

Getting more from less: low-level DNA mixtures on cartridges

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- The views and opinions expressed in this presentation are those of the presenter/author, and does not represent any official views or opinions of the American Academy of Forensic Sciences.
- I am an employee of Cybergenetics.
- TrueAllele® Casework DNA interpretation technology that was developed by Cybergenetics was used during this study.



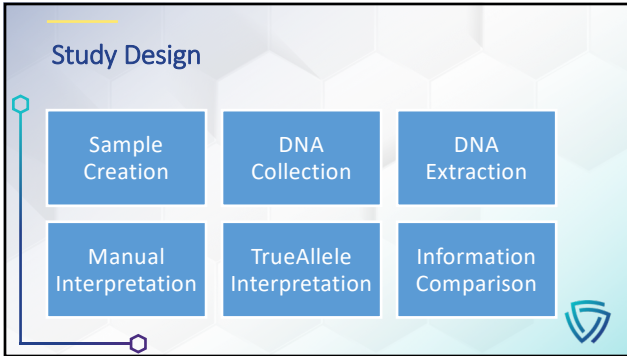
Background

- Cartridge casings are the empty shells left behind after a gun was fired¹
- Nearly 200,000 cartridge cases are recovered annually at U.S. crime scenes¹
- Cartridges that were fired degrade any DNA that was left and have significantly less DNA²
- Caliber of the firearm did not have any impact on the amount of DNA recovered²

1. "Shelling out Evidence: NIST Ballistic Standard Helps Tie Guns to Criminals." NIST, 23 Jan. 2023. www.nist.gov/news-events/news/2023/01/shelling-out-evidence-nist-ballistic-standard-helps-tie-guns-to-criminals.

2. Prasad, Elasha, et al. "Touch DNA recovery from unfired and fired cartridges: Comparison of swabbing, tape lifting and soaking." Forensic Science International, vol. 330, Jan. 2022, p. 111101. <https://doi.org/10.1016/j.forsciint.2021.111101>.





Sample Creation and DNA Collection

- Single source data
 - 910 total cartridge casings
 - Across 7 different cartridge types
- DNA was collected using five collection types
 - Wet:Wet
 - Wet:Dry
 - Soak and Sonicate
 - Tape Lift
 - Scraping

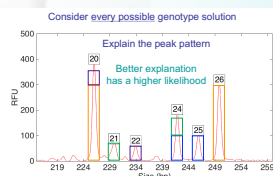
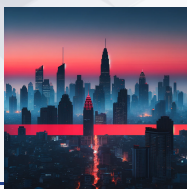
Material	Wet:Wet	Wet:Dry	Collection Soak and Sonicate	Tape Lift	Scraping
45 Fired	30	30	30	N/A	N/A
45 Unfired	30	30	30	N/A	N/A
Aluminum Unfired	30	30	30	30	30
Brass Fired	30	30	10	30	30
Brass Unfired	30	30	30	30	30
Nickel Unfired	30	30	30	30	30
Steel Unfired	30	30	30	30	30

DNA Extraction

- Organic extraction
 - Organic solvents are used for denaturation
 - Denatured proteins are removed then washed
- DNA sequencer
 - Applied Biosystems® 3500 Genetic Analyzer
- STR kit
 - Applied Biosystems GlobalFiler™

Manual Allele Interpretation

- A university laboratory manually interpreted the data
- A peak height threshold was applied to EPG data to form allele events
- *Allele counts*: how many EPG allele events match a reference



TrueAllele Casework Interpretation

- Cybergenetics generated TrueAllele requests assuming the samples were single source
- Completely objective and unbiased
 - TrueAllele processes DNA data without knowing a reference
- *Kullback-Leibler* (KL) genotype statistic
 - Quantifies the identification information in a genotype
 - The expected log(LR) to the true contributor
- *Likelihood Ratio* (LR) match statistic
 - Compares genotype to known reference



Mixtures and Low-Level Data

- Most cartridges had a high TrueAllele KL: the DNA was informative
- Low-level data, little DNA: uninformative manual interpretation
 - Percentage of low-level samples for each cartridge type (Table 1)
- 431 (of 910) samples were found to be mixtures
 - Total number of mixtures for each cartridge type (Table 2)

Percentage of Low-Level Samples		
Material	Wet/Wet	Wet/Dry
45 Fired	40	73
45 Unfired	40	36
Aluminum Unfired	0	16
Brass Fired	3	16
Brass Unfired	6	30
Nickel Unfired	6	13

			Collection Soak and Sonicate			Tape Lift	Scraping
Material	Wet/Wet	Wet/Dry					
45 Fired	10	7	8				
45 Unfired	13	15	9				
Aluminum Unfired	24	17	9	27	11		
Brass Fired	16	12	1	16	10		
Brass Unfired	14	15	0	29	15		
Nickel Unfired	16	20	1	26	6		
Steel Unfired	19	21	9	22	13		

TrueAllele Interpretation Round 2

- Cybergentics generated requests for the mixture data
- TrueAllele Casework processed the requests
 - Some items had multiple contributor assumptions
 - Samples contained 2 to 5 contributors
- TrueAllele found an unknown person in many of the cartridges
 - We compared the cartridge samples with the unknown profile



TrueAllele Information Comparison

- All cartridge samples compared to reference
- LR match statistic calculated for each comparison
 - 351 inclusionary statistics for the reference
 - Total number of inclusionary statistics per cartridge type is shown in the table

Material	Collection				
	Wet:Wet	Wet:Dry	Soak and Sonicate	Tape Lift	Scraping
45 Fired	1	0	9	N/A	N/A
45 Unfired	12	19	6	N/A	N/A
Aluminum Unfired	26	18	9	29	11
Brass Fired	5	13	1	3	3
Brass Unfired	8	7	1	22	0
Nickel Unfired	15	24	0	18	3
Steel Unfired	18	22	17	17	14



TrueAllele Finds Unknown Contributor

- The unknown profile was in many samples
 - Found in **138 of the 910** cartridge samples
 - Total number of inclusionary statistics for the unknown contributor
- The unknown profile was informative
 - Its KL was **30.36** ban
- Who's DNA is in the unknown profile?
 - We don't know



Material	Collection					
	Wet:Wet	Wet:Dry	Soak and Sonicate	Tape Lift	Scraping	
45 Fired	1	2	2	N/A	N/A	
45 Unfired	10	2	8	N/A	N/A	
Aluminum Unfired	4	4	0	9	0	
Brass Fired	14	3	1	5	3	
Brass Unfired	9	1	0	10	1	
Nickel Unfired	9	3	1	10	0	
Steel Unfired	6	1	3	13	3	

Nickel Unfired Example

- Table: statistics for one combination (Unfired Nickel + Wet:Wet)
 - KL and log(LR) inclusionary averages for the reference and unknown person
 - The number of zeros after the 1 in the match statistic (ban)
 - Blank entry: no data available
 - The inclusionary LR values ranged from 10's of billions to 10's of quadrillions (really, really informative)
- A log(LR) of 10.0 ban is **10,000,000,000**
 - Large inclusionary DNA match statistic
 - TrueAllele average from 3-person mixtures

# of contrib	ref inclusion		unknown inclusion	
	KL	log(LR)	KL	log(LR)
1	26.86	15.08		
2	15.53	10.27	22.71	16.14
3	13.94	10.06	14.64	11.38

But human review got no information at all!

Study Conclusions

- Manual interpretation used allele counting and thresholds
 - Could only find the known reference
- TrueAllele considered additional mixture contributors
 - The computer calculated match statistics for both the reference and unknown profile
 - The computer's developed unknown enabled comparison between the different cartridge mixtures
 - The known reference was found in 351 samples (205 manually)
 - The unknown person was found in 138 samples (0 manually)



Study Conclusions

- More informative **collection method**
 - Wet:Wet or Wet:Dry
 - Tape Lift was close
- Least informative was Scraping / Soak and Sonicate
- Most informative **cartridge type** was Aluminum / Steel
- The least informative was 45 Fired



Study Conclusions

- TrueAllele can develop informative data from cartridges
 - All DNA data is used, none discarded
 - Handles low-level data and minor contributors
 - Cartridges are common crime scene evidence
 - TrueAllele motivates gathering cartridge evidence
- Methods that use less data are less informative
- Cybergenetics has analyzed almost a hundred cartridge cases using TrueAllele, getting more DNA information from crime lab data



Questions?

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