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SPEECH CLARITY AND TOPIC RELEVANCE: FORENSIC ANALYSIS IN VARYING ACOUSTIC ENVIRONMENTS

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ABSTRACT

In forensic linguistics, a field dedicated to the interface between language and law, phonetics stands out as a key discipline. In this regard, the present study seeks to emphasize the significance of the interface between phonetics and acoustics, two areas focused on the properties of voice and acoustic signals, and to expand this field of research, particularly within the context of speech clarity.

The methodology involves recording conversations between men and women on various topics to analyze how discourse conditions affect voice properties, such as pitch and fundamental frequency. Additionally, it examines how these characteristics change when the conversation shifts to a confession, particularly in a simulated crime scenario.

This research aims to identify how emotional or psychological factors, such as tension or fear, as well as context, may alter the acoustic features of the voice and influence the perception and comprehension of speech, contributing to the identification of vocal cues useful in forensic contexts. This approach proposes a novel perspective on the analysis of testimony and interrogation techniques, emphasizing the relevance of the interface between phonetics and acoustics for the interpretation of verbal behaviors in judicial investigations.

Keywords: *forensic phonetics, speech clarity, acoustic environment, topic change.*

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1. INTRODUCTION

Forensic linguistics plays a crucial role in legal investigations by analyzing language to aid in justice. Within this field, phonetics and acoustics are essential for understanding voice properties and their implications in forensic contexts. The relationship between these two sciences is very close, although there is currently limited interdisciplinarity between them.

Forensic phonetics is defined by San Segundo Fernández (2023) as the discipline responsible for any legal application of phonetics; that is, the application of general phonetic concepts and methods to the investigation and resolution of crimes in which speech or voice are in some way involved [1]. On the other hand, forensic acoustics is the branch of science that focuses on sound and its environment (recordings, sound systems, software...) in relation to justice and criminal investigations. Although phonetics primarily deals with the voice and acoustics with sound and its surrounding environment, the combined study of both should be essential in forensic research, as sound and environmental factors can influence vocal characteristics.

In this line, there are very few studies that take into account the sound of the environment when analysing the human voice. Jokinen (2017), comments that, in an everyday communication situation, i.e. a communication produced face-to-face, the speaker would modify their speech according to whether the environment is quieter or noisier in an unconscious way to ensure that the listener hears them correctly and to achieve a correct flow of the communication [2]. Authors such as Hollien (2001) or Bottalico and Graetzer (2015) also highlight the importance of contextual assessment in forensic phonetics, underlining the idea that the environment in which a recording is made can influence the acoustic characteristics of the voice [3] [4].

However, after a systematic review of the literature, almost all research focuses on the voice or the impact of the environment on the voice, none focuses on the impact of discourse on the acoustic characteristics of the human voice.

2. METHODOLOGY

In this pilot study, the recorder NAGRA Lino (24 bit/96 kHz DIGITAL RECORDER [1]) was used for the voice recordings of the participants. Seven men and seven women were recorded having conversations in pairs of two in two different environments, a quiet environment, that is, an empty room (between 40 dB and 50 dB), and a noisy environment, that is, a coffee shop (between 70 dB and 80 dB). These conversations were about 4 broad and distinct topics: hobbies, politics, religion and the confession of an alleged (made up) crime [2].

In terms of the last topic, alleged (made up) crime, each participant had to invent two crimes, one for each setting, that they had committed in the last few weeks and that they were worried or afraid of being caught by the police. The topics have been repeated in both environments, but always talking about different concepts.

The methodology followed in this research is based on a quantitative analysis. From this point of view, the clarity of the voice was analysed with the software Praat, a software dedicated to phonetic analysis, analysing the fundamental frequency and intensity of the voice.

3. RESULTS

In terms of the results obtained, looking first at fundamental frequency according to space and subject matter [3], we obtained the following data with the software Praat:

Table 1. Fundamental frequency (Hz) of female participants according to discourse in a quiet space

Participant	Hobbies	Politics	Religion	crime
Female1	153.37	189.62	192.82	179.59
Female2	203.34	191.56	218.90	222.03
Female3	229.27	246.83	232.70	277.58
Female4	226.98	214	211.66	190.89
Female5	236.41	229.19	204.86	201.54
Female6	180.77	172.42	198.35	195
Female7	195.09	201.10	229.18	185.43

Table 2. Fundamental frequency (Hz) of male participants according to discourse in a quiet space

Participant	Hobbies	Politics	Religion	crime
Male1	206.23	125.93	130.34	169.88
Male2	122.76	117.06	158.43	118.71
Male3	198.17	189.98	175.39	175.57
Male4	141.40	185.14	164.79	202.38
Male5	224.53	165.42	172.21	210.48
Male6	155.91	159.43	167.13	166.89
Male7	112.59	213.59	203.89	123.46

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[2] When we talk about a crime, we are referring to a crime (or something illegal) invented by each participant.

[3] Due to space limitations in the tables that will appear in following section, we leave out the word "crime", but we always have to keep in mind that we are referring to a non-real crime, invented by each of the participants.

Table 3. Fundamental frequency (Hz) of female participants according to discourse in a noisy space

Participant	Hobbies	Politics	Religion	crime
Female1	204.31	213.59	202.81	203.85
Female2	226.32	247.02	243.65	221.64
Female3	284.65	244.48	256.98	240.14
Female4	248.03	204.94	200.31	241.40
Female5	246.03	236.50	223.95	210.44
Female6	167.59	186.98	211.86	229.66
Female7	226.81	213.84	243.45	233.85

Table 4. Fundamental frequency (Hz) of male participants according to discourse in a noisy space

Participant	Hobbies	Politics	Religion	crime
Male1	151.70	126.53	165.03	162.45
Male2	131.03	171.63	139.80	134.29
Male3	146.66	155.71	174.38	158.57
Male4	167.11	213.03	181.32	142.98
Male5	195.70	225.86	229.23	184.59
Male6	244.00	164.19	138.83	185.54
Male7	127.79	152.69	142.86	126.13

As for intensity, Praat gave us the following results:

Table 5. Intensity (dB) of female participants according to discourse in a quiet space

Participant	Hobbies	Politics	Religion	crime
Female1	73.78	74.38	72.27	74.75
Female2	70.98	72.51	71.49	74.63
Female3	72.35	72.44	72.98	71.80
Female4	73.96	71.59	72.73	70.80
Female5	74.32	74.40	75.09	75.35
Female6	71.24	69.67	69.24	72.63
Female7	69.84	72.42	73.38	73.73

Table 6. Intensity (dB) of male participants according to discourse in a quiet space

Participant	Hobbies	Politics	Religion	crime
Male1	72.92	74.31	73.46	70.81
Male2	68.13	69.82	70.55	65.83
Male3	71.90	69.38	70.50	71.36
Male4	73.85	73.11	71.93	71.81
Male5	73.20	74.96	73.82	71.78
Male6	72.77	73.03	72.57	70.57
Male7	68.83	65.59	65.89	65.75

Table 7. Intensity (dB) of female participants according to discourse in a noisy space

Participant	Hobbies	Politics	Religion	crime
Female1	74.65	73.60	71.78	73.64
Female2	74.28	74.01	74.20	74.36
Female3	71.68	74.71	73.46	71.37
Female4	75.11	73.26	74.52	74.11
Female5	75.08	73.77	72.59	71.98
Female6	73.32	74.23	74.05	70.89
Female7	74.18	74.74	74.09	72.51

Table 8. Intensity (dB) of male participants according to discourse in a noisy space

Participant	Hobbies	Politics	Religion	crime
Male1	72.74	73.02	75.15	75.02
Male2	73.63	73.86	72.79	73.31
Male3	73.44	72.41	74.30	73.18
Male4	75.51	75.47	75.60	74.80
Male5	75.19	75.39	72.77	74.51
Male6	73.15	73.82	75.22	73.07
Male7	74.55	73.97	74.86	73.97

4. DISCUSSION

Upon examination of the acoustic data obtained in this study, marked inter-individual variation in f_0 is evident among participants of the same biological sex. These variations suggest that speech-related prosodic modulation, particularly with respect to f_0, may be influenced not only by topic but also by individual speaker characteristics and possibly emotional or cognitive engagement with the subject matter.

For the female participants in quiet recording conditions, the following patterns emerged: Female1 and Female7 demonstrated elevated f_0 values during discussions on politically and religiously charged topics, whereas their f_0 values were comparatively lower when addressing less emotionally charged or more personal subjects such as hobbies or criminal confessions. Female2 exhibited the highest f_0 during speech involving crime-related content, followed by moderate elevation during discussions about hobbies, and the lowest f_0 values when engaging in dialogue on politics and religion. Female3's highest f_0 values were recorded during criminal confessions, followed by topics concerning politics and religion, suggesting an emotional or cognitive response to the gravity of these themes. Female4 and Female5 showed a contrasting pattern, with elevated f_0 while discussing hobbies and moderate levels during political conversations; the lowest f_0 values were recorded during crime-related speech. Notably, Female6 exhibited an anomalous trend, characterized by elevated f_0 during religious discourse and reduced values during political speech, potentially indicating differing affective responses to these topics.

Among the male participants, similar variability was observed. Male1 and Male5 displayed increased values when speaking about hobbies and criminal confessions, while notably reduced f_0 was observed during discourse on religion and politics. In contrast, Male2 and Male7 demonstrated elevated f_0 levels during discussions on controversial topics—specifically politics and religion—while their f_0 values decreased during speech related to hobbies or crime, possibly reflecting increased arousal or cognitive load associated with the former. Male3 presented elevated f_0 when discussing hobbies and politics, with similar and lower values for religious and crime-related content. Male4 showed a preference for higher f_0 when addressing themes of criminal confession and political discourse. Finally, Male6 exhibited the highest f_0 values during speech involving crime and religion, suggesting a heightened prosodic response to these themes.

In acoustically challenging or noisy environments, notable inter-individual variation in f_0 was also observed among female and male participants, suggesting topic-dependent prosodic modulation under adverse listening conditions.

Starting with female participants, it is remarkable to say that, while in quiet spaces there were more coincidences between some of the participants, it was not the case in noisier spaces. Female1 exhibited elevated f_0 during discussions on politics, whereas lower f_0 values were observed when addressing hobbies, religion, and crime—these three topics showing approximately similar values. Female2 showed increased f_0 when speaking about politics and religion, with reduced values during

conversations involving hobbies and crime. In the case of Female3, higher f_0 was observed during discussions on hobbies and religion, whereas lower values occurred when addressing politics and crime, the latter two yielding approximately equivalent measurements. Female4 displayed higher f_0 when discussing hobbies and during crime confessions, while lower values were recorded during more controversial themes such as politics and religion. Female5 presented elevated f_0 during speech related to hobbies and politics, followed by religion, with the lowest values observed during discussions about crime. Female6 and Female7 both exhibited increased f_0 while discussing crime and religion. However, their patterns diverged in other domains: Female6 showed markedly lower f_0 values when speaking about hobbies, whereas Female7 demonstrated a pronounced drop in f_0 during political discourse.

To conclude the analysis of f_0 patterns, observations regarding male participants also reveal considerable inter-individual variation influenced by the thematic content of speech, even under acoustically challenging conditions.

Male1 exhibited the highest f_0 during discussions on religion, followed by crime and hobbies, with the lowest values recorded during political discourse. Male2 showed elevated f_0 in political speech, while significantly lower values were observed across religion, crime, and hobbies. Among these, hobbies elicited the lowest f_0, although the three themes yielded relatively similar values overall. Male3 demonstrated the lowest f_0 when discussing hobbies, whereas the highest values were recorded during speech related to religion and crime confessions. Male4 and Male5 both presented elevated f_0 when addressing controversial themes such as politics and religion, and comparatively lower values during discussions about hobbies and criminal confessions. Male6 exhibited the highest f_0 when discussing hobbies, while lower values were associated with crime confessions and controversial topics such as politics and religion. Notably, the lowest f_0 value for this participant occurred during religious discourse. Finally, Male7 demonstrated the highest f_0 values when speaking about politics and religion, while speech related to hobbies and crime yielded the lowest values.

These observations further support the hypothesis that f_0 is modulated not only by environmental conditions but also by the semantic and emotional nature of the spoken content [4], particularly in relation to socially sensitive or controversial themes. In this sense, we can also say that these findings reinforce the notion that topic type, particularly its emotional or social salience, which affects every individual in distinct manners, continues to influence prosodic features. We should also take into account that, in this type of analysis, personal factors such as shyness or shamelessness also come into play.

However, in terms of intensity, we observe that there is not a significant difference between topics for both men and women, with levels remaining between 65 and 75 dB in quiet environments and between 70 and 75 dB in noisier environments.

5. CONCLUSION

In conclusion, as elaborated in the discussion section, while f_0 provides clear evidence of how topic relevance influences individual speakers, suggesting that variations in f_0 when talking about topic change are largely driven by interpersonal or speaker-specific factors, intensity appears to remain relatively stable across topics. This indicates that, within the scope of this study, intensity does not serve as a significant prosodic marker for topic-related variation.

However, it is important to emphasize that, although this is a pilot study, the results suggest that the observed prosodic changes across different topics are more inherently linked to individual speaker characteristics rather than to broader sociolinguistic variables such as age group or sex.

Therefore, it can be said f_0 emerges as a more sensitive and informative parameter for analyzing the prosodic effects of topic salience, whereas intensity contributes less meaningfully to differentiating thematic content in speech.

A potential avenue for future research would involve the analysis of controversial versus relaxed topics in a more controlled environment, such as the semi-anechoic chamber at the Institute for Research in Applied Linguistics at the University of Cádiz, using monologic speech from a single speaker. While the conversational format adopted in the present study was effective in eliciting spontaneous and natural speech, it introduced certain limitations to the analysis—particularly due to frequent speaker interruptions, which affected the continuity and clarity of the recordings.

[4] It is important to note that the results obtained in the hypothetical crime confession topic may be due to the fact that the crime is fabricated and not actually committed, and participants present it as a fictional scenario without fully assuming the role.

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