



The relevant population in forensic voice comparison: Effects of varying delimitations of social class and age

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Received 24 February 2014; received in revised form 20 October 2014; accepted 28 October 2014

Available online 5 November 2014

Abstract

In forensic voice comparison, the expert is typically instructed to compare the voices in a pair of offender and suspect samples. To appropriately evaluate the strength of such evidence, it is necessary to consider both the similarity between the samples and their typicality in the wider, relevant population. This paper considers the effects of different definitions of the relevant population when computing numerical likelihood ratios (LR), with specific regard to socio-economic class and age. Input data consist of cubic polynomial estimations of F1, F2 and F3 trajectories for /er/ in New Zealand English. Calibrated LRs are computed for a sociolinguistically homogeneous sets of test data using three systems comprising of training and reference data which, with regard to the social class or age of the test speakers, are Matched, Mismatched or Mixed. The distributions of LRs were found to be relatively stable across systems, although LRs for individual comparisons may be substantially affected. As expected, the Mismatched systems produced the worst validity, while the Matched systems produced the best validity. The implications of these results for voice comparison casework are considered in light of the paradox that one cannot know for certain the sociolinguistic community to which the offender belongs.
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Keywords: Likelihood ratio; Relevant population; Sociophonetics; Socio-economic class; Age

1. Introduction

Forensic voice comparison (FVC) typically involves comparison between a recording of the voice of an unknown offender (e.g. in a covertly recorded drug deal) and a recording of the voice of a known suspect (from a police interview in the UK). The expert speech evidence is used by the trier-of-fact, along with other evidence in the case, in establishing whether the voices belong to the same or different individual(s). The likelihood ratio (LR) is now widely accepted across forensic disciplines as the logically and legally correct framework for evaluating the strength of such evidence (Robertson and Vignaux, 1995; Aitken and Taroni, 2004). The LR is the ratio of the

probability (p) of the evidence (E) assuming the prosecution proposition (H_p) and the probability of the evidence assuming the defence proposition (H_d). The LR can be expressed as (1):

$$\frac{p(E|H_p)}{p(E|H_d)} \quad (1)$$

In FVC, the prosecution proposition may be expressed as: *the source of the offender recording is the suspect*. Therefore, the numerator of the LR is equivalent to the similarity between the offender and suspect samples. The defence proposition, in general terms, can be expressed as: *the source of the offender recording is not the suspect but some other speaker from the relevant population*. The denominator is equivalent to the typicality of the offender sample (i.e. the evidence) with respect to the relevant population. Therefore, the LR is the answer to a specific question

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(Morrison, 2009a), and the definition of the relevant population is an essential element in determining, specifically, what that question is.

In principle, the relevant population is defined by the defence proposition, which may vary in specificity depending on the case. For example, the defence claim might be that the offender was not their client but his brother. In such a circumstance, analysis need only be made of the speech of the two individuals concerned. Unfortunately, narrowly-defined defence propositions like this are rare in casework. It is far more common that the defence offer a non-specific alternative proposition (e.g. *the offender is not the defendant, it was someone else*) or no alternative at all. In most FVC cases it is therefore important that the analyst considers the appropriate definition of the relevant population (Morrison et al., 2012; Morrison and Stoel, 2014; Morrison 2014). This is highlighted by Morrison et al. (2012) who provide an empirical demonstration of better system performance when selecting speakers to represent the relevant population based on an assumption about what the relevant population is compared with selecting speakers randomly from a larger database.

In the absence of a specific defence proposition, the concept of *logical relevance* (Kaye, 2004) has been used to define the default relevant population (Morrison et al., 2012 propose an alternative based on speaker similarity; for issues with this see Gold and Hughes, 2014). Logical relevance refers to the grouping variables which are known to affect the frequency of observations in the population at large (e.g. ethnicity in forensic DNA analysis). Since the relevant population is defined by the defence proposition, logical relevance must account for characteristics of the offender rather than the suspect. However, in forensic casework we face a paradox: the community of which the offender is a member cannot be established without knowing the offender's identity, yet this is the very issue at stake in the case. As a consequence, the logically relevant factors which define the relevant population cannot themselves be known for certain. It is therefore usually the case that pragmatic decisions, presumably based on some sort of linguistic analysis, are taken by the expert to permit analysis to be undertaken.

The offender sample can be analysed to make reasonable estimates of the speech community (or communities) to which the offender belongs. In effect this means that the analyst must produce a speaker profile of the offender (Ellis, 1994; French and Harrison, 2006; Jessen, 2008). In FVC the default assumption about the defence proposition has predominantly been that: *the voice in the offender sample does not belong to the suspect, but to another same-sex speaker of the language* (Rose, 2004). Thus, the offender profile rarely extends beyond identifying the speaker's sex and main language(s) or dialect(s) (Rose, 2004). This default definition of the relevant population, limited to sex and broadly-defined regional background (dialect or language), has been used extensively in LR-based research

(e.g. Kinoshita, 2002; Rose et al., 2006; Rose, 2006; Morrison, 2009b) and casework (Rose, 2013).

However, speech is a complex form of forensic evidence. As is well known in phonetics and linguistics, particularly sociolinguistics and sociophonetics, speech is affected by a remarkably wide range of factors that generate both within- and between-speaker variation (Rose, 2002; Foulkes and Docherty, 2006; French et al., 2010). Systematic variation is found as a function of social factors such as the speaker's socio-economic class, age, and ethnicity, the social networks and communities of practice in which the speaker participates, and a very broad range of factors that can be collectively labelled 'speech style', which include variation related to topic, formality, self-consciousness, interlocutor, conversational function, and physical setting. Further sources of variation relate to short- and long-term health issues, and technical effects introduced by recording and transmission media. Since these factors can affect linguistic and phonetic variables, it is imperative that appropriate control is exercised over data used in any analysis: incorrect or inappropriate delimitation of extralinguistic factors could in principle yield misleading LRs.

The focus of the present discussion is variation related to sociolinguistic factors. Linguistic-phonetic variables are socially stratified both within and between regional communities (Labov, 1971). This has important implications for FVC. Different variables are often socially stratified in different ways. For example, /u:/-fronting in English (the vowel in *goose*, *boot*, etc.) is a widespread change in progress, and is generally correlated with speaker age. By contrast, another on-going change, /əʊ/-fronting (in *goat*, *boat*, etc.), correlates with both age and speaker sex, being led by young females (Haddican et al., 2013). Thus, based on observed sociolinguistic patterns, analysis of /u:/ in a forensic case would need to control for speaker age, while analysis of /əʊ/ would need to take account of both age and sex. Further, the social stratification of a variable may differ according to regional variety. For instance, the vowels /əʊ/ (*goat*, *boat*) and /eɪ/ (*face*, *bait*) carry a great deal of social conditioning in the north-east of England, but much less so in the south-east of England (Watt, 2000).

Despite such complexity, the potential logical relevance of socio-indexical factors beyond sex and language is rarely considered in LR-based analysis (exceptions include Loakes, 2006; Zhang et al., 2011; Hughes and Foulkes, 2014). Furthermore, an underlying assumption of the Rose (2004) default is that sex and language information is readily accessible from the offender sample. However, many cases present themselves where even speaker sex and the language being spoken are not trivial issues (examples are cited by French et al. (2010, p. 145) and Foulkes and French (2012, p. 569)). Conversely, it will often be possible for the sociolinguistically-informed expert to determine considerably more demographic information about the offender, beyond sex and language. This paper therefore explores the extent to which different delimitations of two important sociolinguistic factors – socio-economic

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