

Central auditory processing skills and speaker comparison in forensic analysis

Habilidades de processamento auditivo central e exame pericial de comparação de locutor

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ABSTRACT

Purpose: to describe which abilities of central auditory processing are more frequently related for the group of specialists to the performance of the speaker comparison test (CL), traditionally performed by forensic experts. **Methods:** a prospective, descriptive study with quantitative and qualitative analysis and data were obtained through a consensus of experts. Five speech therapists participated in the meeting, two specialists in audiology (EA), two specialists in voice (VS), and an expert speech therapist (FP). The meeting was held virtually and synchronously, lasting 1 hour and 30 minutes. The tasks performed during the Speaker Comparison (LC) exam were considered from a protocol available in the literature. The AEs received explanations about each of the tasks and were asked to discuss which auditory processing skills (ACP) would be involved in the performance of each of them. **Results:** seven PAC skills were considered in the experts' meeting as essential for the tasks performed in the CL exam. Temporal ordering was the most cited skill, being present in six tasks, and the speech material transcription task is the one that requires more skills from the PAC. **Conclusion:** Seven PAC skills were considered in the experts' meeting as essential for the tasks performed in the CL exam. Temporal ordering was the most cited skill, being present in six tasks, and the speech material transcription task is the one that requires more skills from the PAC.

Keywords: Auditory perception; Speech; Speech perception; Voice recognition; Vocal quality

RESUMO

Objetivo: descrever quais são as habilidades auditivas do processamento auditivo central mais frequentes, relatadas por um grupo de especialistas para a realização do exame de Comparação de Locutor, tradicionalmente realizado por peritos forenses. **Métodos:** estudo prospectivo, descritivo, com análise quantitativa e qualitativa. Os dados foram obtidos por meio de um consenso de especialistas. Participaram da reunião cinco fonoaudiólogos, sendo dois especialistas em audiolgia, dois especialistas em voz e uma fonoaudióloga perita. A reunião foi realizada de forma virtual e síncrona, com duração de uma hora e 30 minutos. As tarefas realizadas durante o exame de Comparação de Locutor foram consideradas a partir de um protocolo disponível na literatura. As especialistas em fonoaudiologia receberam explicações a respeito de cada uma das tarefas e foram solicitadas a discutir sobre quais as habilidades do processamento auditivo central estariam envolvidas na execução de cada uma delas. **Resultados:** sete habilidades foram consideradas na reunião dos especialistas como imprescindíveis para as tarefas realizadas no exame de Comparação de Locutor. A ordenação temporal foi a habilidade mais citada, podendo estar presente em seis tarefas, e a tarefa de transcrição do material de fala foi mencionada como sendo a que necessita de mais habilidades do processamento auditivo central. **Conclusão:** Sete habilidades foram consideradas na reunião dos especialistas como imprescindíveis para as tarefas realizadas no exame de Comparação de Locutor. A ordenação temporal foi a habilidade mais citada, podendo estar presente em seis tarefas e a tarefa de transcrição do material de fala foi mencionada como sendo a que necessita de mais habilidades do processamento auditivo central.

Palavras-chave: Percepção auditiva; Fala; Percepção da fala; Reconhecimento de voz; Qualidade de voz

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INTRODUCTION

Forensic science is multidisciplinary, and its main role is to provide information based on specialized technical-scientific knowledge, with evidentiary value in legal investigations^(1,2). Forensic science knowledge has raised the interest of speech-language-hearing pathology in recent years, especially after forensic speech-language-hearing analysis was recognized as one of the profession's specialties. Speaker comparison (SC) stands out among forensic audio recording examinations. This complex task analyzes speech materials to determine whether they come from the same individual⁽³⁾, based on their voice/speech properties. Speech material is generally divided between questioned material (when the speaker's identity is unknown) and standard material (when the speaker's identity is known). This examination poses various challenges, the first of which is the difference in how each recording was collected since the questioned material can be obtained through telephone or in adverse contexts with excessive environmental background noise.

SC knowingly requires advanced technical knowledge in linguistics (e.g., acoustic phonetics, articulation, and sociolinguistics) and speech-language-hearing pathology (e.g., auditory-perceptual evaluation of voice). A study in worldwide experts revealed that they mostly perform SC with a combination of methods (acoustic, auditory-perceptual, and automated analysis)⁽⁴⁾.

Since various acoustic analysis and auditory-perceptual evaluation procedures are premised on refined auditory material analysis, the auditory pathway may be greatly related to forensic experts' performance in this task. Specifically, auditory processing skills allow the subject to recognize and interpret the auditory information they receive⁽⁵⁾, which makes them essential for reliable procedures. To date, no studies have been found that seek to relate auditory skills with forensic activities, particularly SC.

This communication aimed to describe the most frequent central auditory processing (CAP) skills, as reported by a group of SC specialists, traditionally performed by forensic experts.

METHODS

This descriptive prospective study based on quantitative and qualitative analysis obtained data from an expert consensus. The project was approved by the Ethics Committee of the Federal University of Paraíba (UFPB), under evaluation report no. 4,937,815/2021. Five speech-language-hearing pathologists participated in the meeting – two of them specializing in audiology (AS), two in voice (VS), and one in forensics (FS). The sample was recruited by convenience. The criteria to include AS were clinical and teaching experience in CAP for at least 10 years to ensure advanced knowledge of the study topic. VS and FS participants did not work in CAP; rather, their inclusion criteria were experience in voice (VS) or forensics (FS) to ensure different perspectives on the study topic. The topic and objective of conducting a consensus study were previously presented to the experts via email, along with the invitation to participate. The meeting, held synchronously online, was recorded by one of the expert group members

and had been scheduled to last 1 hour and 30 minutes. No subsequent opportunity was provided for participants to discuss the content of the meeting. All participants signed an Informed Consent Form.

SC tasks were based on a protocol available in the literature⁽⁶⁾, didactically divided into eight after discussion by the research team (VS and FS), namely: a) preliminary auditory-perceptual evaluation of the speech material; b) evaluation of the speech speed; c) transcription of the speech material; d) speech comprehension with background noise; e) verification of overlapping voices; f) comparison of acoustic properties of similar phonemes; e) identification of idiosyncrasies; g) assessment of voice quality; h) evaluation of prosodic-acoustic aspects.

Next, the AS received explanations about each task and were asked to discuss which auditory processing skills⁽⁷⁾ they would require. They also indicated what training would be necessary to develop or improve these skills. They answered in consensus; when they had different opinions, they discussed the issue until they reached a consensus. Nevertheless, there were no points of disagreement they could not resolve during the meeting. The VS and FS presented the SC tasks in detail before the discussion began, and questions on such task procedures were immediately resolved during the discussions at the meeting.

RESULTS

The expert opinion results indicated that SC tasks involve the following seven CAP skills: closure, figure-ground, temporal resolution, temporal ordering, binaural integration, binaural separation, and auditory memory. Temporal ordering was the most cited skill for the different tasks (six times), while the transcription of speech material was the task that, according to experts, requires the most CAP skills (five skills).

Chart 1 presents the SC tasks and the CAP skills related to them.

DISCUSSION

SC is a complex examination with various procedures, whose analysis stages require prior advanced theoretical/practical knowledge. Besides the intrinsic SC challenges (e.g., obtaining speech material), voice production is multidimensional and can be affected by several aspects, such as physiological, anatomical, and psychosocial ones, making it a complex and variable phenomenon that must be analyzed comprehensively. Perceptual evaluation is considered the gold standard for voice assessment and enables the identification and quantification of vocal characteristics^(8,9).

Knowledge of these processes allows us to infer that auditory information is crucial for voice quality analysis and, therefore, CS examination. Thus, listening skills are a key point in this process, helping perform the examination better and produce more qualified evidence.

The current literature lists eight auditory skills⁽¹⁰⁾, and almost all of them are intrinsically related to the many SC procedures, according to the experts' opinion in this study – which highlights the importance of improving/training these skills.

Chart 1. Speech comparison tasks and central auditory processing skills related to them

TASKS	SKILLS
1 - The expert receives speech material (recording) for auditory-perceptual evaluation (listening to the recording) to classify the overall quality of the audio file (very high, high, medium, poor, or very poor quality). The expert must classify the material from perfectly audible to inaudible and, based on this, decide whether the speech material can be used for forensic purposes.	Auditory closure
	Figure-ground
2 - The expert compares the speech speed/utterance rate between the questioned material and the standard material and analyzes whether there are similarities or differences between the samples.	Temporal resolution
	Temporal ordering
3 - The expert receives speech material (recording) and transcribes it into written text, whether in standard orthographic, phonographic, and/or phonetic transcription, which involves the perception of different dialectal characteristics.	Auditory closure
	Figure-ground
	Temporal ordering
	Binaural integration
4 - The expert receives speech material (recording) with background noise in different frequency ranges. Then, they listen to it and transcribe what is being said.	Binaural separation
	Auditory closure
5 - The expert receives speech material (recording) with overlapping voices (more than one person speaking at the same time). Then, they listen to it and transcribe the speech of only one of the speakers out of the various overlapping voices.	Figure-ground
	Binaural integration
	Binaural separation
6 - The expert receives speech material (recording) to compare acoustic-articulatory characteristics of the same phoneme produced by the speaker in different contexts (different words) to verify whether there is a pattern in their speech production.	Temporal resolution
	Temporal ordering
7 - The expert receives speech material (recording) to identify linguistic (e.g., vocabulary and regional idioms), phonetic (e.g., distortions, omissions, and substitutions), voice quality (e.g., hoarseness and breathiness), and prosodic idiosyncrasies (e.g., intonation and fluency).	Temporal resolution
	Temporal ordering
8 - The expert receives speech material (recording) to analyze the voice quality of the questioned speaker and compare it with samples from the standard speaker, observing whether there are similarities and differences between them.	Temporal ordering
9 - The expert receives speech material (recording) to analyze prosodic-acoustic parameters, considering the fundamental frequency, intensity, and duration of speech sounds in the questioned material in comparison with the standard material.	Temporal ordering

Transcribing speech material – which is basic and essential to every SC examination – is seemingly the stage that recruits the most listening skills. Failures at this stage can compromise other ones in the process, as they imply inadequate consideration of what is heard with what is seen in a spectrogram, for example.

Temporal ordering was the auditory skill most present in the different tasks, being described as important for speech speed comparison between the questioned material and the standard material; phonographic and/or phonetic transcription; comparison of acoustic-articulation characteristics of the same phoneme produced by the speaker in different contexts; identification of idiosyncrasies; analysis of vocal quality; and analysis of prosodic-acoustic parameters in the samples. This skill, related to processing speed, involves the perception and processing of two or more auditory stimuli in the order in which they occur in time⁽⁷⁾. The auditory-perceptual evaluation of voice,

for instance, requires the comparison of different aspects and their gradients by detecting elements such as roughness, breathiness, strain, pitch, and loudness⁽¹⁰⁾.

It is important to highlight that the experts did not raise any aspects related to CAP tests and their standardizations in the meeting. The answers provided in this meeting were based on the participating experts’ experience and need validation from other experts, which is intended for further studies.

CONCLUSION

The experts considered seven CAP skills essential for the SC tasks. Temporal ordering was the most cited one, being present in six tasks, and the transcription of speech material was mentioned as the task that requires the most CAP skills.

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