Gunshot recordings from a criminal incident: Who shot first?

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Outline

• Introduction
  – Audio forensic analysis
  – Gunshot acoustics
  – Forensic acoustical interpretation

• Example 1: who shot first?

• Example 2: who shot first?

• Conclusion
Introduction

• **Audio Forensics** is the field of **forensic science** relating to the acquisition, analysis, and evaluation of sound recordings that may ultimately be presented in court or some official venue.

• Primary forensic concerns:
  
  i. **authenticity**
  
  ii. **enhancement**
  
  iii. **interpretation and documentation**
Gunshot Acoustics

• Confined combustion of gunpowder propels the bullet out of the gun barrel.
• The explosive gases expand rapidly behind the bullet causing the *muzzle blast*.
• The muzzle blast can exceed 150dB in the vicinity of the firearm.
• The muzzle blast is directional.
Gunshot Acoustic Evidence Near the Shooter

- Mechanical Action
- Muzzle Blast
- Supersonic Projectile (shock wave)
- Surface Vibration
- Reflections

Note:
Limitations of microphone and audio recording chain (e.g., codecs)
Example Gunshot Recording

- Muzzle Blast
- Shock Wave
- Muzzle Reflection
- Shock Wave Reflection

Time [ms]
Amplitude [linear scale]
9mm Handgun (anechoic)
Forensic Example 1

- Two armed perpetrators on a city street
  - Witnesses and evidence that both individuals shot handguns, *but* not clear who fired first.
  - One of the individuals died due to gunshot wound, the other individual survived and claims self defense.
  - A residential surveillance system recorded the sound of gunfire, but not video of the scene.
  - Who shot first?
First two shots...

Echo: 0.54 s
First two shots (cont.)
Echo 0.54 seconds

- Air temperature 16 celsius: \( c = 341 \text{ m/s} \)
- 0.54 seconds == 184 meters
Street Geometry

Distance: ~90 meters

Additional path: ~180 meters
Echo 0.54 seconds

- Echo explanation fits geometry, but why not a distinct echo for both gunshots?
Witnesses agree...

• Individual #1 (deceased) was pointing firearm southward
• Individual #2 (claiming self defense) was pointing firearm northward

• Conclusion: northward-pointing gun facing reflecting surface caused more distinct echo, so Individual #2 fired first.
Forensic Example 2

• Law enforcement officers approach a knife-wielding individual.
  – One officer has a Taser, the others have handguns pointed at the suspect.
  – Shots are fired and the Taser is deployed.
  – Audio recordings made by Taser and by nearby dashboard cameras in police cars
  – Which was first, gunshot or Taser?
Taser and Shots
Dashcam Recordings

Taser Camera

Hanson Unit 404

Burrow Unit 1537

Burroughs Unit 408

Culliford Unit 1544

Shot 1 – Shot D: 4.33 seconds
Analysis

- Initial sound of Taser is obscured.
  - Dashboard recorders pick up gunshot sounds, but not Taser.
  - Plan: work backward to align timing based on last gunshot.

- Conclusion:
  - First gunshot at 15.4 seconds
  - Taser deployment at 15.8 seconds
  - Gunshot precedes Taser by 0.4 seconds.
Conclusion

• Care is needed to assess the validity of acoustic analysis claims involving gunshot evidence.
• Forensic gunshot recordings generally contain background noise, distortion, clipping, multi-path reflections and reverberation.
• In some cases, timing analysis of the gunshot sounds and acoustic reflections is appropriate.
• Situations involving multiple concurrent recordings of the same event are particularly useful.