The Retrieval of a DNA profile from Spent Cartridge Cases

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Introduction

Over the five year time period spanning from 1998 – 2002 there was an approximate 30% increase in firearm associated crime in the UK (as reported by the Metropolitan Police). The Home Office reported that gun crime had increased from a reported 4,903 offences in 1997/8 to 9,974 offences by 2001/2 [1].

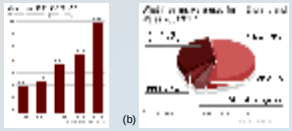

Fig 1. (a) Graphical representation of Gun Crime figures in England and Wales 1997/98 – 2001/02. (b) Gun Crime by Offence in England and Wales 2001/02 [1].

In the year leading up to September 2004 there were a provisional 10,670 firearms offences representing an increase of 5% compared with the previous 12 months.

More recently there has been a spate of gun crime centred around the teenage community in London, demonstrating that the problem of gun crime is real and becoming more prevalent in the UK.

Spent cartridge cases are often found at crime scenes where firearms are discharged and they can be used to connect a weapon to a crime, utilising marks made by the mechanism of the weapon, or to connect a weapon to a person, using latent fingerprints. However, the enhancement of fingerprints is often unsuccessful, especially on smaller calibre cartridges [2].

In these cases, it would be highly useful to have an alternative method of identifying the individual who handled the cartridges prior to firing. DNA profiling would fulfil these requirements as it has the potential to individualise and offers some level of persistence. However, the processes that the cartridge undergoes as it is being fired are not conducive to the persistence of DNA as high temperatures and pressures are involved. In addition to the conditions the DNA may be exposed to during the firing process, heavy metals present in the Gun Shot Residue (GSR) may also have an inhibitory effect on the downstream processes involved in DNA analysis.

Objectives

In an attempt to examine the variables that influence being able to retrieve a successful DNA profile from firearms and firearms related paraphernalia, this research was designed to:

1. Develop a protocol for the retrieval and amplification of DNA from firearms and firearms related articles, such as spent cartridge cases.
2. Determine the influence that firearms type, calibre or GSR has on the ability to retrieve DNA information.

Method

A series of experiments were designed to examine the effect that firing has on the ability to retrieve a DNA profile from spent cartridge cases.

Experiment 1 – Fired vs. Unfired Samples
Cartridges were seeded with a known volume of saliva to ensure the amount of DNA deposited was constant. Cartridges were loaded into the respective weapons and after firing the cartridge cases were collected and swabbed. Cartridge cases that had been passed through the appropriate firearm's mechanism but not fired were also swabbed as an 'unfired' control. Different calibre types were also used for comparison purposes.

Fig 2. (a) Sig Sauer Handgun Model P228. (b) Blaser Rifle Model R93 LRS 2. (c) Sig Sauer Rifle Model 551.

Weapon	Ammunition
Sig Sauer Handgun Model P228	Radway Green 9mm Centre Fire 95 Grain
Sig Sauer Rifle Model 551	Remington Express .223 Centre Fire 55 Grain
Blaser Rifle Model R93 LRS 2	Remington Express .308 Centre Fire 180 Grain

Table 1. Staffordshire Police Firearms Unit, Weapons and Ammunition.

Experiment 2 – GSR Seeded Samples
Saliva samples were seeded with GSR at different stages during the DNA analysis procedure.

1. Apply clean saliva to clean cartridge case, swab, extract DNA, amplify and profile.
2. Apply GSR-seeded saliva to clean cartridge case, swab, extract DNA, amplify and profile.
3. Apply clean saliva to clean cartridge case, swab, extract DNA, seed DNA extract with GSR, amplify and profile.
4. Apply clean saliva to clean cartridge case, swab, extract DNA, amplify, seed PCR product with GSR and profile.

Both Chelex and Qiagen extraction methods were utilised for comparison purposes.

Results

Experiment 1 – Fired vs. Unfired Samples

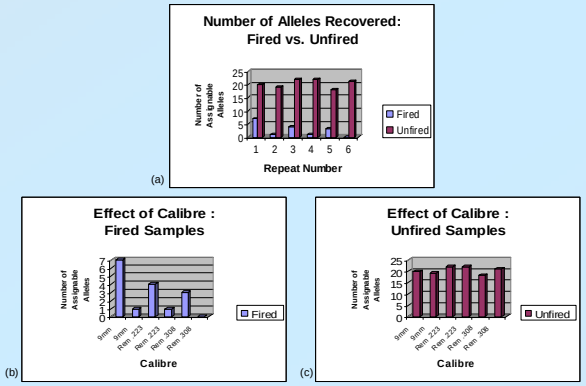

Fig 3. (a) Graph demonstrating the effect of firing on the number of alleles recovered from spent cartridge cases. (b) Graph demonstrating the effect of calibre on the number of alleles recovered from fired cartridges cases. (c) Graph demonstrating the effect of calibre on the number of alleles recovered from unfired cartridge cases.

Experiment 2 – GSR Seeded Samples

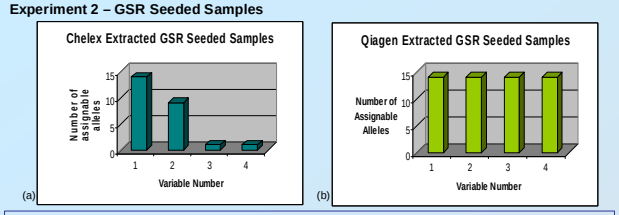

Fig 4. (a) Graph demonstrating the effect of seeding a saliva sample at different stages of the extraction process, on Chelex extracted samples. (b) Graph demonstrating the effect of seeding a saliva sample at different stages of the extraction process, on Qiagen extracted samples.

Variable Number	Cartridge Calibre	Average Peak Height
1	.308	Up to 7000
2	.308	Up to 4000
3	.308	Up to 4000
4	.308	Up to 2500

Table 2. Average peak height of alleles from Qiagen extracted GSR seeded saliva samples, demonstrating reduction in peak height from Variable 1 (No GSR control) to other variables (all seeded with GSR at different stages of the extraction process).

Discussion

The results, shown in Fig 3(a), indicate that the firing process has a detrimental effect on the ability to retrieve a DNA profile from saliva seeded cartridge cases. This reduction in the quality of DNA profile could be a result of the conditions that a cartridge case is exposed to during the firing process. Given [3] reports that approximately 54% of total propellant energy is converted to thermal energy, and 10-25% of this ends up as heat in the barrel wall. Although the exact temperature that a cartridge case experiences during firing is unknown, it would seem reasonable to deduce that this heat may degrade the DNA. As well as the high temperatures experienced during detonation, the burning propellant causes high internal pressure, resulting in the expansion of the casing. This may cause friction between the outside of the cartridge case and the inside of the chamber, resulting in a transfer of DNA from one surface to another.

When different calibre weapons were compared, the results shown in Fig 3(b), indicate that different quality DNA profiles were produce, with preliminary data suggesting that higher calibres produce poorer quality DNA profiles.

Another possible explanation for the poor quality DNA profile produced could be the heavy metals present in GSR inhibiting DNA polymerase, thereby hindering the successful amplification of DNA. The results gained support this theory, but when Qiagen extraction methods were used, the inhibitory effect of GSR was less obvious.

Conclusions

- The mechanism of firing a weapon causes a dramatic reduction in the quality of the resulting DNA profile.
- The calibre of the weapon may have an impact on the degree of DNA degradation encountered.
- The presence of GSR may have a slight inhibitory effect on the quality of DNA profile recovered from spent cartridge cases.

Future Work

- Examine the effect of GSR on lower levels of DNA, i.e. those recovered from handled objects.
- Examine the effect of firing on lower levels of DNA, i.e. those recovered from handled objects.
- Consider utilising LCN amplification, whole genome amplification or DNA concentration devices when analysing low levels of DNA.
- Determine the impact that different calibre and weapon type has on the resulting DNA profile.
- Consider alternative methods of DNA analysis such as HV1 and HV2 in mitochondrial DNA.

Acknowledgments

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