

Master Forensic Science

Research Projects 2020-2021



Research projects 2020-2021

The University of Amsterdam's (UvA) Master's programme in Forensic Science, offered by the Faculty of Science, is unique in the Netherlands. The programme distinguishes itself from most international Master's programmes in Forensic Science by building on a range of scientific disciplines, such as Chemistry, Computer Science, Life Sciences, Mathematics, Physics, and other exact sciences. The goal of the programme is to train good scientists, armed with forensic knowledge and skills.

A part of the curriculum is a six-month internship during which scientific research is executed that is relevant to the forensic field. This document gives an overview of the capabilities of our students and the many ways in which a research project can be conducted.

For more information please contact:

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Title	Organisation	Student	Previous education
Digital Forensics			
The influence of compression on deep fake video detection rates	Netherlands Forensic Institute (NFI)	Meike Kombrink	Artificial Intelligence
The use of Electric Network Frequency presence in video material for time estimation	NFI	Guus Frijters	Electrical Engineering
Hand Recognition in Big Data	NFI	Sander Hansen	Computer Science
Using MedEye As An Automated Visual Recognition Tool For Ecstasy Tablets	Trimbos Institute	Mick Roché	Psychobiology
Uncovering criminal activities by analysing financial transactions using smart filtering and (un)supervised models	ABN AMRO	Sophie Warringa	Applied Mathematics
Ear recognition using convolutional neural networks	NFI	Daphne Westerdijk	Biomedical Sciences
Forensic Biology			
Robustness of DNA Methylation-Based Age Estimation Methods to Varied Genetic, Environmental and Technical Factors	Amsterdam Medical Centre (AMC)	Franka Goossens	Biomedical Sciences
Improvement of sample preparation and DNA-extraction methods on challenging bone samples for a high-throughput workflow	International Commission on Missing Persons (ICMP)	Tom Hopman	Biology
Forensic Biophysics			
Postmortem fingerprinting - capturing surface and internal fingerprints from the deceased using optical coherence tomography for forensic identification	AMC	Tim Stölting	Biomedicine
Oxidation biomarker detection in ageing semen, urine and saliva stains using surface plasmon resonance imaging and enzyme-linked immunosorbent assay	AMC	Roos Otto	Health and Life Sciences

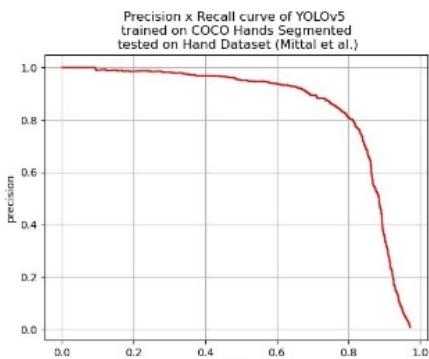
Title	Organisation	Student	Previous education
Forensic Chemistry			
Characterisation of smokeless powders using two-dimensional liquid chromatography	AMC	Anouk van Beurden	Chemistry
New psychoactive substances metabolism: analysis of phenethylamine metabolites using HPLC-MS/MS	Vrije Universiteit (VU)	Raúl Fernández Cereijo	Chemistry
Elucidation of snake venom composition using LC-MS-based metabolomics and its potential use in forensic science	VU	Hannah German	Molecular Life Sciences
Predicting post-pouring-interval based on generic ageing profiles in wine and machine learning algorithms with headspace GC-MS	Amsterdam University of Applied Sciences (HvA)	Andrea Hutani	Pharmaceutical Sciences
Electrochemical detection of cocaine in authentic oral fluid	University of Antwerp	Florine Joosten	Chemistry
Establishing a human C-N-O isotope reference dataset for the Netherlands using human hair keratin, dental enamel, and dentin	VU	Nathan Routledge	Biomedical Sciences
Identifying specific chlorine-tyrosine binding sites characteristic for exposure to chlorine gas	Netherlands Organisation for Applied Scientific Research (TNO)	Irene van Damme	Biomedical Sciences
Tolerance Development in the Zebrafish Embryo Model using Nicotine: Evaluation of Addictive Potency of Substances	National Institute for Public Health and the Environment (RIVM)	Maja Mešković	Biology and Medical Laboratory Research: Zoology
Forensic Medicine			
The inter- and intra-rater reliability of the Sexual Knowledge Picture Instrument (SKPI) - a tool to detect verbal and non-verbal signs of child sexual abuse	Emma Children's hospital	Shanti Bolt	Biomedical Sciences
Chemical analysis of an unknown substance around and soil beneath a body buried in a shallow grave at ARISTA, Amsterdam	AMC	Lynn Buijs	Biology

Title	Organisation	Student	Previous education
Forensic Medicine			
Controversies and alternative theories for Abusive Head Trauma in Dutch court cases	NFI	Hannah Cronenberg	Biology
Prior injuries in medico-legal evaluations of physical child abuse in young Dutch infants.	NFI	Judith van Diggelen	Psychobiology
A comparison of postmortem total body computed tomography and skeletal survey in the detection of fractures in (suspected) child abuse cases	NFI	Veronique Konijn	Biomedical Sciences
Evaluating toxicology in young children referred for potential child maltreatment in the Netherlands	NFI	Nina Onkenhout	Medical Natural Sciences
Fractures in Young Children: Advice Requests to the Dutch Expertise Centre for Child Abuse	NFI	Anika Veenstra	Biology
Doctor or Judge? Why the courtroom needs forensic medical expertise	Public Health Service(GGD) Amsterdam	Veronica Baljé	Psychobiology
Forensic Physics			
The origin of striation patterns in human costal cartilage caused by knife stabbing	NFI	Eva Blom	Mechanical Engineering
Optimisation of high-speed images of a bullet penetrating ballistic gelatine for automated detection and processing of the results	TNO	Sanne Smeets	Chemical Engineering and Chemistry
Forensic Statistics and Mathematics			
Application of Bayesian decision theory to the recovery of traces from firearms	NFI	Yvette van 't Zand	Biomedical Sciences
Human Factors			
Calibrating degree-of-support judgements by providing performance feedback: a pilot study	NFI	Emma Cuperus	Molecular Life Sciences

Digital Forensics

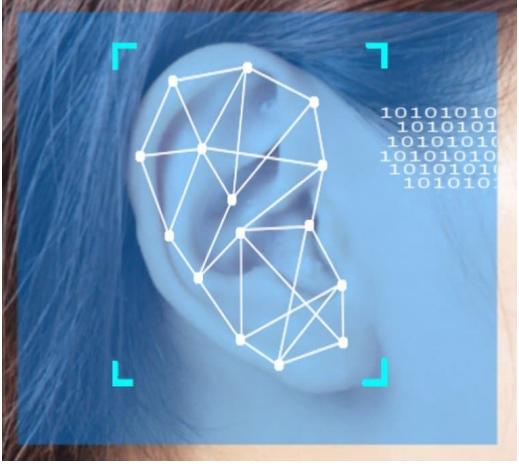
Student	Meike Kombrink
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	prof. dr. ing. Zeno Geraarts
<i>Title thesis</i>	The influence of compression on deep fake video detection rates
<i>Abstract</i>	<p>Recently, the automated detection of deepfake videos has experienced a surge of interest, which lead to a lot of improvements in the performance of algorithms to detect deepfakes. Yet, these improvements have been made on either largely abstracted datasets, or on datasets without annotation of complexities. One such complexity that always occurs is compression, which launders manipulation traces from images. As many deepfakes are shared on social media, where any upload will always first be compressed, it is vital to understand the influence of compression on the detection of deepfake videos. Therefore, this research will investigate the influence of compression on the ability of two promising detection algorithms to distinguish between deepfake videos and genuine videos. The results of this research suggest that the effect of compression on the detection of deepfake is positive at first, but turns negative when too much compression is added. The studied algorithms show almost identical effects to compression. The study also suggests similar effects of compression are seen for H.265 and AV1, though this result is only gathered on a limited dataset and needs more research before any conclusions should be drawn.</p>

Student	Guus Frijters
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	prof. dr. ing. Zeno Geraarts
<i>Title thesis</i>	The use of Electric Network Frequency presence in video material for time estimation
<i>Abstract</i>	<p>In this research the possibility to perform an estimation of the time of recording for videos is explored for different light sources in different circumstances using the Electric Network Frequency (ENF). This research focuses on videos made with smartphones. The smartphone cameras make use of an integrated Complementary Metal Oxide Semiconductor (CMOS) sensor. The filmed videos are analyzed using software created in MATLAB, which uses a small ENF-database to determine the time of recording of a video made in experimental circumstances. This research shows that in ideal circumstances, it is possible to determine the time of recording with a video made with a smartphone. However, it becomes clear that different light sources greatly influence the results. The best results are achieved with Halogen and Incandescent light sources, both of which also seem promising in less ideal circumstances. LED sources do work in ideal circumstances, however, do not show much success in less ideal situations. This research shows there is potential in using ENF to determine a time of recording of a video. It proves usable in ideal circumstances with the presence of a clear light source on a white wall. With more research, it can become a feasible method to use in circumstances that are less ideal.</p> 

Student	Sander Hansen
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	prof. dr. ing. Zeno Geradts
<i>Title thesis</i>	Hand Recognition in Big Data
<i>Abstract</i>	<p>In this research, three different deep learning object detection techniques are compared in their performance to detect hands. The object detectors used, YOLOv5, ExtremeNet and TridentNet, are used to answer the question; what is the performance of deep learning algorithms on the detection of hands in a forensic context? The object detectors are trained on two different datasets to compare the results with earlier proposed techniques used for hand detection. The results show that the techniques used in this research outperform the earlier proposed techniques and that for certain, but not all cases, automatic hand detection can be helpful in a forensic context. YOLOv5 performs on a dataset that resembles the forensic use case, the best of the tested techniques.</p>  <p>Precision x Recall curve of YOLOv5 trained on COCO Hands Segmented tested on Hand Dataset (Mittal et al.)</p> <p>The graph shows precision on the y-axis (0.0 to 1.0) versus recall on the x-axis (0.0 to 1.0). The curve starts at (0, 1.0) and remains near 1.0 until recall reaches approximately 0.7, after which it drops sharply to about 0.15 at a recall of 1.0.</p>  <p>A photograph showing three people sitting around a table in what appears to be a kitchen or dining area. There are various items on the table, including a bottle, glasses, and some food containers. The people are smiling and seem to be engaged in a social gathering.</p>

Student	Mick Roché
<i>Research carried out at</i>	Trimbos Institute
<i>Supervisor</i>	Ruben Vrolijk MSc
<i>Title thesis</i>	Using MedEye As An Automated Visual Recognition Tool For Ecstasy Tablets
Abstract	<p>Since the 1980s, the usage of 3,4-methylenedioxymethamphetamine (MDMA) in the form of ecstasy tablets has increased substantially in the Netherlands, along with an increase in milligram MDMA per tablet. Batches of ecstasy tablets are characterised by their physical features, such as colour, shape, diameter, thickness, and logo. When linked to results from lab analyses on similar ecstasy tablets, such information can be helpful to monitor the drugs market, yield valuable intelligence for ongoing investigations, and help with harm reduction goals of drug testing facilities active throughout the Netherlands. The Drugs Information and Monitoring System (DIMS) aims to monitor the illicit drugs market by allowing drug users to hand in samples of drugs. Those samples are, by default, analysed in a lab. However, if there are too many to be analysed, ecstasy tablets can also be recognised based on their physical features and previous lab results of similar tablets. It is becoming increasingly difficult to differentiate between batches of ecstasy as the differences between said batches are becoming more subtle. Therefore, we propose the adaption of an existing automated visual recognition tool called MedEye, currently used to differentiate between prescription drugs, to help differentiate between batches of ecstasy tablets. An experimental setup was used to determine the accuracy of MedEye. Using ecstasy tablets from the DIMS and police seizures, an initial accuracy of 80% for the front, 76% for the back and 78% for the side was achieved, yielding a total accuracy of 78%. After correcting for mistakes in the pre-processing of samples and accounting for entries where no clear outcome could be scored, an accuracy of 90-94% was found. The results of this research indicate that the application of MedEye as a tool to recognise ecstasy tablets shows potential. Moreover, MedEye's current AI model is not yet optimised for ecstasy tablet recognition. Hence, improvement of the found accuracy is to be expected in the future. The results show great potential for MedEye or similar systems to be used at drug-checking facilities like DIMS or in forensic research, where fast tablet screening or batch differentiation can facilitate ongoing investigations.</p> 

Student	Sophie Warringa
<i>Research carried out at</i>	ABN AMRO
<i>Supervisor</i>	Erwin Heuvelman MSc
<i>Title thesis</i>	Uncovering criminal activities by analysing financial transactions using smart filtering and (un)supervised models
<i>Abstract</i>	<p>The role of Dutch banks as gatekeepers of the financial system is rapidly evolving due to the implementation of new laws and increasing supervision. It sometimes leads to complex and bank-wide investigations containing a large amount of transaction data. Investigators specialized in uncovering criminal activities from financial transaction often lack of experience in and knowledge of analysing large amounts of unstructured data. This results in inefficient and incomplete transaction analyses within criminal investigations. Three data analysis tools are suggested as a possible assistance to improve efficiency and completeness of the transaction analysis: smart filtering based on typologies, supervised models based on historical investigations and unsupervised models based on 'regular' transaction patterns. In this article, the focus lies specifically on investigations within a Dutch bank regarding clients that are linked with highly sensitive, exceptional and unacceptable risks with regard to criminal activities. Results show four methods, with specific parameter tunings, to be most promising: smart filtering, random forests, logistic regression and isolation forest. An advice on further improvement of the methods is provided.</p>

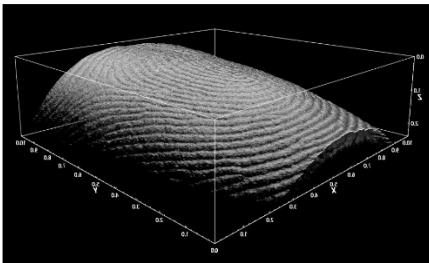
Student	Daphne Westerdijk
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	Arnout Ruifrok
<i>Title thesis</i>	Ear recognition using convolutional neural networks
<i>Abstract</i>	<p>This research paper looks into the use of deep convolutional neural networks (CNN) for ear recognition on multiple ear image datasets. The CNNs used for the experiments are AlexNet, VGG16, ResNet50v2, InceptionV3, DeeperGoogLeNet and ShallowNet. The accuracies and performances are first evaluated using two constrained datasets called AMI and Delhi. Finally, they are also evaluated on the more challenging unconstrained EarVN1.0 dataset. The results show that the DeeperGoogLeNet model achieves the highest rank-1 and rank-5 accuracy on all the datasets. On the first two constrained datasets, AMI and Delhi, the rank-5 accuracy is 92,5% and 97,6% respectively. The EarVN1.0 was more challenging and resulted in a rank-5 accuracy of 83,5%. To visualize the decision-making of this model, the grad-CAM++ method was applied showing that the model focusses on specific areas of the ear. The heatmaps made on the EarVN1.0 dataset clearly show a recognition pattern that focusses on the ear lobe and the top of the ear helix. The results indicate that a DeeperGoogLeNet model can achieve a high-level accuracy on ear images and could be further investigated on forensic relevant scenarios and datasets.</p> 

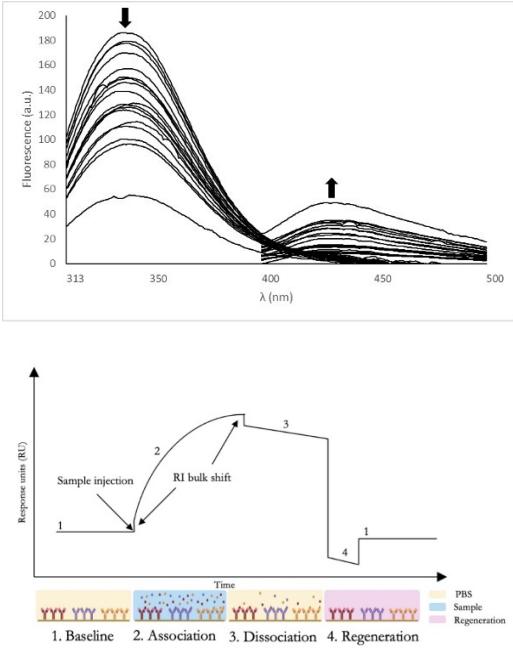
Forensic Biology

Student	Franka Goossens
Research carried out at	AMC
Supervisor	Peter Henneman
Title thesis	Robustness of DNA Methylation-Based Age Estimation Methods to Varied Genetic, Environmental and Technical Factors
Abstract	<p>Two main topics in forensic science are (disaster) victim and suspect identification based on physical evidence. When DNA evidence is available, identification is typically done using short tandem repeat DNA analysis. However, when no reference DNA profile is available to match the sample to and the profile has no matches in the DNA database, creating a phenotypic profile based on the genetics of the possible suspect or victim can provide useful information. One of the phenotypic characteristics that can be obtained from genetic information is age. Several epigenetic clock algorithms, based on DNA methylation (DNAm) levels, exist for age estimation, both in epidemiological and forensic research. However, the robustness of these epigenetic clocks to varied genetic, environmental and technical factors has not been thoroughly investigated. Since the use of robust methods is important to limit error rates, in this study the robustness of well-known and commonly utilised epigenetic clock algorithms (i.e., DNAm GrimAge, DNAm PhenoAge, Hannum's clock, Horvath's clock and PedBE) has been assessed as a proxy for forensic clock algorithms. This was done by determining the correlation coefficient and median error between the chronological age and the DNAm estimated age for cohorts containing individuals with possible compromising traits, such as genetic defects, a migration background, chronic inflammation and post-traumatic stress disorder. Furthermore, possible technical bias of Infinium array and Nanopore sequencing as methods for DNAm detection was assessed. The results show that the estimation error of the algorithms is significantly different for the genetic defect Down's syndrome and the environmental factor migration, compared to their respective controls. Additionally, technical limitations and bias were observed in both Infinium array and Nanopore DNAm detection. We, therefore, conclude that DNA methylation-based age determination methods are not robust to varied genetic, environmental and technical factors. For this reason, extensive testing of the forensic epigenetic clock algorithms on potential biasing factors is required before implementation in forensic investigations.</p>

Student	Tom Hopman
Research carried out at	ICMP
Supervisor	dr. Thomas Parsons
Title thesis	Improvement of sample preparation and DNA-extraction methods on challenging bone samples for a high-throughput workflow
Abstract	<p>As large-scale disaster victim identification responses are regularly occurring and challenging events, forensic scientists and DNA specialists continually work to improve the DNA identification processes from challenging bone samples. Therefore, the International Commission on Missing Persons (ICMP) have developed a powerful SNP assay to identify victims from casualties with the use of MPSplex. This study assesses successful DNA extraction methodologies from ancient and forensic fields to improve the recovery of short DNA fragments for SNP assays with the aim for automated DNA extraction protocols for a high-throughput workflow. Extractions are quantified with real-time PCR and protocols are assessed based on their efficiency of time, costs, throughput, and contamination risks. For downstream analysis, STR profiles were obtained and compared between the methods. The aDNA extraction protocol of Dabney et al. (2013) resulted in overall higher DNA recovery per gram on single extracts. Implementing this method in the workflow of the ICMP would reduce costs, improve the workflow and likely improve the recovery of short DNA fragments suitable for MPS testing. To obtain comparable DNA concentrations as with the current ICMP method, pooling of the aliquots could be considered but increases contamination risks and exclusion of automation. The protocol by Rohland et al. (2018) based on silica bead purification also showed increased DNA yields per gram and is due to the small volumes most suitable for automation purposes. Both extraction methods resulted in partial to full STR profiles which could be used for kinship analysis. To conclude, this study has shown insights in the ability to combine the extraction methodologies that are used in archaeology in a forensic context. DNA processing and extraction efficiencies on the recovery of small DNA fragments should benefit the entire identification process related to mass casualties, especially where large-scale DVI is required.</p>

Forensic Biophysics

Student	Tim Stölting
Research carried out at	AMC
Supervisor	Leah Wilk MSc
Title thesis	Postmortem fingerprinting – capturing surface and internal fingerprints from the deceased using optical coherence tomography for forensic identification
Abstract	<p>Unidentified human remains are frequently encountered during individual missing person cases or victim identification after mass fatality incidents. Besides DNA and dental records, fingerprints are one of the three primary identifiers used to identify human remains and represent the fastest and most cost-effective identification method in most cases. However, current postmortem fingerprinting methods rely on the integrity of the surface fingerprint, which can easily be damaged by decomposition or other external factors, such as fire. Optical coherence tomography (OCT) is a 3D imaging technique that can capture the internal fingerprint - a more protected structure formed by the basal layers of the epidermis that serves as the blueprint for the surface fingerprint. In recent years, OCT has been used to capture the internal fingerprint for biometric purposes. To investigate the influence of decomposition on the surface and internal fingerprint and to explore the potential of OCT for postmortem fingerprinting, this project encompassed two longitudinal studies: Human fingers, that were acquired through a body donation program, were first buried in soil, then excavated and scanned using OCT at increasing time intervals since burial. In-house fingerprint extraction algorithms developed for living individuals were modified for the use on postmortem OCT data. The internal fingerprint was able to be captured for up to 7 days longer than the surface fingerprint in this study. The National Institute of Standards and Technology's Fingerprint Image Quality score (NFIQ 1.0, scores of 1-5) was used to assess the quality of the extracted surface and internal fingerprint images. Overall, the internal fingerprint yielded better NFIQ scores (avg. of 4,57) than the surface fingerprint (avg. of 4,94). To additionally assess the forensic value of the fingerprint images, a fingerprint expert from the Dutch police investigated the fingerprint images for relevant minutiae. The internal fingerprint yielded substantially higher minutiae scores than the surface fingerprint and almost all internal fingerprint images passed the necessary minutiae threshold to be used in a forensic investigation. In summary, the findings presented here demonstrate that OCT has the potential to be a powerful, novel method to capture postmortem fingerprints in future forensic investigations.</p> 

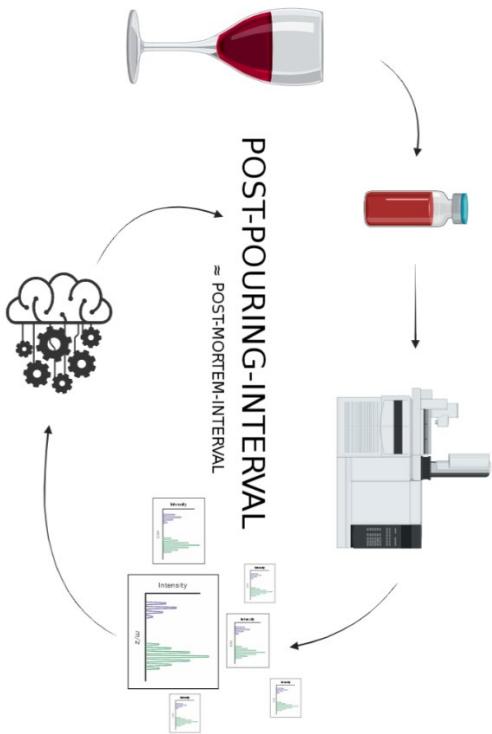
Student	Roos Otto
Research carried out at	AMC
Supervisor	dr. Annemieke Van Dam
Title thesis	Oxidation biomarker detection in ageing semen, urine and saliva stains using surface plasmon resonance imaging and enzyme-linked immunosorbent assay
Abstract	<p>Estimating the time since deposition of a biological stain is crucial for the forensic field. It may indicate if a stain is crime related and helps with narrowing down a timeline of events. Previous research estimated the age of fingermarks and semen stains by examining protein-lipid oxidation reactions using fluorescence spectroscopy. However, it is still unknown which specific oxidation products are formed. Therefore, the aim of this study is to investigate the possibility of detecting lipid and protein oxidation biomarkers in ageing semen, urine and saliva stains up to three weeks. Detection will be done with surface plasmon resonance imaging and enzyme-linked immunosorbent assay. Furthermore, it will be studied if the quantities of the detected biomarkers change upon ageing. The body fluid stains will also be analysed with fluorescence spectroscopy similar to previous research. In fresh and ageing semen and saliva stains malondialdehyde, 4-hydroxynonenal, advanced glycation end products, protein carbonyls and dityrosine were successfully identified, whereas only protein carbonyls and dityrosine could be detected in urine stains. Protein carbonyl concentrations increased in semen and saliva samples over time, but stayed stable in urine stains. The other biomarker quantities also changed upon ageing but large inter-donor variations were observed. Fluorescence measurements showed a typical protein-lipid oxidation pattern in semen stains, but in saliva and urine stains large differences between the donors were observed. Although, additional biomarkers and environmental conditions should be examined, these findings provide new insight in the lipid and protein oxidation processes of ageing semen, urine and saliva stains.</p>  <p>The figure consists of two parts. The top part is a plot of Fluorescence (a.u.) versus wavelength λ (nm) from 313 to 500 nm. Multiple curves are shown, with a prominent peak around 340 nm indicated by a downward arrow. The bottom part is a schematic diagram of a flow system. It shows a sequence of steps: 1. Baseline (PBS), 2. Association (Sample), 3. Dissociation (Regeneration), and 4. Regeneration (PBS). The response units (RU) are plotted against time. Arrows indicate 'Sample injection' at step 2 and 'RI bulk shift' at step 3. A legend identifies PBS (yellow), Sample (blue), and Regeneration (purple).</p>

Forensic Chemistry

Student	Anouk van Beurden
Research carried out at	AMC
Supervisor	Dr. Bob Pirok
Title thesis	Characterisation of smokeless powders using two-dimensional liquid chromatography
Abstract	<p>Smokeless powders (SPs) are low explosives that are typically used as a propellant for ammunition, but can also be used as the main charge in improvised explosive devices (IEDs), such as pipe bombs. In the event of a shooting or an explosion, residues of unburnt or partially burnt powder may be collected and analysed. SPs are composed of two main components: nitrocellulose (NC) and additives. NC is a cellulose-based polymer with a high molar mass and broad mass distribution which makes it challenging to characterise. Therefore, the analysis of SPs is currently performed using mainly the additives. If information about the NC and the additives could be combined, the possible forensic discrimination of SPs would be improved. During this research, an online heart-cut two-dimensional liquid chromatography (2D-LC) method was successfully developed to simultaneously analyse these two sample components. In the first dimension, size-exclusion chromatography (SEC) was performed to compare the molecular-weight distribution (MWD) of the NC in SP samples. In the second dimension, reversed-phase liquid chromatography (RPLC) was conducted to obtain the additive composition of the SP samples. With this method, NC and additive information were obtained simultaneously in a total analysis time of 56 minutes. Twenty SP samples from the database of the University of Central Florida were successfully analysed and compared using the developed 2D-LC method. Combining these two orthogonal chemical features of SPs (NC and additive composition), the options for the forensic comparison of SP samples are improved. Furthermore, no extensive sample preparation was required, making the developed method less labour intensive than conventional methods.</p>

Student	Raúl Fernández Cereijo
<i>Research carried out at</i>	VU
<i>Supervisor</i>	dr. Isabelle Kohler
<i>Title thesis</i>	New Psychoactive Substances metabolism: Chemical metabolism of fluoroamphetamine isomers and analysis using liquid chromatography - mass spectrometry
<i>Abstract</i>	A large diversity of new synthetic drugs is introduced onto the market every year. However, due to their novelty, little is known regarding their pharmacological effects, biotransformation, and toxicity. One example is 3-fluoroamphetamine (3-FA), whose metabolism and toxicity has not been investigated yet. The current standards for the metabolism assessment are human or animal liver microsomal incubations, which usually follow multi-step, elaborate protocols, and involve ethical issues. In this study, a novel methodology based on chemical oxidations, was tested for suitability to replace conventional microsomal incubations to produce metabolites. Two oxidising chemicals were tested, i.e., hydrogen peroxide and potassium permanganate. The metabolites generated were compared with those obtained using rat liver microsomes. After optimization of the oxidising conditions, four products were detected after 2h of reaction using 30% H ₂ O ₂ , only one after reaction with 5 mM KMnO ₄ and another metabolite with the microsomal procedure, respectively. All the metabolites corresponded to the addition of a single oxygen atom ($\Delta m/z$ 15.99) except for one of the peroxide products, which showed addition of two oxygen atoms ($\Delta m/z$ 31.99). Only two products, produced with the procedure using H ₂ O ₂ , could be structurally identified, indicating ring hydroxylated 3-FA molecules. For the other products, the location of the added oxygen atom(s) could not be assessed. Due to low sensitivity of the MS/MS method, the suitability of chemical reactions to substitute microsomal reaction could not be assessed but shows great potential. Comparison with the products of the structural isomer 2-fluoroamphetamine showed inability of the developed LC-MS method to discriminate the metabolic products issued from both approaches. Nonetheless, other separation techniques, i.e., CE, and detection techniques, i.e., NMR and infrared ion spectrometry (IRIS), are valuable candidates to improve the analytical method in future research.

Student	Hannah German
Research carried out at	VU
Supervisor	dr. Jeroen Kool
Title thesis	Elucidation of Snake Venom Composition using LC-MS-based Metabolomics and its Potential Use in Forensic Science
Abstract	<p>Snakebite envenoming has been classified as a neglected tropical disease by the World Health Organization, causing over 100.000 deaths yearly. It is for that reason that thus far, the main focus of snake venom research has been on the larger toxin proteins, as these cause the severe symptoms and are the main targets for antivenoms. However, smaller peptides and metabolites have received little attention, despite the fact that there are indications that they may aid in toxicity or on the other hand, inhibit it. Furthermore, small molecule identification in snake venom can be the first step in novel drug design and would allow for more extensive molecular profiling of venoms. The latter would possibly allow for tracing back certain venoms to the individual snakes they originated from based on their molecular profiles, which could be valuable for criminal investigations of illegal venom trade or cases of deliberate or accidental envenoming. Therefore, this study aimed to elucidate the small molecule contents of different sets of snake venoms using an LC-MS-based metabolomics approach and use this information to assess inter- and intra-species variation for forensic and medical purposes. It was found that crude injection of venom gives the most metabolite information, in combination with measurements in a lower mass range than usually used for toxin analysis. Furthermore, it was found that metabolite content may aid in distinguishing between venoms sourced from snakes from different genera, species, gender, age and possibly other factors. This in turn may be valuable for administering the correct antivenom or in criminal investigations.</p>

Student	Andrea Hutani
Research carried out at	HvA
Supervisor	Brent Maagdelijn
Title thesis	Predicting post-pouring-interval based on generic ageing profiles in wine and machine learning algorithms with headspace GC-MS
Abstract	<p>POST-POURING-INTERVAL ≈ POST-MORTEM-INTERVAL</p>  <p>Estimations on the time of death of a victim are the most essential questions in forensic casework. In the present, various methods exist which can give estimations on the post-mortem interval (PMI). However, these methods come with a certain margin of error complicating the practical universal use and interpretation of the results. Methodologies that could contribute to more accurate and reliable PMI estimations are therefore required in forensic casework. The present study introduces a new analysis on wine, which can be encountered at a crime scene, by developing an accurate PPI estimation model. A headspace gas chromatography-mass spectrometry (HS-GC-MS) method with an SPME fibre was developed and a total of 26 ageing marker compounds in the headspace of a Merlot wine were identified. The changes in the relative abundance of the ageing marker compounds found in the headspace of the a Merlot wine were evaluated over time, relating to increasing PPI. It was observed that all ageing marker compounds are of chemical importance by either oxidation-reduction reactions, esterification, polymerization, or dehydration. Based on generic ageing profiles for the identified ageing markers in wine, a machine learning algorithm was applied to model an RF model for predicting the PPI of a wine sample. A univariate linear regression test for non-negative features was applied to select the best features out of the ageing markers. The eight best features that have the strongest relationship with the output were selected as the best ageing marker set. The RF regression model was trained and tested and was able to predict PPI in a Merlot wine with an MAE of 6.65 ± 0.03 hours, and an RMSE of 8.37 ± 0.06 during 9.25 days. An R² score of 0.99 indicates that the RF regression model performs well. However, the validation of the RF model computed PPI values with large deviations from the true PPI values. Nonetheless, to our knowledge, the present work for the first time introduces a PPI estimation model for wine that can be applied to provide more accurate and reliable PMI estimations for forensic casework and intelligence purposes.</p>

Student	Florine Joosten
Research carried out at	University of Antwerp
Supervisor	prof.dr. Karolien De Wael
Title thesis	Electrochemical detection of cocaine in authentic oral fluid
Abstract	<p>Illicit drug consumption remains a problem to public safety and health, with abuse of illicit drugs having increased significantly over the last years. A concern related to this abuse is driving under the influence of drugs (DUID). Currently, police and law enforcement agencies rely on the use of lateral flow immunoassays (LFAs), which suffer from a lack of sensitivity. In this report, we present a rapid, sensitive, and affordable electrochemical method for the detection of cocaine in oral fluid (OF) by square-wave adsorptive stripping voltammetry on screen printed-electrodes (SPE). For the first time, the effects of the OF matrix on the electrochemical sensing of cocaine are deeply explored. First, the electrochemical method for the detection of cocaine in buffer solution is optimized to reach lower LODs. Second, the interference of endogenous compounds in OF and cutting agents and adulterants is studied. Interestingly, the electrochemical signal for cocaine is shown to be partially suppressed by the biofouling properties of albumin and most probably other proteins present in the OF matrix. Strategies to mitigate these biofouling properties are explored. Subsequently, two sampling methods for OF, expectoration and the use of a commercial OF collection device (i.e. the Intercept i2), are investigated. Finally, the developed methodology was interrogated with authentic OF spiked with cocaine, and compared with the roadside test (i.e. LFA) currently employed by police.</p>

Student	Nathan Routledge
<i>Research carried out at</i>	VU
<i>Supervisor</i>	prof.dr. Gareth Davies
<i>Title thesis</i>	Establishing a human C-N-O isotope reference dataset for the Netherlands using human hair keratin, dental enamel, and dentin
<i>Abstract</i>	<p>Isotope analysis can be used as an aid in forensic identification when primary identifiers provide no or inconclusive results. The establishment of a modern reference database of isotope values from the population living in the Netherlands will aid in including or excluding if the person of interest came from or lived in the Netherlands. The analysis of dentin collagen and enamel will provide an insight into where a person lived during their childhood, while the analysis of hair keratin can provide insight into their recent movements. The analysis of carbon and nitrogen isotopes provides an insight into the diet of an individual, while the analysis of oxygen determines the region where water utilised by the individual originated. In this study, $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values from 32 hair keratin samples were analysed. The samples produced ranges of 7.9 to 10.6 ‰ for $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ range of -21.6 to -20.4 ‰. In dentin collagen, $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values were analysed in 48 samples which produced a $\delta^{15}\text{N}$ range of 10.2 to 11.9 ‰ and a $\delta^{13}\text{C}$ range of -22.0 to -19.9 ‰. In enamel 81 samples produced a $\delta^{18}\text{O}$ range of -7.4 to -4.6 ‰ and $\delta^{13}\text{C}$ range of -14.8 to -12.8 ‰. Additionally, a comparison was made between two methods of hair leaching and hair preparation for isotope analysis. The impact of adding an extra step of hydrochloric acid to the leaching process and the difference of using a cryo-mill compared to cutting with scissors was determined. Neither technique significantly altered the $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values.</p> 

Student	Irene van Damme
<i>Research carried out at</i>	TNO
<i>Supervisor</i>	Mirjam de Bruin-Hoegée MSc
<i>Title thesis</i>	Identifying specific chlorine-tyrosine binding sites characteristic for exposure to chlorine gas
<i>Abstract</i>	<p>In 1997, the Chemical Weapons Convention entered into force, prohibiting the use of toxic chemicals as warfare agents. Since the Syrian civil war started in 2011, numerous allegations of chlorine gas attacks have been made, emphasizing the pressing necessity of a robust chemical analytical method that reliably distinguishes whether or not a person has been exposed to chlorine gas. Previous research demonstrated that upon inhalation, chlorine binds to tyrosine residues of blood proteins, forming 3-chloro-tyrosine (Cl-Tyr) and 3,5-dichlorotyrosine (Cl2-Tyr). While these adducts have the potential to provide strong evidence of chlorine gas inhalation, elevated blood levels of Cl-Tyr and Cl2-Tyr have multiple possible explanations. The aim of this study was to identify specific protein sites where chlorine-tyrosine adducts are predominantly formed upon chlorine gas exposure. In vitro, blood plasma was exposed to different chlorine gas concentrations and the plasma proteins were digested with trypsin and pepsin. The digests and their modifications were measured by the Q ExactivePlus Orbitrap and analysed by Peaks X+ software, which facilitated rapid interpretation of all the MS/MS spectra. A python script was written to identify the protein sites of interest. 50 different tyrosine residues were identified that were specifically chlorinated following the chlorine gas exposure and now form a promising basis for further research. The identified chlorinated peptides were only detected following exposure to 70 mM and 350 mM. This indicates that the method could aid in distinguishing long-term exposure to low concentrations from acute exposure to high concentrations, which should be further explored. A number of the identified tyrosine residues were already identified in previous research as target protein sites of tyrosine nitration during inflammation. During inflammation, the chlorination of tyrosine residues presumably competes with the nitration reaction. The chlorination-to-nitration ratio of these tyrosine residues could be helpful in distinguishing between chlorine gas exposure and non-chlorine gas triggered inflammation.</p>

Student	Maja Mešković
<i>Research carried out at</i>	RIVM
<i>Supervisor</i>	dr. Anne Havermans
<i>Title thesis</i>	Tolerance Development in the Zebrafish Embryo Model using Nicotine: Evaluation of Addictive Potency of Substances
<i>Abstract</i>	<p>While smoking cigarettes is not illicit, it contains one of the most addictive substances; Nicotine. In this study, we developed a model and data analysis strategy to assess addictive substances in zebrafish embryos. Till date, most addiction studies use adult zebrafish and we propose an innovative way of use of zebrafish embryos up to 120 hours post fertilization. Besides that the model is applicable to reduce animal use in pre-clinical research, it has potential to be used as a toxicological tool for forensic purposes. In that way, law and policymakers can be provided with helpful insights to assess potential addictive substances such as compounds in tobacco smoke or designer drugs. To achieve this, nicotine was used as a reference substance to demonstrate tolerance development in zebrafish embryos. The high-throughput light-dark transition test was used in the ZebraBox to evaluate behaviour in zebrafish embryo activity. Furthermore, tolerance was assessed by pre-treating zebrafish embryos with nicotine before exposure to acute nicotine. The results suggested that acute nicotine exposure decreases activity in zebrafish embryos compared to non-exposed zebrafish embryos in the light-dark transition test. However, when pre-treating zebrafish embryos with nicotine prior to acute exposure, the acute nicotine effect was overturned by pre-treatment and more acute nicotine was needed to achieve the same decreasing effects in activity in zebrafish embryos. This results in nicotine tolerance development. Furthermore, after data analysis optimisation, it is recommended to analyse the six minutes middle part of the first dark block since it gives the most reproducible and robust results within the zebrafish embryo model. The zebrafish embryo model and the ZebraBox light-dark transition test proved to be a good model for assessing nicotine tolerance. This model can be used as a forensic toxicological tool to evaluate other drugs of abuse such as cocaine designer drugs. Or, investigate other non-nicotine substances in cigarettes that are assumed to contribute to nicotine addiction. Our study is the first to demonstrate tolerance development for a substance in the zebrafish embryo model with the ZebraBox.</p>

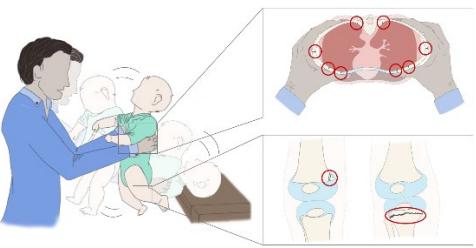
Forensic Medicine

Student	Shanti Bolt
Research carried out at	Emma Children's Hospital
Supervisor	drs. Kirsten van Ham
Title thesis	The inter- and intra-rater reliability of the Sexual Knowledge Picture Instrument (SKPI) - a tool to detect verbal and non-verbal signs of child sexual abuse
Abstract	<p>Child sexual abuse (CSA) is a worldwide problem with potentially devastating consequences for victims. To date, no validated test or instrument is available for medical, psychological and forensic professionals to confirm or reject suspicions of CSA. An illustrated child-friendly book called the Sexual Knowledge Picture Instrument (SKPI) is routinely used at the Emma Children's Hospital (Amsterdam), where it is considered to be particularly valuable in confirming or rejecting suspicions of CSA in children aged three to eight years. The SKPI contains fifteen pictures on family routines, gender differences and normal intimacy. Because of the open, non-suggestive character of the semi-structured SKPI interview method, it is potentially a suitable tool for forensic, medical and psychological professionals to confirm or reject suspicions of CSA. We aimed to determine the inter- and intra-rater reliability of the SKPI as a diagnostic instrument for CSA. Video-recorded SKPI interviews with children aged three to eight years with and without suspicion of CSA were observed by two independent raters, who scored verbal and non-verbal signs of CSA using standardized scoring forms. Inter- and intra-rater reliability of the scoring data was evaluated by Cohen's kappa and percentage of agreement (POA). A total of 78 subjects participated in this study, of which 39 with CSA-suspicion and 39 without. The intra-rater reliability on both the verbal (Cohen's kappa 0.931, POA 97.4) and non-verbal (Cohen's kappa 0.902, POA 100.0) scoring data was almost perfect. The inter-rater reliability on the verbal scoring form was overall substantial (Cohen's kappa 0.673, POA 89.7). The overall inter-rater agreement on the non-verbal scoring form was fair (Cohen's kappa 0.360), and thereby substantially lower than on the verbal scoring form, although the POA was remarkably higher (97.4). The reliability of the SKPI was evaluated as sufficient for further validation. The verbal scoring method as a whole showed satisfactory inter- and intra-rater agreement and thereby proved to be reliable. However, the non-verbal scoring method suffered from substandard inter-rater reliability when evaluating the aggregate of the scoring items. This may be remedied by removing the apparently unreliable items from the scoring form.</p>

Student	Lynn Buijs
<i>Research carried out at</i>	AMC
<i>Supervisor</i>	dr. Erik Cammeraat
<i>Title thesis</i>	Chemical analysis of an unknown substance around and soil beneath a body buried in a shallow grave at ARISTA, Amsterdam
<i>Abstract</i>	<p>Soil thanatochemistry is the study of grave soil surrounding decomposing human cadavers. This field of study is relevant for forensic science, as grave soil can give additional information about the process of decomposition of the deceased and the post-mortem interval (PMI). During this study a crust-like substance found around a buried body at taphonomic research facility ARISTA (Amsterdam) was chemically analysed, together with grave soil samples from beneath the body, approximately one year after burial. We investigated the pH, electrical conductivity, levels of total nitrogen, total carbon, organic carbon, bioavailable nutrients (such as K, Na, Mg, P and Ca), organic acids and amino acids in the crust-like substance, the grave soil beneath the body and control soil. The results of this research show that the crust as well as the grave soil contain statistical significant higher concentrations of nitrogen, total carbon, organic carbon, potassium, sodium and phosphorous compared to the control soil. Also a significant lower pH was found for crust and grave soil. Various organic acids were found in the crust and grave soil, of which acetic acid, pyruvic acid and succinic acid were confirmed and five other organic acids were unknown. Of the 19 analysed amino acids, 12 different amino acids were present in crust and grave soil. In control soil no organic acids and amino acids were found. We found that the crust-like substance likely consists of a combination of soil (inorganic compounds), organic acids and amino acids. Further research should be conducted to get more insight in the formation and structure of the crust. As ARISTA is the first forensic research cemetery in Europe, studying buried bodies here can give new insights into the decomposition process of human bodies in this region of the world. This study is innovative as this crust-like substance is never reported before. It is a first step to establish how and why the crust was formed around this particular body in this particular place: knowledge that can reveal more about the process of decomposition in general.</p>

Student	Hannah Cronenberg
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	dr. Wouter Karst
<i>Title thesis</i>	Controversies and alternative theories for Abusive Head Trauma in Dutch court cases
<i>Abstract</i>	<p>Abusive head trauma (AHT) is an inflicted brain injury in young children with high mortality and morbidity rates. When there is suspicion of AHT, the Public Prosecution Services always asks for expertise from forensic medical experts of the Netherlands Forensic Institute. The court is faced with the questions what caused the injuries and who can be held criminally responsible. Interpretation of the medical evidence plays an important role in answering these questions. The defense may propose alternative theories to explain the injuries, sometimes supported by a counter-expert. The aim of this research is to make an overview of AHT court cases with specific focus on the role of medical experts and alternative theories. Published verdicts of court cases involving the NFI and children with brain injury were analyzed. Characteristics of the victim and suspect, factors influencing the verdict and the proposed alternative theories were reviewed. The demographic results of this study correspond to worldwide data. Almost all of the alternative theories were rejected by the court based on information in the NFI-reports. The discussion around the timing of the traumatic event has in some cases led to enough reasonable doubt to acquit the suspect. The only accepted theory that was supported by a contra-expert involved a forensic physician from Germany. None of the Dutch counter-experts were deemed qualified by the court to give expert testimony, since they were retired doctors or not experienced in the field. The long duration of the trials, the many factors influencing the verdict and the comprehensive medical information demonstrate the complexity of AHT cases. Alternative theories are often proposed, but rarely accepted, showing that the court almost always follows the conclusions of the NFI. The major stumbling points during trial were the discussion about timing of the traumatic event and the lack of experienced Dutch contra-experts. It is important that the defense gets a fair chance to prove their innocence and call the conclusions drawn by the NFI into question. The absence of professional medical expert independent from the NFI is a problem with societal and forensic consequences.</p> 

Student	Judith van Diggelen
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	Michelle Nagtegaal
<i>Title thesis</i>	Prior injuries in medico-legal evaluations of physical child abuse in young Dutch infants.
<i>Abstract</i>	<p>Young children may present to healthcare professionals with injuries that are suspicious for physical child abuse. These injuries are often called sentinel injuries, but this term is used ambiguously in literature. Therefore, the first aim of this study is to develop a consensus definition of the term sentinel injury. To find a consensus definition for the term sentinel injury, a Delphi study is performed with a Dutch expert panel. The Delphi study contained three rounds of surveys with feedback and a conference call. Furthermore, the prevalence of prior injuries that have been observed by healthcare professionals in cases of suspected physical child abuse in the Netherlands is still unknown. Therefore, this study aims to investigate the prevalence of prior injuries in Dutch children with suspected physical child abuse. To determine this prevalence, data from medico-legal evaluation reports from the Netherlands Forensic Institute and the medical files of 37 infants up to two years old were gathered in a database and analysed. Based on the prior injuries and characteristics of the children, the prevalence of prior opportunities to evaluate for abuse were also assessed. The Delphi study found consensus on nine characteristics of the definition of the term sentinel injury, but no consensus was found on six other characteristics. Hence, no complete consensus definition was found for the term sentinel injury and it is recommended to use this term with caution and to investigate a consensus on an international level. The prevalence study showed that 43% of the children in this study had prior injuries and 41% of children had prior opportunities to evaluate for abuse. These findings indicates that there were prior injuries and prior opportunities to evaluate for abuse, observed by healthcare professionals, in children with a medico-legal evaluation for suspected physical child abuse. This calls for improvements in the recognition of injuries that are suspicious for physical child abuse by Dutch healthcare professionals to avoid subsequent abuse.</p>

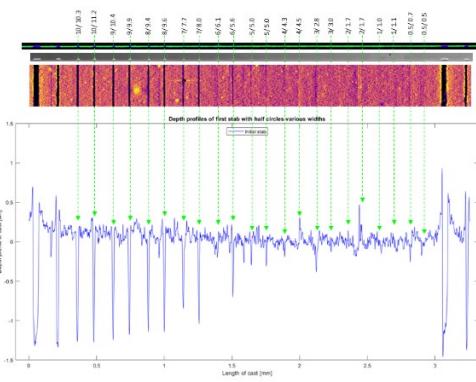
Student	Veronique Konijn
Research carried out at	NFI
Supervisor	drs. Selena De Vries
Title thesis	A comparison of postmortem total body computed tomography and skeletal survey in the detection of fractures in (suspected) child abuse cases
Abstract	<p>To compare total body postmortem computed tomography (PMCT) and the skeletal survey (also referred to as conventional radiography or CR) in the detection of skeletal injuries in (suspected) child abuse cases. In this retrospective observational study, we reviewed children aged 0-4 years old in whom both a PMCT and skeletal survey were obtained prior to autopsy performed by a forensic pathologist at the Netherlands Forensic Institute (NFI) between November 2008 and December 2020. All skeletal surveys and PMCT images were reassessed by one of two experienced (forensic) pediatric radiologists for fractures. Out of the 81 included cases (median age: 4.0 months, 60.5% male), fractures were observed in 36 children (44.4%). Over the whole body, PMCT ($n=182$) detected significantly more fractures compared to the skeletal survey ($n=75$) ($p=0.011$). No significant difference was evident in detecting skull fractures between PMCT ($n=22$) and the skeletal survey ($n=17$) ($p=0.063$). PMCT ($n=149$) yielded significantly more rib fracture than the skeletal survey ($n=37$) ($p=0.026$) – most notably anterior, posterior, transverse, torus and acute fractures. No classic metaphyseal lesions (CML) present on PMCT ($n=2$) were missed with the skeletal survey ($n=10$). The detection of other fractures, including clavicular, vertebrae, and other extremity fractures, was varying for PMCT and the skeletal survey. PMCT detects more skull fractures and rib fractures, than the skeletal survey. However, our findings suggest that the skeletal survey is more likely to identify CML and other extremity fractures. Clavicular and vertebrae fractures were observed with both modalities. With a note of caution, PMCT may be performed with only some specific CR for more efficient postmortem radiological imaging in infants and young children.</p> 

Student	Nina Onkenhout
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	Michelle Nagtegaal
<i>Title thesis</i>	Evaluating toxicology in young children referred for potential child maltreatment in the Netherlands
<i>Abstract</i>	<p>Exposure to drugs or other toxic substances can be related to a form of child maltreatment. Several studies from the USA have been published on this topic, but currently, literature on performing toxicology screening on young children is lacking in the Netherlands, even though both the risk of abuse and intoxication are reportedly increased in this age group. Therefore, a retrospective chart review was performed on cases of children up to 6 years old referred to the Netherlands Forensic Institute for medico-legal evaluation between 2011 and 2020. Over the ten-year study period, a total of 182 cases of children younger than 6 years old were identified in which a toxicological assessment was performed. Overall, exposure to substances was detected in 59.9% of children and non-medical exposure was detected in 23.6% of children. In 32.6% of all non-medical exposures, the exposure was determined to be clinically relevant by the forensic toxicologist and could explain the symptoms and/or death of the child. While most of the non-medical exposures were to painkillers (39.5%) and cocaine or its metabolites (23.3%), non-medical exposures to other medicinal drugs, illicit drugs and in other categories were also found. To our knowledge, this is the first study to assess the prevalence and relevance of substances found during toxicology testing in young children referred for medico-legal evaluation in the Netherlands. Although this study provides some first insights into toxicology testing performed in a medico-legal setting in the Netherlands, there were some considerable limitations. It is therefore important to perform more research on this topic, to determine whether routine toxicology testing should be considered as a screening tool in the detection of child maltreatment.</p>

Student	Anika Veenstra
<i>Research carried out at</i>	NFI
<i>Supervisor</i>	drs. Selena De Vries
<i>Title thesis</i>	Fractures in Young Children: Advice Requests to the Dutch Expertise Centre for Child Abuse
<i>Abstract</i>	<p>Fractures are common injuries as a result of non-accidental trauma. Healthcare professionals encountering children that sustained fractures play an important role in the early recognition of non-accidental trauma and consequently the prevention of further harm. The Dutch Expertise Centre for Child Abuse (DECCA), consisting of paediatricians with expertise in child abuse cases and forensic physicians specialized in children, provides advice to healthcare professionals when any suspicion of non-accidental trauma is raised. The aim of this study is to determine for which fractures a DECCA advice was requested for children younger than three years of age. A database designed for this study was used to gather data from 141 DECCA advice reports, written between 01/07/2019 and 31/12/2020, that concerned young children with at least one fracture. Fracture-characteristics as well as case-characteristics were collected. Most children about whom an advice was requested had at least one fracture in the lower extremities (54%), upper extremities (20%) and/or the skull (20%). In 41% no mechanism of injury was reported that could explain the fracture. Dutch healthcare professionals that requested advice from the DECCA are in doubt or uncertain about a fracture being the result of either non-accidental or accidental trauma. The cases evaluated by the DECCA might not include the ones in which high-specificity fractures for non-accidental trauma are present, since these would not cause any doubt and immediate actions are taken without advice from the DECCA. Therefore, it is recommended for future research to collect all fractures that raised any degree of suspicion in order to get a complete overview of fracture- and case-characteristics that are being considered for non-accidental trauma by Dutch healthcare professionals.</p>

Student	Veronica Baljé
<i>Research carried out at</i>	GGD Amsterdam
<i>Supervisor</i>	dr. Maartje Goudswaard
<i>Title thesis</i>	Doctor or Judge? Why the courtroom needs forensic medical expertise
<i>Abstract</i>	<p>High quality medical information is of key importance in the courtroom. In criminal cases where victims have injuries, this information is important for the judges to understand the nature of these injuries and to determine whether the charge (e.g. severe assault or attempted manslaughter) is justified. Earlier research showed that forensic injury reports are valuable to the judicial system, but are scarcely requested and used. The unavailability of proper forensic medical information in court cases can result in lack of evidence, compromised fact-finding, low burden of proof or improper sentencing. In this study, we elaborated on this problem further. We investigated the availability and usefulness of medical information used in criminal cases in the region of Amsterdam and explored possible solutions to improve the usage of medical information in the courtroom. We performed a file study (part 1) of criminal cases involving injury and organized focus groups (part 2) with judges and counsellors that are active in the Amsterdam region. Our study found that (medical) information in criminal cases is not always available and of good quality. In many cases, no medical information is available at all. When medical information is available, it is often treatment information which is not adapted for judicial purposes, making it hard to interpret for judges and counsellors. Forensic injury reports are specifically suitable for judicial purposes, but are not widely requested. Judges and counsellors expressed the desire for the usage of forensic injury reports in specific cases. There is need for a standardized protocol describing when to refer victims to the PHS injury consultation hour and there should be a focus on the quality of police reports and treatment information from attending physicians.</p>

Forensic Physics

Student	Eva Blom
Research carried out at	NFI
Supervisor	ir. Koen Herlaar
Title thesis	The origin of striation patterns in human costal cartilage caused by knife stabbing
Abstract	<p>Worldwide, stabbing plays a large role in murder-cases [1, 2, 3, 4]. Forensic investigation is conducted in which striation patters of the wound, caused by a knife, are compared to striation patterns of test-stabs made with suspected knives [5, 6]. Based on the observed similarities and differences in the striation patterns, the examiner draws a conclusion about the probability of these observations given the prosecutor and defence hypothesis [5, 6]. To increase the time-efficiency, objectivity and robustness of this assessment, prediction software and a database could be developed. The software will predict, based on a 3D scan of the knife's cutting edge, which configuration of striation marks could be produced by the knife. This database could contribute to the possibility of assigning evidential value to phenomena which are observed. For this, the influence of various parameters is studied, such as done for screwdrivers [7, 8, 9], so the software can take their influence into account. Indicative experiments to the influence of the following parameters is performed: geometry of the irregularities in the knife's cutting edge, re-stabbing in cartilage-simulating material, angle of attack, axial rotation angle, incision-depth, blade shape and vulnerability of the cutting edge. Irregularities larger than 15 µm wide are visible in the striation patterns in 95% of the cases. Re-stabbing in cartilage-simulating material does not have an impact on the relevant striation marks. The angle of attack could be taken into account in prediction software by downscaling the virtual 3D cutting edge to the virtual stab-marks with the cosine of this angle. The axial rotation angle seem not to influence the striation pattern. The incision-depth experiments were inconclusive due to a lack of homogeneous material. Data from the curved blade was scaled non-linearly according to its blade shape to take its influence into account. Re-stabbing in bone seem not to be of influence on the cross correlation between the striation pattern before and after re-stabbing. Thorough research is advised for the influence of the incision depth, knife blade shape of drop-pointed knives and the vulnerability by performing more realistic bone stabbing experiments.</p> 

Student	Sanne Smeets
<i>Research carried out at</i>	TNO
<i>Supervisor</i>	Yoeng Sin Khoe MSc
<i>Title thesis</i>	Optimisation of high-speed images of a bullet penetrating ballistic gelatine for automated detection and processing of the results
<i>Abstract</i>	<p>Images taken with two high-speed cameras at orthogonal sides of a bullet penetrating 10% ballistic gelatine, are loaded into MATLAB for automated analysis. The analysis method starts optimising the image for analysis. This is done by removing background noise by cropping the image and masking certain parts of the gelatine to remove the calibration pins. The images are converted from grayscale to black and white. Then, the dataset of images taken from the top view are analysed to find the contour of the temporary cavity. From this contour the cavity volume is calculated. The datasets from both sides are used for the contour detection of the bullet inside the image. These datapoints are processed to reconstruct the 3D path of the bullet. This reconstructed path is corrected for outliers by the fitting of a model. From this model additional data is obtained, namely the velocity, absolute deflection angle, and kinetic energy of the bullet. All results are visualized, to make them more intuitive to understand. The results can be used for the reconstruction of the bullet path on a crime scene to determine the position of the shooter based on the absolute deflection angle of the bullet when passing through the victim. Other applications include evaluating the lethality of the bullet and the possibility of the bullet to break bones at certain depth.</p>

Forensic Statistics and Mathematics

Student	Yvette van 't Zand
Research carried out at	NFI
Supervisor	dr. Bas Kokshoorn
Title thesis	Application of Bayesian decision theory to the recovery of traces from firearms
Abstract	<p>The present paper describes an exploratory study into the application of Bayesian decision theory to the analysis strategy regarding trace recovery from firearms. With decision theory, decision problems can be modelled to become more insightful and enables standardized decision-making. This potentially reduces the human factor and improves the reliability of forensic science. The study shows that there is a lack of consensus among Dutch Police units when deciding what analysis strategy to adopt, more specifically regarding the choice whether or not to recover DNA and fingermarks from objects. Especially when dealing with firearms, making the correct decision is important, since traces will be corrupted in firing tests. With this information as well as specific case information a decision model was built to give insight into all factors that affect the decision with a focus on the potential outcomes that trace recovery could have. The model illustrates how complex decision-making is and what factors should be taken into account, but more research will be needed to assign probabilities to uncertain case circumstances and to value the desirability of different consequences. When these components are added to the model and after validation, it would potentially be a useful tool for forensic practitioners to base their decisions on and to perform research <i>in silico</i> to test the potential of different strategies.</p> <pre> graph LR A[1. Conducting interviews] --> B[2. Creating the model] B --> C[3. Conducting a case file study] C --> D[4. Testing the model] subgraph Laboratory_possibilities [Laboratory possibilities] direction TB A1[Utility DNA] <--> S1[Sample for DNA?] S1 <--> C1[Combined sampling?] C1 <--> S2[Sample for fingermarks?] S2 <--> U1[Utility fingermarks] end subgraph Sampling_area [Sampling area] direction TB SA1[Sampling area] --> PDR1[Potential DNA recovery] PDR1 --> DP1[DNA analysis potential] DP1 --> U1 PDR1 --> WFW1[Was the firearm wiped?] WFW1 --> DP1 WFW1 --> FPR1[Potential fingermark recovery] FPR1 --> FA1[Fingerprint analysis potential] FA1 --> U1 end subgraph DNA_transfer [DNA transfer] direction TB DT1[DNA transfer] --> PPT1[Perp wearing gloves?] PPT1 --> WFW1 PPT1 --> FPT1[Fingerprint transfer] FPT1 --> FPR1 end </pre>

Human Factors

Student	Emma Cuperus
Research carried out at	NFI
Supervisor	dr. Erwin Mattijssen
Title thesis	Calibrating degree-of-support judgements by providing performance feedback: a pilot study
Abstract	<p>Recent research has shown that the judgements of firearm examiners are not well-calibrated and that they are often overconfident in their statements. Additionally, it has been shown that performance feedback can improve the calibration of expert judgements in several disciplines. However, this had never been tested for firearm examinations. Therefore, this pilot study aimed to provide first insights into the effect of performance feedback on the calibration of firearm examiners. This study focused on one specific mark present in the cartridge cases fired with Glock pistols, namely the firing pin aperture shear mark. Non-firearm-expert participants were asked to complete online surveys evaluating comparison images. Based on the observed degree of similarity (or dissimilarity) of features on compared cartridge cases, the participants were asked to judge whether the comparison provided support for the proposition that the two cartridge cases were fired with the same or with different firearms, after which they had to judge the degree of support for that proposition. The PAV-based numerical metric 'devPAV' was used to indicate whether the participant's degree-of-support judgements were well or ill-calibrated. The average deviation (devPAV) of the degree of support from perfect calibration was measured twice for each participant: before receiving feedback and after receiving feedback. In total, three out of the four participants showed a change in their devPAV score before and after receiving feedback. For only one participant, the performance improved and for the other two, it worsened after feedback. Although this study is the first to provide performance feedback to examiners of firearm examination in order to attempt to provide better-calibrated degree-of-support judgements, the study had several major limitations and the findings do not clearly indicate whether performance feedback improves the calibration of degree-of-support judgements. The devPAV score does not seem appropriate for this study and it is recommended to proceed with other calibration scores, such as the CllrCal and Brier scoring rule.</p>

