



Bundeskriminalamt



Expert Working Group
Firearms

ENFSI Workshop I & II

On the
**“Application of the Bayesian Approach
in Gunshot Residue Investigation”**

Final Report



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ENFSI Monopoly 2010 Project HOME/2010/ISEC/MO/4000001759 (M5)
under the supervision of the ENFSI Expert Working Group "Firearms/GSR"

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CONTENT

	page
1. Introduction	3
2. Workshop I	3
3. Workshop II	5
4. Evaluation of the Survey	6
5. Final Conclusions	9
Appendix	page of Appendix
A. Agenda of the 1 st workshop	1
- Copies of the Presentations (as far as submitted by the authors)	3
B. Survey	149
C. Agenda of the 2 nd workshop	151
- Copies of the Presentations (as far as submitted by the authors)	152

1 INTRODUCTION

Within the framework of the ENFSI Monopoly Program 2010 the Expert Working Group "Firearms/GSR" received a funding for organizing an *ENFSI Workshop on the "Application of the Bayesian Approach in Gunshot Residue Investigation"*. The workshop was divided into two consecutive meetings:

1. Workshop I in Dresden, Germany, June 2013
2. Workshop II in Helsinki, Finland, May 2014

The objective of the workshop was:

- to initiate a training course/workshop on Bayesian Approach and its specific applications to GSR casework,
- to provide a sound theoretical basis to ENFSI GSR experts,
- to engender transparency for scientific assessment and a high standard in forensic GSR investigation, and
- to harmonize forensic investigative/evaluate methods for firearms crime throughout Europe

This report gives an overview on the performed measures and summarizes the results of the workshop.

2 WORKSHOP I

The first workshop was held in Dresden, Germany, on June 11th to 12th, 2013. A call for participation was sent out to all ENFSI Expert Working Group members who were interested in this topic and intended to use the Bayesian approach in future casework. Therefore, a variety of experts (on the fields of statistics as well as on the forensic application of the Bayesian approach) were invited in order to provide some basic knowledge regarding the application of the Bayesian approach in the area of forensic GSR investigations/reports, and to give examples.

The first workshop was attended by 20 participants in total, of which 10 of them were invited speakers and/or project group members (see table 1). There were only 8 representatives from the ENFSI member institutes and one from an Associate Member institute present as regular participants. The program of the first workshop is shown in Appendix 1.

#	surname	firstname	affiliation	status
1	Niewoehner	Ludwig	BKA, Germany	PG Member
2	Gunaratnam	Lawrence	NBI, Finland	PG Member
3	Charles	Sebastien	NICC; Belgium	PG Member
4	Moynehan	Chris	LGC Forensics, United Kingdom	PG Member
5	Prof. Corrande	Jukka	University of Helsinki, Finland	Invited Speaker
6	Prof. Taroni	Franco	University of Lausanne, Switzerland	Invited Speaker
7	Biedermann	Alex		
8	Prof. Uhlig	Steffen	QuoData GmbH, Germany	Invited Speaker
9	Baldauf	Henning		
10	Trimpe	Michael	ASCLD representative, USA	Invited Speaker
11	Barth	Martin	BKA; Germany	Regular participant
12	Schumacher	Rüdiger		
13	Brouwer-Stamouli	Amalia	NFI, The Netherlands	Regular participant
14	Fojtasek	Lubor	IPC, Czech Republic	Regular participant
15	Hannigan	Tom	FSL, Ireland	Regular participant
16	Irwin	Ann	FSNI, United Kingdom	Regular participant
17	Izraeli	Elad	DIFS, Israel	Regular participant
18	Larsson	Magnus	SKL, Sweden	Regular participant
19	Saraiva	Andre F.	LPC, Portugal	Regular participant
20	Vesers	Valdis	State Forensic Science Bureau, Latvia	Regular participant

Table 1: List of participants in workshop I

Summary of the 1st workshop

Introductions to the Bayesian approach to evaluating forensic evidence were provided for those unfamiliar with the approach, including the benefits and drawbacks. Presentations were also given explaining some of the statistical foundations behind the approach and discussing measurement of uncertainty. Discussion was held on the tools available (e.g. software) to assist those investigating this approach.

A presentation was given detailing the responses to a previous collaborative exercise, which asked respondents how they would report a given set of results. The majority of respondents did not use a Bayesian/evaluative approach, instead using a “results and disclaimer” approach – providing the results but highlighting that a positive finding did not prove that somebody fired a gun, whilst a negative result did not prove the reverse.

Some participants gave case studies. Those participants that used a Bayesian/evaluative approach to this evidence type tended not to use it for all cases, only those where it was felt to be most applicable (for example, where the defence and prosecution hypotheses were clear). The methodology varied between labs, with approaches including the collection of data from previous cases for future use in evaluation of results; conducting experiments in a specific case to obtain data relative to a particular scenario; and reliance on published literature and personal experience.

The importance of pre-assessment of cases was highlighted by some presenters, with benefits including demonstrating the impartiality of the scientist and ensuring the correct exhibits are selected for examination. A perspective was given from the USA, where the Bayesian/evaluative approach is not used, as it is generally felt there are too many variables and insufficient data to enable a robust evaluation.

There was also the opportunity for discussion of the presentations and debate about the merits of the different approaches. Participants were asked to respond to a questionnaire about the ways they reported casework results, to be discussed at the second workshop. Those using the Bayesian approach were asked to record how often they did so, and to bring some case studies to the next workshop.

3 WORKSHOP II

The second workshop took place in Helsinki, Finland, on May 20th, 2014. The target of this workshop was to exchange the experiences of the participants which they had made during the spent year when applying the Bayesian approach in some selected cases.

The second workshop was attended by 15 participants in total, of which 8 of them were invited speakers and/or project group members. This second workshop was attended only by representatives from 6 ENFSI member institutes as regular participants. The program of the second workshop is shown in Appendix 2.

#	surname	firstname	affiliation	status
1	Niewoehner	Ludwig	BKA, Germany	PG Member
2	Gunaratnam	Lawrence	NBI, Finland	PG Member
3	Charles	Sebastien	NICC; Belgium	PG Member
4	Moynehan	Chris	LGC Forensics, United Kingdom	PG Member
5	Prof. Corrande	Jukka	University of Helsinki, Finland	Invited Speaker
6	Prof. Taroni	Franco	University of Lausanne, Switzerland	Invited Speaker
7	Biedermann	Alex		
8	Baldauf	Henning	QuoData GmbH, Germany	Invited Speaker
9	Barth	Martin	BKA; Germany	Regular participant
10	Hannigan	Tom	FSL, Ireland	Regular participant
11	Vesers	Valdis	State Forensic Science Bureau, Latvia	Regular participant
12	Sjierps	Marjan	NFI, Netherlands	Regular participant
13	Brouwer-Stamouli	Amalia		
14	Saraiva	Andre F.	LPC, Portugal	Regular participant
15	Larsson	Magnus	SKL, Sweden	Regular participant

Table 2: List of participants in workshop II

Summary of the 2nd workshop

The results of a survey that had been circulated to the participants of the first workshop were presented and discussed. There was considerable variation in the approach used by different laboratories. Most respondents still used the “traditional” approach of presenting the results along with a disclaimer acknowledging alternative explanations for a positive finding other than the subject having fired a gun (e.g. being the bystander to a shooting). Other labs used an evaluative (but not necessarily numerically-based) approach to reporting the evidence, based on the specific case circumstances and any explanations put forward by the prosecution and defence. It was agreed by respondents that no method of reporting could conclusively show that the presence of GSR particles on a subject was the result of that person having discharged a firearm.

Case studies were presented by several participants of examples where either a Bayesian or evaluative approach had been adopted. The use of what could strictly be considered a Bayesian approach was limited. One Laboratory (NICC) used data compiled from casework to populate likelihood ratio calculations (using results from undisputed cases). The NFI and FSLI gave examples of when this approach had been used for specific cases, and LGC used some hypothetical examples to explore the benefits and limitations of the approach. Working on other types of hypothesis (i.e. compatibility of GSR found on suspects and available reference material or link between bullet holes and firearms), the NFI conducted case-specific tests in order to

formulate values for likelihood ratio calculations. The FSLI used experience garnered from previous cases and available literature.

Presentations were also given on the pitfalls of using limited datasets to generate numbers for likelihood ratio calculations. The variation in results obtained when extrapolating data using different distribution calculations (e.g. Poisson vs negative binomial) was highlighted, and some recent papers on the subject were reviewed.

Significant time was given to discussion on the relative merits of the different techniques. Some participants highlighted the value of pre-case assessment, regardless of the method ultimately used to report the results. There was general agreement that more data would be invaluable in improving the basis for interpreting results, and that significant amounts of training would be necessary for anyone adopting the Bayesian approach in this area, both practitioners and end users. It was highlighted that the legal system in some countries was not in favor of an evaluative approach (or at the least, had not considered it necessary).

4 EVALUATION OF THE SURVEY

Currently, there are three different types of approach being used to report the findings of GSR:

- a) Reporting the results with a disclaimer,
- b) Scale of Conclusions and
- c) Bayesian approach.

a) Results and Disclaimer:

The wording of the report in this approach is to report the presence or the absence of GSR particles together with a disclaimer. Typical examples are the following:

Particles characteristic of primer residue were found on the samples taken from the hands of the suspect A.

- *The presence of primer residues on the samples taken from the hands of the suspect is consistent with that suspect having discharged a firearm, been in the vicinity of a firearm when it was discharged or having handled a firearm or objects contaminated with gunshot residue.*

Particles characteristic of primer residue were not found on the samples taken from hands of the suspect A.

- *The absence of primer residue on the sample taken from the suspect does not eliminate that suspect having discharged a firearm.*

b) Scale of Conclusions:

This approach uses pre-assessment to determine expectations for a number of different result outcomes, in advance of undertaking the work. For example, the expectation of finding no GSR, or a Low, Moderate, High or Very High amount of GSR (see Table 3), given the allegation and any alternative defence explanation. Once the results are obtained, the strength of evidence of the findings may be expressed using an appropriate point on the verbal scale of conclusion (see Table 4). The wording of the report in this approach is based on relevant information from the case scenario and the results obtained from the analysis.

1 – 3 particles	Low
4 – 12 particles	Moderate
13 – 49 particles	High
50 or more particles	Very High

Table 3: Wording in the report depending on the number of detected particles (example)

no support
limited
moderate
moderately strong
strong
very strong
extremely strong

Table 4: Correlating Strength of Evidence Scale depending on additional case relevant information

c) Bayesian Approach / Evaluative approach

Bayesian Approach or the evaluative approach allows the scientist to offer an opinion on the extent to which the scientific findings support the proposition that the suspect is the shooter over an alternative proposition (that the suspect was not the shooter) or vice versa.

Hypothesis:

- H_p - prosecution hypothesis (e.g. the suspect is the shooter)
- H_d - defense hypothesis (e.g. the suspect is not the shooter)

This is done by estimating the probability of obtaining these findings if the suspect is the shooter, and the probability of obtaining these findings if the suspect is not the shooter based on forensically relevant information from the Case Scenario and analytical results etc. The ratio of these two probabilities gives the Likelihood Ratio (i.e. how many times more likely these findings are if the suspect is the shooter rather than if the suspect is not the shooter). Building a statistical model using the data from the undisputed cases was discussed.

Based on the likelihood ratio one can choose the appropriate point on the Verbal Scale of Conclusions.

weak support
moderate support
moderately strong support
strong support
very strong support
extremely strong support

Table 5: Verbal Scale of Conclusions

Those who participated in the first workshop were asked to write the pros & cons about the three distinctive approaches discussed in the workshop and the answers are compiled and shown in Table 3.

There are two labs that claim using Bayesian approach by calculating the likelihood ratios and few labs using scale of conclusions for reporting the findings of GSR. Because of the several factors that influence the number of GSR particles detected on the samples taken from the hands of a shooter and the difficulties to distinguish between the shooter and bystander on the basis of particle numbers the majority of the labs want to report the finding of GSR using "traditional approach" which is writing the results with disclaimer.

Approach	Pros	Cons
Results and disclaimer	<ul style="list-style-type: none"> -Applicable to most cases -Based only on analytical data -No need to pre-assess the case 	<ul style="list-style-type: none"> -Strength of evidence is weak -Doesn't give any preference to any other options (shooter, bystander or due to secondary contamination)
Scale of Conclusions / Evaluative approach	<ul style="list-style-type: none"> -Provides more value to the investigator -It is less likely to be misinterpreted by non-specialist -Uses pre-assessment to determine expectations for a number of different results outcomes advance of undertaking the work -Gives information on the strength of evidence based on the number of GSR particles 	<ul style="list-style-type: none"> -Scale of conclusion is not based on sound basis -More particle does not mean more probability the suspect is the shooter
Bayesian approach	<ul style="list-style-type: none"> -Provide more information to the police and court -Easy to apply when one suspect is involved 	<ul style="list-style-type: none"> -Usually there is not enough data to support any of the assumptions needed for this approach -Difficult to apply when more than one suspect is involved

Table 6: Pros & Cons given by the participants of the survey

5 FINAL CONCLUSIONS

The engagement to this Monopoly Project MP210, M5 was quite limited amongst ENFSI GSR practitioners. The two workshops for GSR Practitioners were focused on the use of Bayesian interpretation in GSR casework, but attendance at the workshops was disappointing, particularly from those laboratories that do not use an evaluative approach in this area. It is the view of probably the majority of practitioners that this approach is not readily applicable to GSR analysis in their casework, for reasons that are detailed below.

The majority of respondents to this consultation were from those familiar with the principles of the Evaluative/Bayesian approach and its use in forensic casework. It was felt that, although it has a place in GSR casework, many GSR cases are unsuitable for this type of reasoning, major obstacles being a lack of appropriate data or the absence of a suitable defence-hypothesis. For such cases an investigative approach is preferred.

It was felt that large amounts of time and resource would need to be devoted to training practitioners (at least 1 – 2 weeks) to adopt the principles of evaluative reporting and it was felt that this level of resource would be unlikely to be made available in the current economic climate, especially in small GSR laboratories.



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Agenda of the workshop

Wednesday, June 12th 2013

18:00 – 20:00 Registration / welcome reception at the Hotel Pullman, Prager Strasse 2c in Dresden

Thursday, June 13th 2013

08:00 – 09:00 Registration at QuoData

09:00 – 09:15 **Opening of the workshop by the chairman of the ENFSI EWG "Firearms/GSR"**

Dr. Ludwig Niewöhner, BKA

09:15 – 09:30 **Providing a rough and simple idea of the Bayesian Approach**

PD Dr. Steffen Uhlig, QuoData

09:30 – 10:00 **What does the Bayesian approach do and not do?**

Prof. Taroni / Dr. Biedermann, University of Lausanne

10:00 – 10:30 **Why is the Bayesian approach useful for GSR evaluation?**

Prof. Taroni / Dr. Biedermann, University of Lausanne

10:30 – 10:45 **Coffee Break**

10:45 – 11:15 **Why is the Bayesian approach not useful for GSR evaluation?**

Prof. Corander, Finland

11:15 – 11:45 **Discussion round:**

Short response of each statistician and questions from participants

11:45 – 12:15 **Collaborative study on the interpretation of GSR findings**

Lawrence Gunaratnam, NBI

12:15 – 13:00 **snack**

13:00 – 13:15 **Case study presentation**

Chris Moynehan, LGC Forensics

13:15 – 13:30 **Case study presentation**

Sebastian Charles, NICC

13:30 – 13:45 **Case study presentation**

Amalia Browsers-Stamouli, NFI

13:45 – 14:00 **Discussion**

All participants

14:00 – 14:15 **Coffee Break**

14:15 – 15:00 **Some difficulties on using Bayesian approach; alternative by classical approach**

PD Dr. Steffen Uhlig, QuoData

15:00 – 15:30 **Evaluation of GSR evidence using Bayesian networks**

Prof. Taroni / Dr. Biedermann, University of Lausanne

15:30 – 16:00 **Talk about paper recently published**

Prof. Corander, Finland

16:00 – 16:30 **Discussion**

All participants



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Expert Working Group
Firearms / GSR

Agenda of the workshop

Friday, June 14th 2013

09:00 – 09:15 Summary from discussion of 1st day from a statistical point of view

PD Dr. Steffen Uhlig, QuoData

09:15 – 09:45 Bayesian approach in USA

Mike Trimpe, Crime Lab Director, SWG-GSR; USA

09:45 – 10:15 Some case scenarios

Lawrence Gunaratnam, NBI

10:15 – 10:30 Coffee break

10:30 – 11:00 Further case scenarios

All participants

11:00 – 12:00 Discussion round:

All participants

12:00 – 13:00 snack

13:00 – 13:30 Final Discussions & Closing of the Workshop



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Agenda of the 2. workshop (draft)

Sunday, May 18th 2014

18:00 – 20:00 Registration / welcome reception at the Radisson Blu Royal Hotel, Helsinki

Monday, May 19th 2014

08:00 – 09:00 Registration

09:00 – 09:15 **Opening of the workshop by the chairman of the ENFSI EWG "Firearms/GSR"**
Chris Moynehan, **LGC**; Lawrence Gunaratnam, **NBI**, Ludwig Niewöhner, **BKA**

09:15 – 10:30 **Evaluation of the questionnaire of the 1st workshop in Dresden, 2013**
Lawrence Gunaratnam, **NBI**

10:30 – 10:45 **Coffee Break**

10:45 – 13:00 **Case study presentation**
Chris Moynehan, LGC Forensics
Case study presentation
Sebastian Charles, NICC
Case study presentation
Amalia Brouwer-Stamouli, NFI

12:15 – 13:00 **Lunch Break**

13:00 – 14:00 **Experience with the Bayesian Approach in daily GSR casework**
Tour de Table with all participants

14:00 – 15:00 **New aspects on Bayesian Applications – Round Table**
Prof. Taroni / Dr. Biedermann, University of Lausanne, Switzerland
Prof. Corander, University of Helsinki, Finland
Prof. Steffen Uhlig, quodata GmbH, Germany

15:00 – 15:15 **Coffee Break**

15:15 – 16:00 **Final Discussions & Closing of the Workshop**
All participants