results regarding the process of vowel alternation between [ə]-[ɪ] confirm previous studies that reported variation between these two variants in SSBE (Wells 1982; Cruttenden 2001), and as commented on previously, this variation is correlated with gender. Moreover, results on the individual analysis of these two variables show that this process is only discriminatory in the context considered by variable 1 (in beginnings of words such as *begin, depend*) and only when considering samples produced by men, since men show much higher inter-speaker variation whereas women exhibit a near-categorical production of [ɪ] that implies low inter-speaker variation. The second variable related to the process of vowel alternation (variable 2, in words such as *positive, happily*), despite showing variation by male speakers, has not proved to be discriminatory either for male or female speakers due to its low inter-speaker variation. So this latter variable should be reconsidered in future studies.

Variable 5 considers insertion of epenthetic [t] between [n] and [s]. Some authors (Harms 1973; Ohala 1974; Donegan & Stampe 1979) claim that this process is the result of a gestural mismatch, and therefore a purely phonetic and universal phenomenon. In contrast, other authors (Jones 1966; Fourakis & Port 1986; Cruttenden 2001) suggest that speakers may have some control over it, and that it may not only be language-specific, but dialect-specific, since some accents of English such as American exhibit this process whereas others such as South African and SSBE do not show it so often. As regards SSBE, Jones (1966) states that insertion of [t] is not characteristic of "British English", whereas Cruttenden explains that "few RP speakers regularly maintain the distinction between /ns/ and /nts/ which is widespread in regional speech" (2001: 187). Moreover, Wells notes that there is variation in SSBE, although the major variant is /ns/ (although the poll is perceptual, rather than a pronunciation test, so results might only be indicative). Results reported in Chapter 8 show that all the subjects under study exhibit variation between the two variants, so Cruttenden's (2001) and Well's (1999) observations that speakers of SSBE show occasional insertion of [t] are confirmed. There is some inter-speaker variation, since some speakers insert [t] around 10%-20% of the times, whereas other speakers do so around 50-60% of the times (see Figure 52 and Figure 53 in section 8.4). In this sense, the variable that considers this phenomenon, variable 5, has proved to be a pretty discriminatory variable but only for samples produced by men, although its low frequency of occurrence may limit its application to short forensic samples. Therefore, this variable may be interesting to consider in a forensic context if it presents a considerable number of realisations in the samples at hand.

Regarding linking /r/ and variable 6, some authors claim that it may be a source for inter-speaker variation. Windsor Lewis claims that "the use or non-use of linking /r/ is a notable field for idiosyncratic variation on the part of individual speakers". (1975: 39). Similarly, Hannisdal (2006), also considering newsreaders, reports that the use of linking /r/ in the subjects of her study is lower than expected, and that there is a great deal if inter-speaker variation, since some of them favour the Ø variant and others the linking /r/ variant. Thus, linking /r/ seemed to be a pretty good candidate to consider in forensic terms. However, results in the present study show that the process of linking /r/ is not discriminatory, since inter-speaker variation is very low. Most speakers show a near-categorical production of linking /r/, so, despite there is some variation, the percentage of instances of no linking /r/ is generally very low. These results differ noticeable from Hannisdal's since, in comparison with participants in her study, no speaker has shown a tendency to produce the Ø variant and inter-speaker variation is very low. The reason for this may be a stylistic factor. The speech style for Hannisdal's study is broadcast speech, which is a more formal context than the speech style in the present dissertation, which is spontaneous. As a matter of fact, authors such as Cruttenden (2001) have claimed that the fact that intrusive /r/ has some stigma in SSBE may lead some speakers to avoid not only instances of intrusive /r/ but also of linking /r/. Consequently, the production of linking /r/ may be related to an awareness of a stigma present in the process of intrusive /r/, which may be the source for a correlation between both types of r-sandhi with speech style. A higher awareness of linking and intrusive /r/ in more formal contexts would explain the different results in Hannisdal's study, which reports several speakers showing a tendency towards not producing linking /r/, and the results in the present study, which show a near-categorical tendency for the production of linking /r/ by all the speakers. It would have been interesting to count on samples collected in different styles for the different subjects in the present study in order to test this hypothesis of intra-speaker stylistic variation in linking /r/, however, the style factor was controlled and only spontaneous speech was regarded. Future studies may need to take this fact into account and investigate further the correlation between linking /r/ and speech style and its forensic implications.

The process of yod coalescence, both in stressed and unstressed position, has been reported to be present in SSBE by authors such as Cruttenden (2001) and Hannisdal (2006), in contrast with authors such as Wells (1982) who considers it part of SSBE only in unstressed syllables. Besides, Hannisdal notices that all the speakers in her study show both coalesced and non-coalesced variants and that there is a great amount of inter-speaker variation (2006: 211). Results in the present study confirm previous studies that affirm that yod-coalescence is present in SSBE both in stressed and unstressed positions (Cruttenden 2001; Hannisdal 2006), and that speakers exhibit variation between the two variants. Moreover, results indicate that there is no correlation between this feature and gender, since male and female speakers do not show different variation patterns. However, a correlation has been proved to exist in relation to linguistic context, since coalescence is much more usual word-internally than across word boundaries. In this sense, correlation analyses showed that there is no linear relationship between variables 3 and 4, so a high proportion of coalesced forms in one variable does not necessarily imply a high proportion of the same variant in the other variable and vice versa. As regards the discriminatory potential of variables 3 and 4, these variables turned out to exhibit low inter-speaker variation, which is translated into a low discriminatory potential, so they proved not to be good candidates to consider on their own in forensic contexts.

Chapter 7 also included a section dedicated to speaking tempo, more specifically to Articulation Rate (AR), with the aim to test whether it is a factor that can influence the inter-speaker variation of the variables under analysis. Many of the phonological features analysed may somehow be affected by speed of delivery. For example, all the allophonic variants of /t/ that have been studied (glottalling, tapping and frication) may be regarded as processes of lenition, which may be prone to appear in rapid speech (Wells 1982; Harris 1994; Shockey 2003). In particular, t-tapping has traditionally been considered to be connected with speaking rate, so it is not expected to occur in slow careful speech in SSBE (Wells 1982: 324-325). However, Hannisdal states that the fastest speakers in her study did not necessarily use more tapping than speakers with lower speech rates (2006: 198). Therefore, the aim of an analysis of the speakers' speed of delivery was to investigate the possible correlation between articulation rate and the variables under study, in order to test whether the inter-speaker variation found in the speakers' production of the variables was really due to idiosyncratic differences and not differences in speaking rates. The measure of articulation rate was chosen over that of speech rate because it is reported in the literature as being more useful in forensic contexts due to its low intra-speaker variation and high inter-speaker variation (Künzel 1997). Indeed, our results show that AR exhibits low intra-speaker variation and higher inter-speaker variation –which confirms Künzel's results– even over time. In those speakers who showed more variation over time, no common pattern was found as to whether the tendency is to decrease or increase AR, so it would be interesting to carry out further research with more speakers analysed in real time so as to investigate further how AR is affected by change over time. Apart from this, correlation analyses by means of Spearman's coefficient –since some of the variables exhibited a non-normal distribution– showed that AR does not have a linear relationship with any of the variables under study. In particular t-tapping, since it is the process that has been most clearly associated with speaking tempo, does not show any particular relationship with this feature, hence confirming Hannisdal's findings (2006). If we look at Figure 23 (section 7.2.3), which shows the results for articulation rate by male speakers, and Figure 35 (section 8.1.6), which shows the percentage of production of t-tapping in variables 10, 11 and 12 by male speakers, we can see that the male speakers who speak faster do not necessarily show the highest production of [ɾ]. Speaker *InSit*_m_1 shows very high production of taps in the three variables and his AR is 5.2 (MT1) and 5.7 (MT1) syll/sec, whereas the speaker who shows the lowest production of taps, *LanCon*_m_1, exhibits a very similar AR (5.7 and 5.8). On the other hand, the speakers who show the fastest AR are *InSit*_m_4 (6.7 and 6.4 syll/sec) and *LanCon*_m_3 (6.9), and their production of taps are not among the highest. From these results we can infer that neither t-tapping nor any of the other variables are correlated with speaking tempo, a fact that indicates that the inter-speaker differences observed are due to idiolectal choices, rather than differences in speed of delivery.

Results on the discriminatory potential of individual variables, as well as the correlation analyses that have shed some light on the relationship between them, have important implications as regards the IIS protocol. As commented on before, the IIS was generally able to distinguish between samples produced by different speakers only 80% of the times. Although this proportion is pretty high, and despite the fact that samples produced by female speakers and also by speakers who have been in a situation of language contact have proved to show lower inter-speaker variation, the IIS might benefit from a reconsideration of some of its variables considering the results that have been achieved. Future IIS experiments may need to focus on the variables that have proved to be more discriminatory, and new variables will need to be formulated and tested.

In the light of the results obtained through the experiments concerning the IIS protocol, as well as the individual analysis of all the variables, it is possible to address the general question that was posed, which is of concern not only to the present PhD dissertation, but also to the general field of forensic linguistics:

> ***GRQ: Is it possible to distinguish between inter- and intra-speaker variation?***

Results attained in Chapter 7 and chapter 8 indicate that inter-speaker variation is generally higher than intra-speaker variation. In fact, even the variables that exhibited less idiosyncratic potential showed lower intra- than inter-speaker variation. However, as has been previously commented on, it is fundamental to define variables that are discriminatory in order to distinguish between both types of variation. If suitable variables are chosen, such as the eight variables that have proved to be particularly discriminatory in the present study, it is indeed possible to distinguish between inter- and intra-speaker variation when addressing two samples with the aim to reach conclusions regarding the possibility of them having been produced or not by the same individual.

As stated in Chapter 4, the context for the present PhD dissertation can be found in three research projects that have been carried out, and still are, at ForensicLab, IULA, Universitat Pompeu Fabra. Apart from the phonological module of English, which has been developed in the present study, the projects also consider two other linguistic modules, morphosyntactic and discourse-pragmatic, for four languages, Catalan, Spanish, English and the recently added Arabic. The results obtained in the present study regarding the IIS protocol are in line of the results provided by the other modules that have been carried out (for the moment only for Spanish, Catalan and English), for which a corpus of six speakers has been used per module. The two general hypotheses stated in this wider project are the two first hypotheses presented in this study, namely 1) inter-speaker variation is higher than intra-speaker variation; and 2) an individual's idiolectal style stays relatively stable over time. The wider project also introduces a third hypothesis which has not been investigated yet, but will be in the project that has been recently granted: 3) an individual's idiolectal style will also remain relatively stable despite the use of different genres or textual registers but possibly not as stable as it might be over time. All the different modules have been tested with three, and sometimes four, different methods: 1) a method based on the calculation of the difference in the percentage of occurrence of the variables –which was the method used in the PhD dissertation proposal leading to the present PhD dissertation (Gavaldà 2009); 2) a method based on the Adjusted Residual Value obtained by means of contingency tables; 3) the method based on the Phi Coefficient presented in the present dissertation; and 4) a method based on the Euclidian distance, which was only applied to the Spanish and the English phonological modules. After several experiments, method number 3 was the one that exhibited better results since it was able to account better for the difference between intra- and inter-speaker variation. Therefore, this method was the one used in the present dissertation.

Results of the IIS experiments carried out for all the modules generally confirm the first two hypotheses, since intra-individual comparisons give IIS results higher in the IIS continuum, and inter-individual values are generally lower in this continuum. However, the morphosyntactic and the discourse-pragmatic modules do not give as good results as the phonological modules, in the sense that comparisons between different speakers are very often too high in the IIS continuum. We believe that these results are due to certain methodological difficulties that we encountered in the process of our research. These difficulties are mainly related to sampling stratification –different measurement times, genres and genders are very often difficult to find–, and the nature of the variables, in the sense that morphosyntactic and discourse-pragmatic variables show lower frequency than phonological variables and they are more difficult to be formulated as binary categorical variables. Details on the results that have been obtained so far can be found in Turell and Gavaldà (2013). Future research will focus on the discriminatory potential of variables in order to formulate more variables that may be considered in the IIS protocol. Moreover, future experiments will also apply the three modules (phonological –only in the case of oral samples–, morphosyntactic and discourse-pragmatic) to the same samples, since the final aim is to be able to analyse samples from an integrating perspective, so as to add as much information to the analyses as possible.

Therefore, the IIS is proposed as a complementary quantitative tool that can help distinguish between inter- and intra-speaker variation.

However, it is important to emphasise the word ‘complementary’. The IIS is not presented here as a foolproof tool that can successfully classify samples as belonging to the same or different individuals by itself. The IIS was designed from the beginning as a tool that is to be applied to forensic contexts together with other quantitative and qualitative methods. In the case of oral samples, an acoustic analysis that regards the physical properties of sounds is an essential part of forensic analysis. And regarding linguistic information, the IIS is not the only method that can help identify linguistic properties that can provide useful information about the samples at hand. For example, one of the variables that were discarded in preliminary observations that were explained in section 6.2 was the pronunciation of the word *often* as [ɒfən] or [ɒftən], and it was discarded because its frequency of occurrence was limited to only one word, and consequently, the variable was not very productive for the purpose of the IIS. However, if in the process of forensic speech comparison of two samples the investigator encounters this phenomenon, the fact that the two samples show a tendency towards one single variant, or different tendencies towards different variants may provide extremely valuable information about the individual(s) who have produced the samples. Therefore, the IIS is a further method to analyse linguistic properties and one of the many methods that can be used when analysing oral samples for forensic purposes.

In addition to this, the IIS hereby proposed is not a tool that can only consider the variables that have been analysed here. Rather than being a fixed tool, the IIS needs to be adapted depending on the corpus of study, or if used in real forensic cases, on the samples being compared. If the IIS was to be tested with a corpus containing data from speakers from, say, the North of England, considering the variables that have been analysed here would dramatically decrease its usefulness, since most of the variables under study would not be relevant to the speech of those speakers, and the protocol would be missing other potential variables that would work better in its application to such corpus. Inter- and intra-speaker variation is fundamentally dependent on the speech community, so the variables to be analysed following the IIS protocol also need to change depending on the community under analysis. And within a single speech community, variables will also need to be adapted depending on stylistic factors and also sociolinguistic factors such as social class, age, or gender.

The present dissertation provides a few of the possible variables that can be analysed for forensic purposes, but which may only be useful with samples produced by speakers with the same sociolinguistic characteristics as the ones included in the corpus under study. If these sociolinguistic characteristics change, the variables to be studied will inevitably need to change as well. On the contrary, what can be used in other contexts is the methodology proposed, which has been quite successful as a method for statistical comparison with categorical variables. Therefore, it is important that future work carried out around the IIS protocol should focus on the formulation of new variables for different speech communities. This future work will not only be useful for the IIS protocol, but it will also contribute to the Base Rate Knowledge that is so essential for current forensic linguistics, so as other linguists carrying out research and expert witness work can benefit from these study within and outside the IIS protocol. Despite acoustic analysis is essential for forensic phonetics, the analysis of information related to the linguistic mechanism (in Nolan's (1997) terms) is as important, if not more, and more studies need to be carried out which focus on the determination of what linguistic features can be useful to be analysed in forensic contexts. The present dissertation is only a small contribution to this purpose.

Chapter 10
Conclusions

The main framework of the present PhD dissertation is the common space that can be found between the field of sociolinguistics and the field of forensic linguistics, more specifically, the area of forensic phonetics. This common space concerns the study of variation, both inter- and intra-individual, and the concept of idiolectal style proposed by Turell (2010a) as constituted by a set of individual linguistic selections that separates an individual linguistically from the rest of the members of their speech community. Sociolinguistic variation has not been studied for forensic purposes as much as other phonetic characteristics, despite the fact that some recent studies have demonstrated that the study of features that show variation provides important information about speakers (Moosmüller 1997; Loakes & McDougall 2004, 2007, 2010; de Jong *et al.* 2007a and 2007b). The fact that a feature is undergoing change and shows synchronic variation implies that the speaker has a choice, and these are the kinds of choices of which the idiolectal style is composed. The present PhD dissertation builds on these studies and analyses fourteen variables that show variation in the sixteen speakers of SSBE who comprise the corpus under analysis. Moreover, the present study also proposes a protocol for the creation of an Index of Idiolectal Similitude which can help determine whether two samples show intra- or inter-speaker variation, which in turn can help decide upon the probability of the samples having been produced by the same individual or by two different individuals.

Results on the IIS experiments have shown that it is possible to distinguish between inter- and intra-speaker variation since inter-speaker variation is generally higher than intra-speaker variation and that a speaker's idiolectal style remains relatively stable over time. However, it is of great importance to select suitable variables that show low intra-speaker variation, high inter-speaker variation and high frequency of occurrence, so as to maximise the discriminatory potential of the IIS.

The present dissertation proposes the IIS as a tool that, together with other quantitative and qualitative techniques that the linguist expert witness may have at their disposition, can provide important information as regards the variation present in pairs of samples. The research carried out in the present dissertation has put forward a set of phonological variables which, when considered jointly, can help determine that two samples have been produced by the same individual 100% of the times and that they have been produced by different individuals 80% of the times. Despite the pretty high percentage of discrimination between different individuals, it is still fundamental to consider this remaining 20%, which, if applied in real forensic cases, would imply samples produced by different individuals being classified as belonging to one single speaker. Individual analyses of the variables under study have shown that six of these variables do not exhibit high discriminatory value, and therefore, future IIS experiments might need to consider only the eight variables that are highly discriminatory and reconsider the ones that are not. Moreover, the IIS has turned out to be more efficient when comparing samples produced by men than those produced by women, since women have proved to exhibit less inter-speaker variation, in other words, they are more similar to each other. These observations regarding gender differences in inter-speaker are to be taken into consideration in future studies of linguistic phenomena for forensic purposes.

Apart from the cases where the IIS has not been able to distinguish between samples produced by different speakers, the IIS protocol has other major limitations. Firstly, the research carried out here has proved to be quite successful with samples that are 30 minutes long on average, but no experiments have been carried out with shorter samples. It is undeniable that, despite the fact that some forensic cases may involve samples that are as long as 30 minutes, many others entail the analysis of very short samples, and also very often, with a very poor quality. The efficiency of a tool such as the IIS in such situations might surely be dramatically reduced due to the lack of realisations of the variables and the poor acoustic conditions that might not allow the researcher to categorise realisations as one variant or another. Consequently, it is likely that the scope of application of the IIS may be reduced to cases where the samples are long enough and the quality of the recording is good enough. Nevertheless, as stated previously, the IIS is presented as a complementary tool, so the fact that it may only be applied to a limited number of cases does not compromise its value completely. Similarly, the IIS has so far been applied only to non-forensic recordings, which have a good quality and abundant linguistic material, so future research will need to tackle this matter and start applying the IIS protocol to real forensic recordings in order to study its forensic value in more depth.

Another limitation of the present PhD dissertation regards the fact that the variables that have been presented here can only be applied to samples produced by speakers with the same sociolinguistic characteristics of the speakers under analysis. However, this limitation is intrinsic to sociolinguistic analysis, since sociolinguistic variation depends exclusively on the speech community under study. Different speech communities have different phonological properties, and even within a narrowly defined community, differences may arise in relation to social factors such as gender, age, social class etc. This dependency on specific social groups that characterises linguistic parameters may be the reason for the fact that acoustic properties, which are less language- and dialect-specific, have been analysed for forensic purposes in much more depth. But the few studies concerned with linguistic properties and, more specifically, linguistic properties that show variation, have demonstrated that the choices that speakers make of a particular variant of a variable feature provide valuable idiosyncratic information, and that the study of idiolectal style is a fundamental part of forensic linguistic research. In this sense, the present dissertation has carried out the analysis of fourteen phonological variables that show variation in SSBE, either stable variation or variation due to change in progress. Nevertheless, as discussed in Chapter 9, the IIS protocol needs to adapt the choice of its variables to the particular samples at hand. For the moment, the IIS can only be used in English with the variables that have been formulated so far, which constitutes an evident limitation. Further research needs to be carried out in order to determine discriminatory variables that can be applied to samples belonging to speakers with other sociolinguistic characteristics, so that the IIS can be applied to other contexts and other accents. At the same time that future IIS experiments will contribute to the extension of the scope of application of the IIS, these same experiments will contribute to the Base Rate Knowledge with the establishment of phonological features that can be useful to be considered in forensic contexts, either within the IIS protocol or in isolation.

Apart from the choice of variables, the corpus that has been considered in the present study may be rather limited too. Only sixteen speakers have been analysed, and only thirteen of these have been analysed in real time. And apart from measurement time, the corpus was also stratified according to gender and language contact, so the final number of speakers included in each of the groups was rather limited. In this sense, the generalisations which the analysis of the corpus has led to regarding the speakers' behaviour in their phonological patterns are also very limited. However, two major challenges that the present dissertation has faced need to be put forward. On the one hand, one of the major difficulties in collecting the corpus of study was to count on real time data. Studies in real time were proposed by variationist sociolinguistics as the most suitable methodology to observe change in progress, but in light of the difficulties it posed, which were discussed in Chapter 1, a suitable surrogate, studies in apparent time, was proposed. However, given that the focus in forensic linguistics is the individual, rather than the community, an apparent-time study was not appropriate, and the only way to approach change over time was to carry out a real-time study. In this sense, after the compilation of data on sociolinguistic interviews in real time (the *LanCon* subcorpus) proved to be very limited, since only data on three speakers could be collected, it became necessary to rely on spontaneous broadcast speech available on Internet sources. And even in this case, finding relevant data on subjects of study that shared as many similar sociolinguistic characteristics as possible proved to be very difficult as well. However, the real time study carried out in this dissertation is its main challenge, but it is also its main value, since not much research considering real time data has been carried out for forensic purposes, and even less research in real time that focuses on phonological characteristics. On the other hand, it needs to be born in mind that, with two recordings for the majority of the speakers, the total number of samples that have been analysed is 26, which is a considerable number of samples to analyse manually with the auditory-acoustic method by only one investigator. This is precisely another major challenge of the analysis of linguistic properties in contrast with acoustic parameters: the fact that there is no automatic way of analysing linguistic properties, since they can only be analysed by a linguist, and despite the important support of speech analysis software, the linguist’s ear is a fundamental part of the process. In any case, despite the fact that 26 samples have been analysed, future research will need to increase the number of subjects under study in order to infer more reliable conclusions.

Apart from the limitations that have been mentioned, the present dissertation also provides several contributions to the fields of variationist sociolinguistics and forensic linguistics. On the one hand, the present study has carried out a real-time study of fourteen phonological processes and has reached some conclusions regarding its behaviour in female and male speakers of SSBE. Many of these processes have been extensively studied in sociolinguistic and dialectological research, mainly t-glottalling, linking /r/ and yod coalescence. However, other processes have not been so much studied in relation to SSBE, in particular t-tapping, frication of /t/ and /k/, vowel alternation between [ɪ] and [ə] and insertion of [t] between [n] and [s]. Therefore, results obtained in the present dissertation add further information regarding these processes to the field of variationist sociolinguistics and dialectology, which can consider these results in future descriptions of SSBE. On the other hand, the study of the discriminatory potential of these processes also constitutes a major contribution to the field of forensic linguistics. Only the processes of frication of /t/ and /k/ have been approached from a forensic perspective, although not in relation to SSBE, however, the other processes had not, to my knowledge, been considered for forensic purposes. In this sense, the analysis of the fourteen variables proposed in a corpus that contains data on sixteen speakers and that is stratified according to measurement time –as a result of a real time study–, language contact and gender, provides an important contribution to the Base Rate knowledge, which constitutes one of the main challenges of current forensic linguistics (Turell 2010b). Research on the different factors for which the corpus is stratified has contributed to the field of forensic linguistics with reference data on group and individual tendencies in the production of the variables, and results for both the more discriminatory variables and the less discriminatory ones provide valuable data to be considered in forensic contexts. In addition to this, the proposal of the IIS as an innovative quantitative tool is also a major contribution to the field of forensic linguistics, which is constantly looking for more features to be analysed for forensic purposes, as well as more quantitative techniques that can complement qualitative inferences.

The research carried out on language contact and the effects that a permanent migratory situation can have on the phonology of a L1 is also an important innovation of the present dissertation. To my knowledge, no studies are available which analyse the L2→L1 effects on sociolinguistic variables such as the ones examined here, and there are no other studies which consider this issue for forensic purposes. Despite the fact that the corpus under study is quite limited due to several methodological shortcomings, as previously explained, some interesting conclusions could be inferred in relation to the speakers that were examined. On the one hand, L1 phonological processes do not seem to be as affected by a L2 as phonetic traits or features pertaining to other linguistic levels such as syntax. On the other hand, speakers who have been in a permanent migratory context, living away from their community of origin, seem to show differences in respect to other members who have remained in the community. Firstly, male speakers seem to adopt more prestigious or standard variants so as members of their community of destination can understand them better when speaking their L1. Secondly, speakers who have been away from their community seem to exhibit less inter-speaker variation, which means that they become similar to each other over the years. Finally, these speakers do not seem to participate from sound changes that originated in their community of origin once they had left it in the same way the members of their community do. These conclusions have implications from a sociolinguistic as well as from a forensic linguistic perspective and invite further research on the effects of a migratory situation in a L1 with particular emphasis on forensic applications.

Future studies to which this PhD may lead will need to keep focusing on the study of intra- and inter-speaker variation as well as defining other idiosyncratic variables. Other variables need to be formulated in relation not only to other languages, but also to other dialects and speech communities. One of the most immediate studies that could be carried out, which was not possible during the elaboration of the present PhD dissertation, is the application of the IIS to an existing corpus, called *DyVis*[34], which contains data that are, although not from real forensic cases, collected in simulated forensic contexts, and it also includes different styles (reading style, police interview and spontaneous conversation). This corpus would be suitable in the formulation of new variables that can be applied to SSBE –in this case to a younger generation since speakers are young adults– because it is controlled but it is also closer to the type of samples that can be found in a real forensic case. In this sense, since the final aim of the IIS protocol is that it is used in real forensic cases, future studies should start testing the IIS with real forensic data. Such further research will contribute to future applications of the IIS in real forensic cases, as well as to the establishment of a Base Rate Knowledge for different variables and different dialects and languages, which is of crucial importance to present-day forensic linguistics.

[34] The *DyVis* corpus (Dynamic Variability in Speech) is being compiled at the University of Cambridge as part of a research project whose principal investigator is Professor Francis Nolan. http://www.ling.cam.ac.uk/dyvis/

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Appendix

IIS RESULTS

IIS VALUE	Intra-speaker comparisons
0.9	*InSit*_m_1
0.87	*InSit*_m_4
0.86	*InSit*_f_2
0.85	*InSit*_f_1
0.85	*InSit*_f_2
0.85	*LanCon*_f_1
0.85	*LanCon*_m_2
0.84	*InSit*_m_2
0.82	*InSit*_f_4
0.82	*InSit*_f_5
0.8	*InSit*_m_3
0.79	*LanCon*_m_1
0.77	*InSit*_m_5

IIS VALUE		Inter-speaker comparisons (*InSit*-MT1)
0.84	MT1	***InSit*_f_4-*InSit*_f_1**
0.81	MT1	***InSit*_m_5-*InSit*_m_4**
0.81	MT1	***InSit*_f_4-*InSit*_f_2**
0.8	MT1	***InSit*_m_1-*InSit*_m_2**
0.79	MT1	***InSit*_m_4-*InSit*_m_1**
0.76	MT1	*InSit*_f_1-*InSit*_f_2
0.76	MT1	*InSit*_f_2-*InSit*_f_2
0.76	MT1	*InSit*_m_4-*InSit*_m_3
0.76	MT1	*InSit*_f_4-*InSit*_f_5
0.75	MT1	*InSit*_f_1-*InSit*_f_2
0.75	MT1	*InSit*_m_2-*InSit*_m_3
0.73	MT1	*InSit*_m_4-*InSit*_f_2
0.73	MT1	*InSit*_f_4-*InSit*_f_2
0.72	MT1	*InSit*_m_2-*InSit*_f_2
0.72	MT1	*InSit*_m_5-*InSit*_m_2
0.72	MT1	*InSit*_m_4-*InSit*_f_1
0.72	MT1	*InSit*_m_4-*InSit*_m_2
0.72	MT1	*InSit*_m_4-*InSit*_f_4
0.71	MT1	*InSit*_m_1-*InSit*_m_3
0.71	MT1	*InSit*_m_5-*InSit*_f_1
0.71	MT1	*InSit*_f_5-*InSit*_f_1
0.7	MT1	*InSit*_f_2-*InSit*_m_3
0.7	MT1	*InSit*_m_5-*InSit*_m_1
0.7	MT1	*InSit*_m_5-*InSit*_f_2
0.7	MT1	*InSit*_m_5-*InSit*_f_4
0.7	MT1	*InSit*_f_5-*InSit*_f_2
0.69	MT1	*InSit*_f_2-*InSit*_m_2
0.68	MT1	*InSit*_m_5-*InSit*_m_3
0.68	MT1	*InSit*_m_4-*InSit*_f_5
0.67	MT1	*InSit*_m_5-*InSit*_f_2
0.66	MT1	*InSit*_m_4-*InSit*_f_2
0.65	MT1	*InSit*_f_2-*InSit*_m_3
0.65	MT1	*InSit*_m_1-*InSit*_f_2
0.65	MT1	*InSit*_f_4-*InSit*_m_1
0.65	MT1	*InSit*_f_4-*InSit*_m_2
0.65	MT1	*InSit*_f_5-*InSit*_m_1
0.65	MT1	*InSit*_f_5-*InSit*_m_2
0.64	MT1	*InSit*_f_5-*InSit*_f_2
0.63	MT1	*InSit*_f_4-*InSit*_m_3
0.62	MT1	*InSit*_f_1-*InSit*_m_1
0.62	MT1	*InSit*_f_1-*InSit*_m_2
0.62	MT1	*InSit*_f_1-*InSit*_m_3
0.62	MT1	*InSit*_f_2-*InSit*_m_1
0.62	MT1	*InSit*_f_5-*InSit*_m_3
0.61	MT1	*InSit*_m_5-*InSit*_f_5

IIS VALUE		Inter-speaker comparisons (*InSit*-MT2)
0.82	MT2	***InSit*_m_2-*InSit*_m_3**
0.82	MT2	***InSit*_f_4-*InSit*_f_5**
0.79	MT2	***InSit*_f_4-*InSit*_f_2**
0.79	MT2	***InSit*_f_5-*InSit*_m_3**
0.78	MT2	***InSit*_f_4-*InSit*_m_3**
0.77	MT2	***InSit*_m_5-*InSit*_m_2**
0.77	MT2	***InSit*_m_5-*InSit*_m_3**
0.77	MT2	***InSit*_f_4-*InSit*_f_1**
0.76	MT2	*InSit*_f_5-*InSit*_f_2
0.75	MT2	*InSit*_m_1-*InSit*_m_3
0.75	MT2	*InSit*_m_4-*InSit*_f_4
0.74	MT2	*InSit*_m_5-*InSit*_m_1
0.74	MT2	*InSit*_f_5-*InSit*_f_1
0.73	MT2	*InSit*_f_1-*InSit*_f_2
0.73	MT2	*InSit*_f_2-*InSit*_f_2
0.73	MT2	*InSit*_m_4-*InSit*_m_3
0.72	MT2	*InSit*_m_5-*InSit*_f_5
0.71	MT2	*InSit*_f_1-*InSit*_f_2
0.71	MT2	*InSit*_m_5-*InSit*_m_4
0.71	MT2	*InSit*_f_5-*InSit*_m_2
0.7	MT2	*InSit*_f_2-*InSit*_m_2
0.7	MT2	*InSit*_m_1-*InSit*_m_2
0.7	MT2	*InSit*_m_4-*InSit*_f_1
0.7	MT2	*InSit*_f_4-*InSit*_f_2
0.7	MT2	*InSit*_f_4-*InSit*_m_2
0.7	MT2	*InSit*_f_5-*InSit*_f_2
0.69	MT2	*InSit*_f_2-*InSit*_m_3
0.69	MT2	*InSit*_f_2-*InSit*_m_3
0.69	MT2	*InSit*_m_5-*InSit*_f_4
0.69	MT2	*InSit*_f_5-*InSit*_m_1
0.68	MT2	*InSit*_f_1-*InSit*_m_3
0.68	MT2	*InSit*_m_4-*InSit*_f_5
0.68	MT2	*InSit*_f_4-*InSit*_m_1
0.67	MT2	*InSit*_m_5-*InSit*_f_1
0.67	MT2	*InSit*_m_5-*InSit*_f_2
0.66	MT2	*InSit*_m_2-*InSit*_f_2
0.65	MT2	*InSit*_f_1-*InSit*_m_2
0.64	MT2	*InSit*_f_1-*InSit*_m_1
0.64	MT2	*InSit*_m_4-*InSit*_m_1
0.64	MT2	*InSit*_m_4-*InSit*_f_2
0.63	MT2	*InSit*_m_4-*InSit*_m_2
0.62	MT2	*InSit*_m_5-*InSit*_f_2
0.61	MT2	*InSit*_m_4-*InSit*_f_2
0.56	MT2	*InSit*_m_1-*InSit*_f_2
0.55	MT2	*InSit*_f_2-*InSit*_m_1

IIS VALUE		Inter-speaker comparisons (mixing Subcorpora MT1)
0.82	**MT1**	***InSit_f_1-LanCon_f_1***
0.81	**MT1**	***InSit_f_4 -LanCon_m_2***
0.8	**MT1**	***InSit_f_4-LanCon_f_1***
0.8	**MT1**	***InSit_f_5-LanCon_f_1***
0.79	**MT1**	***InSit_f_2-LanCon_m_2***
0.78	**MT1**	***InSit_m_3-LanCon_m_2***
0.77	**MT1**	***InSit_m_4 -LanCon_m_2***
0.75	MT1	*InSit_f_5 -LanCon_m_2*
0.74	MT1	*InSit_m_1-LanCon_m_2*
0.74	MT1	*InSit_m_2-LanCon_m_2*
0.71	MT1	*InSit_f_1-LanCon_m_2*
0.71	MT1	*InSit_f_2-LanCon_m_2*
0.7	MT1	*InSit_f_2-LanCon_f_1*
0.69	MT1	*InSit_m_1-InSit_f_2*
0.69	MT1	*InSit_m_3-InSit_f_2*
0.68	MT1	*InSit_f_2-InSit_f_2*
0.68	MT1	*InSit_m_5-LanCon_m_2*
0.68	MT1	*InSit_m_4-LanCon_f_1*
0.68	MT1	*InSit_m_4 -LanCon_m_1*
0.66	MT1	*InSit_f_2-InSit_f_2*
0.66	MT1	*InSit_m_2-InSit_f_2*
0.65	MT1	*InSit_f_2-LanCon_f_1*
0.65	MT1	*InSit_m_5-LanCon_f_1*
0.63	MT1	*InSit_m_1-LanCon_f_1*
0.63	MT1	*InSit_f_4 -LanCon_m_1*
0.62	MT1	*InSit_m_2-LanCon_f_1*
0.61	MT1	*InSit_f_1-InSit_f_2*
0.61	MT1	*InSit_m_3-LanCon_f_1*
0.61	MT1	*InSit_f_5 -LanCon_m_1*
0.58	MT1	*InSit_m_5-LanCon_m_1*

IIS VALUE		Inter-speaker comparisons (*LanCon*)
0.83	**MT2**	***LanCon_f_2-LanCon_m_1***
0.8	**MT2**	***LanCon_f_2-LanCon_f_1***
0.79	**MT2**	***LanCon_f_1-LanCon_m_1***
0.78	**MT1**	***LanCon_f_1-LanCon_m_2***
0.76	MT2	*LanCon_f_1-LanCon_m_2*
0.76	MT2	*LanCon_m_3-LanCon_f_1*
0.76	MT2	*LanCon_m_4-LanCon_f_2*
0.75	MT2	*LanCon_m_3-LanCon_m_1*
0.75	MT2	*LanCon_m_3-LanCon_m_2*
0.75	MT2	*LanCon_m_3-LanCon_f_2*
0.75	MT2	*LanCon_m_4-LanCon_f_1*
0.74	MT2	*LanCon_m_4-LanCon_m_1*
0.73	MT2	*LanCon_m_3-LanCon_m_4*
0.72	MT2	*LanCon_m_4-LanCon_m_2*
0.69	MT2	*LanCon_f_2-LanCon_m_2*
0.68	MT2	*InSit_f_2-LanCon_m_2*
0.67	MT1	*InSit_f_2-LanCon_m_2*
0.63	MT1	*LanCon_f_1-LanCon_m_1*

IIS VALUE		Inter-speaker comparisons (mixing Subcorpora MT2)
0.87	**MT2**	***InSit_f_5-LanCon_f_1***
0.84	**MT2**	***InSit_f_4-LanCon_f_1***
0.83	**MT2**	***InSit_f_4 -LanCon_f_2***
0.82	**MT2**	***InSit_f_5 -LanCon_f_2***
0.82	**MT2**	***LanCon_m_3-InSit_m_3***
0.82	**MT2**	***LanCon_m_4 -InSit_m_3***
0.81	**MT2**	***InSit_f_1-LanCon_f_1***
0.81	**MT2**	***InSit_f_4 -LanCon_m_4***
0.81	**MT2**	***InSit_f_5 -LanCon_m_1***
0.81	**MT2**	***LanCon_m_3-InSit_m_2***
0.8	**MT2**	***LanCon_f_2 -InSit_f_2***
0.79	**MT2**	***InSit_f_4 -LanCon_m_1***
0.79	**MT2**	***InSit_f_5 -LanCon_m_3***
0.78	**MT2**	***LanCon_f_2-InSit_f_1***
0.77	**MT2**	***InSit_m_3-LanCon_f_1***
0.77	**MT2**	***LanCon_m_4 -InSit_m_2***
0.76	MT2	*InSit_m_3-InSit_f_2*
0.76	MT2	*InSit_m_4 -LanCon_m_3*
0.75	MT2	*InSit_f_5 -LanCon_m_2*
0.75	MT2	*LanCon_f_2 -InSit_m_3*
0.74	MT2	*InSit_f_2-LanCon_f_1*
0.74	MT2	*InSit_m_5-LanCon_m_4*
0.74	MT2	*InSit_m_4 -LanCon_f_2*
0.73	MT2	*InSit_m_1-LanCon_f_1*
0.73	MT2	*InSit_f_2-InSit_f_2*
0.73	MT2	*InSit_m_5-LanCon_f_2*
0.73	MT2	*InSit_m_4 -LanCon_m_2*
0.73	MT2	*LanCon_m_3-InSit_f_2*
0.73	MT2	*LanCon_m_4-InSit_f_1*
0.72	MT2	*InSit_m_4-LanCon_f_1*
0.72	MT2	*InSit_m_4 -LanCon_m_4*
0.72	MT2	*InSit_f_4 -LanCon_m_2*
0.71	MT2	*InSit_f_1-LanCon_m_2*
0.71	MT2	*InSit_m_1-LanCon_m_2*
0.71	MT2	*InSit_f_5 -LanCon_m_4*
0.71	MT2	*LanCon_m_4 -InSit_f_2*
0.7	MT2	*InSit_m_2-InSit_f_2*
0.7	MT2	*InSit_m_4 -LanCon_m_1*
0.7	MT2	*LanCon_m_3-InSit_f_2*
0.7	MT2	*LanCon_m_3-InSit_m_1*
0.7	MT2	*LanCon_m_4 -InSit_m_1*
0.7	MT2	*LanCon_f_2 -InSit_f_2*
0.7	MT2	*LanCon_f_2 -InSit_m_2*
0.69	MT2	*InSit_m_5-LanCon_f_1*
0.69	MT2	*LanCon_f_2 -InSit_m_1*
0.68	MT2	*InSit_f_2-LanCon_f_1*
0.68	MT2	*InSit_m_3-InSit_f_2*
0.68	MT2	*InSit_m_5-LanCon_m_1*
0.67	MT2	*InSit_m_1-InSit_f_2*
0.67	MT2	*InSit_m_2-LanCon_f_1*
0.67	MT2	*InSit_m_2-LanCon_m_2*
0.67	MT2	*InSit_m_5-LanCon_m_2*
0.67	MT2	*InSit_m_5-LanCon_m_3*
0.67	MT2	*LanCon_m_3-InSit_f_1*
0.67	MT2	*LanCon_m_4 -InSit_f_2*
0.66	MT2	*InSit_f_1-InSit_f_2*
0.64	MT2	*InSit_f_2-InSit_f_2*
0.64	MT2	*InSit_f_2-LanCon_m_2*
0.64	MT2	*InSit_f_4 -LanCon_m_3*
0.61	MT2	*InSit_f_2-LanCon_m_2*

Raters' sheet of answers for the perception test

Raters' sheet

Task: please say whether the realisation of the word you hear is more similar to **option A** or to **option B** (write **A** or **B** in the square) and rate your level of confidence from 1 (less confident) to 7 (more confident).

1. Vowel reduction (/ɪ/→/ə/) in weakened (pre-tonic) be-, de-, pre-, re-, e-.

Become:	option		1 2 3 4 5 6 7	**Depending:**	option		1 2 3 4 5 6 7
Before (1):	option		1 2 3 4 5 6 7	**Enough (1):**	option		1 2 3 4 5 6 7
Beginning:	option		1 2 3 4 5 6 7	**Equipment:**	option		1 2 3 4 5 6 7
Believe:	option		1 2 3 4 5 6 7	**Events:**	option		1 2 3 4 5 6 7
Beloved:	option		1 2 3 4 5 6 7	**Precise:**	option		1 2 3 4 5 6 7
Before(2):	option		1 2 3 4 5 6 7	**Prepared:**	option		1 2 3 4 5 6 7
Betrayed:	option		1 2 3 4 5 6 7	**Remark:**	option		1 2 3 4 5 6 7
Between:	option		1 2 3 4 5 6 7	**Returned:**	option		1 2 3 4 5 6 7
Decided:	option		1 2 3 4 5 6 7	**Enough (2):**	option		1 2 3 4 5 6 7
Definitive:	option		1 2 3 4 5 6 7	**Selection:**	option		1 2 3 4 5 6 7

2. Vowel reduction (/ɪ/→/ə/) in terminations -ible, -ily, -ity-

Charity:	option		1 2 3 4 5 6 7	**Possible:**	option		1 2 3 4 5 6 7
Community:	option		1 2 3 4 5 6 7	**Qualities:**	option		1 2 3 4 5 6 7
Forcibly:	option		1 2 3 4 5 6 7	**Reality:**	option		1 2 3 4 5 6 7
Identity:	option		1 2 3 4 5 6 7	**Sophisticated:**	option		1 2 3 4 5 6 7
Majority:	option		1 2 3 4 5 6 7	**Terrible:**	option		1 2 3 4 5 6 7
Opportunity:	option		1 2 3 4 5 6 7	**Visible:**	option		1 2 3 4 5 6 7
Possibly:	option		1 2 3 4 5 6 7	**Complicated:**	option		1 2 3 4 5 6 7

3. Palatalisation of [t, d, s, z] before [j] across word boundaries

About you:	option		1 2 3 4 5 6 7	**Once you**	option		1 2 3 4 5 6 7
As you:	option		1 2 3 4 5 6 7	**First year (2):**	option		1 2 3 4 5 6 7
Those years:	option		1 2 3 4 5 6 7	**Kid you:**	option		1 2 3 4 5 6 7
But you:	option		1 2 3 4 5 6 7	**Six years:**	option		1 2 3 4 5 6 7
Third year:	option		1 2 3 4 5 6 7	**Things you:**	option		1 2 3 4 5 6 7
Fist year (1):	option		1 2 3 4 5 6 7	**This year:**	option		1 2 3 4 5 6 7
Force your:	option		1 2 3 4 5 6 7	**Unless you:**	option		1 2 3 4 5 6 7
In case you:	option		1 2 3 4 5 6 7	**Was young:**	option		1 2 3 4 5 6 7
Last year:	option		1 2 3 4 5 6 7	**Would you:**	option		1 2 3 4 5 6 7
Makes you:	option		1 2 3 4 5 6 7	**Second year:**	option		1 2 3 4 5 6 7

4. Palatalisation of [t, d, s, z] before [j] word-internally

Stupid:	option		1 2 3 4 5 6 7	**Individuals:**	option		1 2 3 4 5 6 7
Costume:	option		1 2 3 4 5 6 7	**Opportunity:**	option		1 2 3 4 5 6 7
Educated:	option		1 2 3 4 5 6 7	**Produce:**	option		1 2 3 4 5 6 7
Education:	option		1 2 3 4 5 6 7	**Situation:**	option		1 2 3 4 5 6 7
Gradually:	option		1 2 3 4 5 6 7	**Student:**	option		1 2 3 4 5 6 7
Graduates:	option		1 2 3 4 5 6 7	**Studio:**	option		1 2 3 4 5 6 7
Under-graduates:	option		1 2 3 4 5 6 7				

5. Frication of /t/ in intervocalic position

Athletic:	option		1 2 3 4 5 6 7	**Later:**	option		1 2 3 4 5 6 7
Beat it:	option		1 2 3 4 5 6 7	**Letter:**	option		1 2 3 4 5 6 7
Beautiful:	option		1 2 3 4 5 6 7	**Majority:**	option		1 2 3 4 5 6 7
City:	option		1 2 3 4 5 6 7	**Promoting:**	option		1 2 3 4 5 6 7
Daughter:	option		1 2 3 4 5 6 7	**Sensitive:**	option		1 2 3 4 5 6 7
Eighty:	option		1 2 3 4 5 6 7	**Started:**	option		1 2 3 4 5 6 7
Eighties:	option		1 2 3 4 5 6 7	**Thirty:**	option		1 2 3 4 5 6 7
Forty:	option		1 2 3 4 5 6 7	**Water:**	option		1 2 3 4 5 6 7
Fanatical:	option		1 2 3 4 5 6 7	**Writer:**	option		1 2 3 4 5 6 7
Hurting:	option		1 2 3 4 5 6 7	**Writing:**	option		1 2 3 4 5 6 7

6. Frication of /k/ in intervocalic position

Back away:	option		1 2 3 4 5 6 7	**Record (1):**	option		1 2 3 4 5 6 7
Like it:	option		1 2 3 4 5 6 7	**Making (2):**	option		1 2 3 4 5 6 7
Looking (1):	option		1 2 3 4 5 6 7	**Record (2):**	option		1 2 3 4 5 6 7
Back into:	option		1 2 3 4 5 6 7	**Making (3):**	option		1 2 3 4 5 6 7
Second:	option		1 2 3 4 5 6 7	**Working (2):**	option		1 2 3 4 5 6 7
Back over:	option		1 2 3 4 5 6 7	**Walk on:**	option		1 2 3 4 5 6 7
Make up:	option		1 2 3 4 5 6 7	**Working (3):**	option		1 2 3 4 5 6 7
Making (1):	option		1 2 3 4 5 6 7	**Walking:**	option		1 2 3 4 5 6 7
Working (1):	option		1 2 3 4 5 6 7	**Making (4):**	option		1 2 3 4 5 6 7
Picking:	option		1 2 3 4 5 6 7	**Working (4):**	option		1 2 3 4 5 6 7