C31 Principal Components Analysis Applied to the Gunshot Case Determination

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After attending this presentation, attendees will understand the problem associated with determining who was the perpetrator of a criminal gunshot. The classical approach through the use of SEM-EXD is not possible for many developing countries due to the associated high costs. AA-GF equipment can be used as a replacement and the quantitative results interpreted with multivariate analysis techniques including Principal Components Analysis (PCA).

This presentation will impact the forensic science community by demonstrating the use of multivariate analysis giving forensic laboratories in non-developed countries the chance to determine with statistical certainty and with equipment of average value, the presence of gunshot residues on the hands of a suspect or the victim committing suicide. Through the construction of a solid database with several types of firearms, calibers, and ammunition trademarks, the quantitative analysis of metals present on the hands of an individual will allow its classification as "not shoot" and "shoot" situation, which graphically are visualized as clusters of data points represented in a 3D vector space. On the other hand, sampling is accomplished at a low cost with cotton swabs soaked with an EDTA solution along with the use of a universal reagent present in almost every chemical laboratory.

Forty volunteers with different jobs fired one different weapon each, including carbines, rifles, semiautomatic pistols, revolvers, shotguns, and submachine guns of the marks Mauser, Savage, italo Gra, Taurus, Smith and Wesson, and Sig Sauer, among others. Ammunition brands used included Remington, CBC, Federal, and TEC in the calibers .22LR, .38 special, 9mm Luger, 7x57mm, and the gauges 12 and 16. Samples were taken from the palm and back of the hands of the shooters with cotton swabs and 2% EDTA solution before and after every single shot. After dissolution and centrifugation, supernatants metal contents of lead, barium, and antimony were read using Atomic Absorption Spectrometry (AAS) into graphite furnace chambers. PCA was applied to the results, assuming that the following factors were analyzed: lead, barium, and antimony amount detected (each separately), shooter, zone analyzed in the hand and situation (before or after the gunshot). To simplify the analysis, all the variables were considered as numerical ones, defining before and after the shot as -1 and +1, identifying each shooter correlatively as 1, 2, 3, and so on. Zones tested on the hand were defined as -1 and +1 for back and palm, respectively.

Six eigenvalues were obtained for each of the sis principal components calculated previously. The first two values account for 68.9% of the variability of the data; the 3D eigenvalues explain at least 83.2% of the data variation. As could be expected, no correlation was observed between metal amount and the other variables. On the other hand, a strong relation between shooter and gunshot time-dependence is detected, which allows one to differentiate between after and before the shot. When two score plots were displayed, at least three populations can be seen, which are split clearly into four populations, corresponding at before and after shot case for each zone on the hand.

Two cases of databases constructed for multivariated analysis of the results will be presented, showing in this way the universality of the procedure.

GSR, AA-GF, PCA

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