Best Practice Manual for Facial Image Comparison

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ENFSI wishes to promote the improvement of mutual trust by encouraging forensic harmonisation through the development and use of Best Practice Manuals.
Furthermore, ENFSI encourages sharing Best Practice Manuals with the whole Forensic Science Community which also includes non ENFSI Members.
Visit www.enfsi.eu/documents /bylaws for more information. It includes the ENFSI policy document Policy on Creation of Best Practice Manuals within ENFSI (code: QCC-BPM-001).

Official language
The text may be translated into other languages as required. The English language version remains the definitive version.

Further information
For further information about this publication, contact the ENFSI Secretariat. Please check the website of ENFSI (www.enfsi.eu) for update information.

Best Practice Manual for Facial Image Comparison

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1. AIMS

This Best Practice Manual (BPM) aims to provide a framework for procedures, quality principles, training processes and approaches to forensic facial image comparison (FIC). This BPM can be used by member laboratories of the European Network of Forensic Science Institutes (ENFSI) and other forensic science laboratories to establish and maintain working practices in the field of forensic facial image comparison that will deliver reliable results, maximize the quality of the information obtained and produce robust evidence. The use of consistent methodology and the production of more comparable results will facilitate interchange of data between laboratories.

The term BPM is used to reflect the scientifically accepted practices at the time of creating. The term BPM does not imply that the practices laid out in this manual are the only good practices used in the forensic field. In this series of ENFSI Practice Manuals the term BPM has been maintained for reasons of continuity and recognition.

2. SCOPE

2.1 General

This BPM addresses the processing, examination and comparison of imagery depicting faces and the evaluation of findings in a forensic context.

This BPM is aimed at facial image examiners and assumes prior knowledge in the discipline of facial comparison. It is not a standard operating procedure and addresses the requirements of the judicial systems in general terms only.

BPMs are overarching document that describe recommended working practices for a process. BPMs sit above detailed standard operating procedures, which describe the laboratory specific method of a process. The recommendations within the BPM are not mandatory and will be updated to reflect new empirical research where appropriate.

Facial comparison is widely used in other areas of law enforcement, such as when gathering intelligence on persons of interest, during the process of a criminal investigation, verifying a person's identity for access control or reviewing the output of an automated facial recognition system. These types of comparison are defined as facial review by the Facial Identification Subcommittee of OSAC, in document ASTM E2916 Terminology for Digital and Multimedia Evidence Examination [1] as:

> **facial review**, (1) the review of a facial recognition (FR) system candidate list to identify a possible match; (2) the one-to-one comparison (verification) conducted in a high-throughput environment (for example, border crossing).

Generally facial reviews are considered to be non-evidential facial comparisons, staff who conduct these comparisons may be trained facial reviewers but not to the level of facial examiner. Although facial reviews are currently outside the scope of this BPM the principles discussed for forensic facial image comparison are still relevant to facial review.

For the purpose of this document the term imagery will be used to describe both still images and moving video.

Activity level reporting is outside the scope of this document.

2.2 Limitations

This BPM does not address the following aspects of facial identification:

- The recognition of familiar faces
- The use of automated facial recognition algorithms
- Age-progression of faces
- Facial reconstruction
- Facial composites
- Determining subject age and ethnicity from images
- Forensic artistry

This BPM also does not address comparison of other parts of the human body, object and clothing comparison or gait analysis from imagery. Future versions of this BPM may address other areas of comparison and also reviewing results from automated facial recognition systems.

The restoration of corrupt or incomplete digital data, physical repair of storage media, repair of analogue media and complex imagery enhancement (e.g. frame integration techniques) are outside the scope of this BPM. Where relevant and appropriate these tasks should be undertaken by examiners with competency and training relevant to that field.

This BPM will address the authentication of imagery insofar as to determine if the imagery has been provided in its original format. Authentication methods to determine if imagery has been manipulated are outside the scope of this BPM.

3 DEFINITIONS AND TERMS

For the purposes of this BPM, the relevant terms and definitions given in ENFSI documents, the International Laboratory Accreditation Cooperation (ILAC) G19 “Modules in a Forensic Science Process” [ILAC G19:08/2014], as in standards like International Standardisation Organisation (ISO) 9000 [ISO 9000:2005], ISO 17000 [ISO/IEC 17000:2004], 17020 [ISO/IEC 17020:2012] and 17025 [ISO/IEC 17025:2005] apply.

For definitions of terms specific to facial image comparison used in this BPM refer to the document: ASTM E2916 Terminology for Digital and Multimedia Evidence Examination [1].

For definitions of terms specific to image processing and enhancement used in this BPM please refer to the ENFSI BPM for Forensic Image and Video Enhancement (ENFSI-BPM-DI-02) [2] (Note that at the time of writing this BPM (ENFSI-BPM-DI-01), the BPM for Forensic Image and Video Enhancement (ENFSI-BPM-DI-02) is in draft and a date of publication has not been finalised).

For definitions and terms related to the evaluation of evidence and reporting conclusions refer to the ENFSI Guideline for Reporting Evaluative Opinions [3].

Other specific terms used in this BPM are:

Questioned image: Imagery in which the identity of the depicted subject is contested or uncertain. Questioned imagery is typically captured in uncontrolled conditions.

Reference image: Imagery in which the identity of the depicted subject is known and has been verified. Reference imagery is often captured under controlled conditions.

4. RESOURCES

4.1 Personnel

4.1.1 Facial Image Examiners

This BPM is specific to facial examiners conducting FIC examinations. FIC examinations are defined as follows by FISWG [4]:

> 'The task of facial examination includes, but is not limited to, a rigorous one-to-one analysis, comparison, and evaluation of controlled and uncontrolled images for the purpose of effecting a conclusion. Examiners in this situation have to draw on a larger foundation of knowledge, skill, and ability to accurately reach their conclusions. Additionally, the articulation of the scientific and legal basis for the expression of conclusions for many forensic, intelligence, or law enforcement purposes requires an even more advanced level of training to include an expanded set of knowledge, skills, and abilities above the level of basic concepts.'

Throughout this document the terms 'facial image comparison' and 'FIC' will be used to refer to all aspects of the facial comparison examination.

4.1.2 Testing Innate Ability

The laboratory should implement a facial comparison testing programme as part of its recruitment scheme, to gauge examiner ability before training. There is a wide range in innate ability when comparing unfamiliar faces [5], [6]. Such a testing scheme can be used to highlight individuals with high innate performance for recruitment as facial examiners and enrolment in subsequent training and mentoring.

Throughout training regular testing and evaluation of trainee performance should be conducted using ground truth facial comparison tasks. These tasks should cover the range of imagery that will typically be encountered in casework. Empirical research has demonstrated that providing trainees with feedback on facial comparison tests improves trainee ability [7].

4.1.3 Training

In order to undertake FIC, examiners must be trained and competent in appropriate procedures and have specialist knowledge in relevant topics. The following is a list of recommended competencies for facial examiners. Which competencies are required will depend upon the operational requirements of the agency or organisation for whom the examiner works and the types of casework undertaken. **Not all of the points will be relevant to every agency or organisation and not all topics are required to become a competent facial examiner in a specific situation.**

A detailed list of topics and references for the education and training of facial examiners can be found in Appendix A.

New examiners should have a training plan devised prior to commencing training and be assigned a mentor to guide them through their training and provide feedback on tasks. The organisation's Quality Management System (QMS) should describe how examiners are to be trained and tested to achieve competency and how competency should be maintained.

4.2 Equipment

IT hardware and software is utilised for the viewing, processing and possible enhancement of imagery for FIC. Such hardware and software should be fit for purpose and where possible validated for its intended use. The laboratory should keep an up-to-date list of all hardware and software used including identifying information such as the version or build number of software and the serial number of hardware.

There is a wide range of software and hardware that can be used for facial image comparison, these can be broadly defined as:

Hardware

- Computer hardware
- Storage and archiving system
- Graphical output devices (e.g. displays or printers)
- Graphical input devices for analogue media if appropriate (e.g. scanners, digital cameras, video capture cards)

Graphical output devices, such as display monitors and printers, should be calibrated to determine the accuracy of the outputted image. Likewise graphical input devices should also be calibrated to ensure that the digital image generated captures information at the required level of detail.

Software

- General purpose image processing tools
- General purpose video editing tools
- Image and video data analysis tools
- General and manufacturer specific (proprietary) viewing tools

The software used to view and process digital imagery should be validated insofar as possible for its intended purpose. This validation should, at the bare minimum, determine if the process results in any visual loss of quality to the displayed or outputted imagery and if this loss has an impact upon the subsequent examination and comparison.

If it is not possible or appropriate to validate a piece of software, such as proprietary CCTV replay software, examiners should use the ‘dual-tool’ approach and utilise more than one piece of software to try to achieve consistent results [8].

4.3 Reference materials

The use of reference materials from a known source can be used to validate processes, test examiner competency and calibrate equipment.

4.3.1 Validating technical processes

For image capture and enhancement techniques reference materials may be used for validating the process, to ensure that the process is fit for purpose and produces the intended result. For example, by using a reference signal or data input a process can be checked for any types of degradation occurring in the signal pathway by observing the process output (See ENFSI BPM for Forensic Image and Video Enhancement (ENFSI-BPM-DI-02) [2]).

4.3.2 Testing examiner competency

The laboratory should retain a collection of facial imagery that can be used for internal

proficiency testing of examiners and validation of comparison procedures. The ground truth of this material should be known (i.e. the true responses for match and non-match pairs are known) and encompass a range of image qualities that accurately represents casework material. For details on conducting proficiency tests see ENFSI Guidance on the conduct of Proficiency Tests and Collaborative Exercises [9]

Proficiency tests should be conducted using laboratory procedures to meaningfully test examiner competency in those procedures. As comparison methods are subjective they are reliant on the observations and interpretation of the examiner. FIC proficiency test should be designed to allow effective evaluation of human performance [10].

4.4 Accommodation and environmental conditions

FIC should be conducted in a controlled environment. As with all forensic disciplines safe and secure storage of submitted items is required to ensure the integrity and continuity of the imagery. The movement and storage of items should be auditable and traceable.

Depending upon internal procedures, copies of imagery submitted for comparison may be retained for a set period of time after completion of the examination, for example on a secure internal network. This digital storage should equally be auditable and ideally cross referenced to a database to ensure that data are managed and traceable at all times.

Consideration should be given to laboratory lighting conditions to optimise viewing of imagery and minimise issues such as screen glare (e.g. using matte rather than glossy screens or installing monitor hoods). Examiners should take regular screen breaks to prevent fatigue when examining imagery.

When conducting independent verifications as part of the ACE-V process (see Section 5) the position of monitors and desks should be considered. Ideally examiners should not be exposed to imagery before conducting their structured ACE-V examination, in order to minimise possible sources of bias, such as confirmation bias caused by viewing the reference imagery prior to the questioned imagery. This can be challenging in open office environments but should be taken into account when positioning desks and monitors and deciding the order in which examinations are conducted and at what stage reference imagery is viewed.

4.5 Materials and Reagents

Questioned imagery submitted for FIC is typically uncontrolled and the quality of the imagery will be beyond the examiners control. Questioned imagery will encompass a range of different sources and quality.

The reference imagery used in the comparison should be captured in a controlled environment and ideally include the following:

- Imagery captured and stored at a sufficient level of detail to include fine feature detail such as scars, marks and small creases
- Imagery captured in a range of different camera angles and poses, including the camera angle and pose of the questioned imagery
- Imagery captured at a similar time to the questioned imagery (if the questioned imagery was captured a significant amount of time ago recent reference imagery of the subject should also be supplied to highlight any age-related changes)

Reference imagery that does not meet the criteria above may be detrimental to the results of the

comparison and could cause errors [11]–[13]. If the reference imagery is unsuitable or of limited scope for comparison the examiner should make efforts to source additional suitable reference imagery.

Comparisons should not be restricted to single images (e.g. a still from a video). Where possible, examiners should utilise a range of questioned and reference imagery when conducting a comparison to provide the maximum amount of subject detail [14].

If possible, capturing additional reference imagery using the same or similar recording device and conditions of the questioned imagery may be beneficial [15].

In some circumstances the examiner may be requested to compare multiple sources of questioned imagery without reference imagery.

5. METHODS

5.1 Case Strategy

Prior to undertaking the FIC examination, a case strategy should be established defining the following:

- The methods to be used in the examination
- Which imagery is to be compared
- Dates on which the imagery was taken
- Any additional relevant information concerning the subject or the imagery (e.g. cosmetic surgery)
- Critical dates for completion of the examination
- Any other types of forensic examination and the order in which this will be conducted (e.g. DNA profiling or fingerprint development)
- The propositions under evaluation

Ideally the case strategy should be set by a competent member of laboratory staff who does not take part in the FIC examination, to mitigate contextual bias. The strategy setter can then remove non-essential sources of information that may cause bias (e.g. identification by other means, background information of the investigation) and retain relevant information that the examiners need to know (e.g. dates of image capture).

The strategy setter should establish what question(s) or propositions are to be addressed by the examination. The examination should not be aimed at addressing only one proposition, such as the proposition that the subject in the CCTV is the defendant, as this may bias results towards that outcome and other likely alternatives may not be considered. An approach to overcome this is for at least two mutually exclusive propositions for the evaluation of the comparison findings to be set as part of the case strategy for evaluation. Facial image comparison should be reported at the source level rather than activity level. The propositions should reflect both the view of the prosecution/mandating authority and the defence/alternative scenario. If a defence statement has not been provided the examiner should set a competing proposition. When setting the competing proposition the reporting examiner should adopt a scenario that likely and reasonably reflects the party's position, such as:

H^1 - Subject A is the defendant
H^2 - Subject A is another individual or Subject A is another adult male

The examiner should not adopt a competing proposition that is too broad as this will maximise the evidential value of the observations. Likewise, the competing proposition should not be too narrow as this may exclude realistic potential candidates. The propositions should be set prior to commencing the examination. If new information comes to light during the examination that alters the propositions this should be recorded and the strategy updated accordingly.

5.2 Technical Processes

5.2.1 Conversion of imagery

If the submitted imagery is supplied in a non-standard or proprietary format it may be necessary to convert the imagery to another format for analysis or subsequent processing. Any processes used to convert imagery should be validated to determine if there is any degradation to the output. When converting imagery examiners should consider the following:

- The converted imagery is maintained at the native resolution of the input imagery
- The aspect ratio of the input imagery is maintained
- If transcoding to a new format the converted imagery is produced in a losslessly compressed or uncompressed format
- Any colour space conversions do not cause a loss of facial detail or clipping of colour values

Examiners should record the processes applied when converting the imagery, the software used, the version number, parameters and format of the output file.

5.2.2 Digitisation of Analogue Imagery

The conversion of an analogue source to a digital file will inevitably result in the loss of some information. The processes used to digitise analogue imagery should be validated to ensure that there is not a significant loss of facial detail. When digitising analogue media examiners should consider the following:

- Where possible adjustments to the imagery (e.g. brightness) should be applied in the analogue domain before digitisation
- The digital file should be produced with lossless compression or in an uncompressed format
- The resolution of the digital file is sufficient so that there is not a loss of facial detail
- The bit depth of the digital file is sufficient so that there is not a loss of facial detail
- The transmission of analogue signals should be via the highest quality pathway available to minimise degradation of the signal

Examiners should record the make, model and serial number of digitisation hardware, any software used and the version number, the format and parameters of the output file and any processing applied.

5.2.3 Enhancement of Imagery

During the examination there may be the potential to enhance the submitted imagery through processing, to produce a result that is better suited for the purpose of comparison or provides additional clarity of facial feature detail. The ENFSI BPM for Forensic Image and Video Enhancement (ENFSI-BPM-DI-02) [2] provides detailed guidance on how the forensic enhancement of imagery should be conducted. This guidance also applies to imagery enhanced for FIC. However not all of the processes mentioned within the ENFSI BPM for Forensic Image and Video Enhancement (ENFSI-BPM-DI-02) should be applied in facial image comparison. Image enhancement processes alter the appearance and content of an image and may distort

facial features or introduce artefacts that mislead the comparison examination. Any applied enhancement procedures should be validated for their intended use.

Examiners should be competent in any enhancement processes applied to imagery and have knowledge of what alterations to an image will occur from a process. Examiners should be capable of identifying artefacts introduced by an enhancement process and any potentially detrimental impacts on image quality. Additionally examiners should also consider the following when attempting to enhance imagery for FIC:

- Digital enhancement processing should only be applied to a copy of the imagery
- The output format of the enhanced image should be losslessly compressed or uncompressed
- Ideally the output format of the enhanced image should support the processing steps of the enhancement to be revisited for transparency (e.g. using smart objects or layers within .TIFF or .PSD files)
- A copy of the imagery without the enhancement should also be available for the subjective analysis
- The introduction of artefacts into the image should be kept to a minimum
- Alterations to the facial appearance of the subject in the image should be kept to a minimum
- Complex enhancement processing, such as image deconvolution, adaptive filtering and inter-frame processing (e.g. super resolution) should be used with caution, due to the high propensity of these techniques to introduce artefacts
- Any enhancement processes applied to an image for facial comparison should be validated, insofar as possible, for its intended use

Examiners should record the type of processes used to enhance an image, the parameters applied, the order in which processes were applied, the format and parameters of the output file, the name and version number of the software used and a rationale for why a process was applied.

If an enhanced image is to be used for FIC the examiner should always refer back to the original un-enhanced image as well as the enhanced version when conducting their analysis, due to the potential introduction of erroneous image artefacts by an enhancement process.

5.3 Subjective Examination

The ENFSI Digital Imaging Working Group (DIWG) and FISWG currently recommend that morphological analysis be used for FIC. Empirical evidence indicates that this method improves accuracy in facial comparison tasks [16]. Morphological analysis is defined as follows [17]:

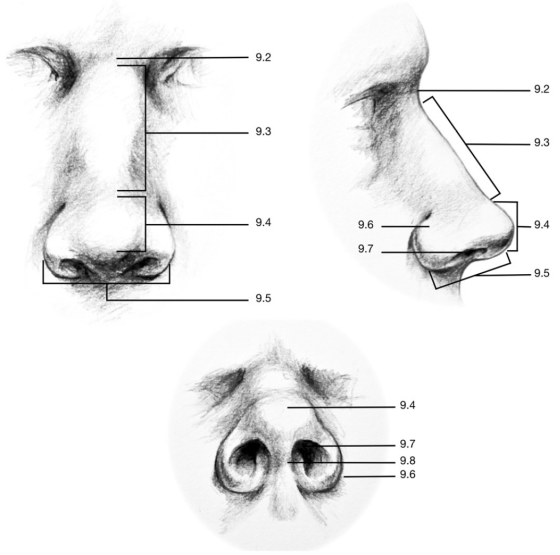
> ‘Morphological analysis as a comparison method is based on the assessment of correspondence of the shape, appearance, presence and/or location of facial features. These features include global (corresponding to the overall face), local (including anatomical structures such as nose or mouth and their components, e.g., nose bridge, nostrils, ear lobes) and discriminating characteristic facial marks such as scars or moles.’

It is recommended that a facial feature checklist with standardised terminology is used by a laboratory, such as the FISWG facial feature list [18]. This will provide consistency and repeatability between different examiners in the laboratory when using the morphological approach. Table 1 shows an example of the facial features used by the FISWG list.

Table 1 - Facial components of the FISWG Facial Feature List

ID	Facial Components
1	Skin
2	Face/Head Outline
3	Face/Head Composition
4	Hairline/Baldness Pattern
5	Forehead
6	Eyebrows
7	Eyes
8	Cheeks
9	Nose
10	Ears
11	Mouth
12	Chin/Jawline
13	Neck
14	Facial Hair
15	Facial Lines
16	Scars
17	Facial Marks
18	Alterations
19	Other

General facial features (aka class feature detail) should be further sub-divided into sub-features (aka sub-class feature detail) to allow the analysis of higher quality imagery. Figure 1 shows an example of sub-class feature detail for the nose.



9-Nose	
Component Characteristics	**Characteristic Descriptors**
9.1 Nasal Outline (Profile and Front view)	• Overall Shape • Length and/or width • Prominence • Symmetry
9.2 Nasal Root (Bridge)	• *Front View:* width, length, shape, depth • *Profile View:* length, depth, angle
9.3 Nasal Body	• *Front View:* width, length, shape, angle • *Profile View:* length, angle, contour
9.4 Nasal Tip	• Shape (in front and profile view) • Angle (e.g. up, down) • Symmetry
9.5 Nasal Base	• Width • Height • Deviation to the right or left
9.6 Nasal Base: Alae (Wings of Nose)	• Thickness • Symmetry • Shape
9.7 Nasal Base: Nostrils (Nasal Openings)	• Shape and size of opening • Symmetry • Hair
9.8 Nasal Base: Columella (Soft Tissue between Nostrils)	• Width and length • Relative position • Symmetry

Figure 1 – Sub-class characteristics of the nose from the FISWG facial feature list

In addition to facial features the checklist should also include fine feature detail, such as scars, marks and small creases and alterations such as piercings and tattoos. Fine feature detail can

prove very useful in FIC when used in combination with facial feature detail, and can distinguish between identical twins [19].

The following comparison methods are currently **not recommend** for FIC of uncontrolled imagery. Current empirical research indicates that these methods may not produce accurate comparison results and have issues concerning repeatability and reliability:

- Facial feature classification [20], [21]
- Photo anthropometry/proportional alignment [22], [23]
- Superimposition/overlaying [24], [25]

A brief review of the above facial comparison techniques is provided in Appendix C.

In the absence of empirical research supporting the use of a method in casework, any method used to analyse and compare facial imagery should be validated by the laboratory to demonstrate the accuracy of the method and show that it produces reliable results. The laboratory should also state why the method has been used, supported by the results from any relevant validation studies.

In order to perform the examination and comparison of facial imagery an ACE-V workflow is recommended. This approach is characterised by applying the following subjective phases of the examination: analysis, comparison, evaluation and verification. Although ACE-V is described as a linear workflow examiners may not necessarily work completely in a linear fashion.

5.3.1 Analysis

The analysis of the questioned imagery is the first stage of the process. The analysis phase is intended to determine whether the quality of the questioned imagery is sufficient for meaningful facial comparison. The analysis phase consists of an assessment of the quality of the questioned imagery to determine the degree of facial detail present and what features are available for comparison. The reference imagery should not be analysed in detail at this stage to mitigate the risk of confirmation bias (i.e. being potentially misled by viewing features in high quality reference imagery that are not resolvable in the lower quality questioned imagery).

Imagery of low quality may result in limited or at worst unreliable findings in FIC [26]. The image quality assessment of the questioned imagery should address, but not be limited to, the following aspects:

- Pixel resolution of the face as determined by the overall resolution of the image and the distance of the subject from the camera
- Compression artefacts visible within the imagery causing a irrecoverable loss of detail
- The lighting conditions of the image and the impact this has on the visibility of features and the degree of contrast between different features
- Blur within the image causing a potentially irrecoverable loss of detail
- Geometric distortions such as lens barrelling that may distort the appearance of facial features
- If the angle of the camera is causing occlusion of facial features
- If other factors such as clothing or physical obstruction are occluding facial features

During analysis the examiner should note if there are factors affecting the appearance of the observed features, such as expression, pose, clothing or image quality issues (see Appendix B for details).

When analysing the questioned imagery all the relevant submitted material should be reviewed. Specific images may then be selected that provide the most facial detail for comparison and at a similar pose and camera angle to the reference imagery. Where possible, observations should not be restricted to just a single image. Features only observed in a single image, particularly if that image is of low quality, may be attributable to image artefacts.

Examiners should also ascertain whether the imagery has been submitted in its original format, as generally this will provide the highest quality imagery for examination. Examples of converted imagery that may have introduced a loss of quality include:

- Screen grabs of video
- Transcoded video (e.g. conversion to AVI or DVD video formats)
- Still images taken from a video
- Photographs of a display screen replaying imagery
- Still images resaved in a lossy format (e.g. JPEG)
- Digital conversions of analogue imagery

Examiners should be competent in establishing if imagery is presented in its original format. If imagery is not provided in its original format and the examiner believes this has introduced a loss in quality from the original or may have significantly altered the imagery the examiner should request the original imagery from the investigation or an explanation of why the original is not available.

If the findings of the analysis phase are that there is insufficient facial feature detail for reliable comparison this decision should be reviewed by another competent examiner. If the reviewer is in agreement with the findings the party requesting the comparison should be contacted as soon as practicable to inform them of the result.

5.3.2 Comparison

The aim of this stage is to systematically compare the facial features observed in the questioned and reference imagery to establish any similarities or differences between the observed features. The comparison should follow the morphological approach and utilise a standard reference facial feature list [18].

When making observations the examiner should consider the impact of image quality factors on apparent similarities and differences, such as resolution, occlusion or motion blur (see Appendix B for further details). For example, if a difference or similarity is observed but it is readily explainable by imaging factors this should be noted as it will impact upon the evaluation stage.

When conducting the comparison ideally the questioned and reference imagery should:

- Be captured on a similar date
- Be captured at a similar camera angle
- Show the subject in a similar pose and expression
- Be captured under similar lighting conditions

If the above are not met this could impact upon the reliability of the observations and limit the suitability of the imagery for meaningful comparison. Empirical evidence has demonstrated reduced accuracy in facial comparison tasks when these conditions are not met [13], [27].

During the comparison the examiner may resize or rotate the imagery to aid in the observation of similarities and differences. Examiners should have an awareness of the impact of different

image resizing algorithms on the appearance of facial feature detail. When resizing any image for FIC the aspect ratio of the image must be maintained.

Rotating an image will also result in the interpolation of pixels and alteration to the image. When rotating images for comparison the examiner should rotate the highest quality image (typically the reference image) as this will have less of an impact on image detail than rotating a lower quality image.

5.3.3 Evaluation
See section 12

5.3.4 Verification
The FIC ACE process should be repeated by a second independent examiner to provide a verification of the result.

The term verification may be used to refer to the following processes [28]:

- Blind verification: an independent verification done by a second examiner using the ACE method, without knowing the conclusion of the first examiner
- Non-blind verification: an independent verification done by a second examiner using the ACE method, knowing the conclusion of the first examiner

Due to the subjective nature of FIC a **blind verification is recommended** for all examinations as this will help prevent confirmation bias that can occur in non-blind verification. Agency SOPs should define how the stages of the ACE processes are repeated during the verification. Verification should be performed on all examinations that progress to the evaluation stage.

The verification should be documented to the same level of detail as the initial examiner's examination.

Where there are sufficient resources there should also be a critical findings check of the conclusions as part of the peer-review process (see Section 5.3.6).

5.3.5 Resolving Disagreements
Agencies should have written procedures to address differences in interpretation by different examiners arising from the verification. As FIC is a subjective process it is expected that there will be differences in how features and aspects of an image are described by different examiners, but these differences may not have a significant impact upon the overall findings.

The resolution procedure should define when differences in interpretation are treated as significant, supported by validation of the process and define steps to resolve the difference in interpretation (e.g. a third independent verification or a panel review process).

5.3.6 Peer Review
The findings of the FIC examination should be peer reviewed before release to the customer. The peer review should comprise of two aspects; a critical findings check and a technical fact check.

- Critical findings check: A competent facial examiner reviews the ACE-V process of the examination and checks the findings of the examination to ensure they are consistent with the documented process.
- Fact check: The technical aspects of the examination are checked for consistency, such as dates of when an examination was conducted or the seal numbers of exhibit continuity bags.

Errors found during the fact check should be corrected by the examiner responsible for reporting the conclusion before release to the customer. Errors encountered during the critical findings check should be addressed using the agencies policy for resolving disagreements (Section 5.3.5).

6. VALIDATION AND ESTIMATING UNCERTAINTY OF MEASUREMENT

6.1 Validation

The laboratory should use validated methods for the processing, examination and evaluation of facial imagery. Before a validation process can be started the critical aspects of the method or procedure should be identified and the limitations defined. This information should be recorded in a validation plan as per laboratory SOPs.

During validation it is important to investigate the following aspects of the method:

- Accuracy
- Precision
- Range
- Repeatability
- Reproducibility
- Robustness

The validation process must be developed in accordance with the provisions of section 5.4.5 of ISO 17025 [29]. At the time of writing there are no published standards addressing procedures used in the field of FIC.

The final aim of the validation process is to establish whether the method meets the required accuracy, precision, repeatability, reproducibility and robustness of its intended use. The results of the validation study should be produced in a report as per laboratory SOPs.

Additional guidance of validating laboratory procedures can be found in the ENFSI Guideline for the Single Laboratory Validation of Instrumental and Human Based Methods in Forensic Science [30]

6.2 Estimating Uncertainty of Measurement

At present, it is not possible to calculate the probability of a match between two faces. This is due to the absence of relevant population data, i.e. the frequency of occurrence of different facial features within the relevant. In the absence of such data an estimation of the error in FIC should be established through black box studies, validation studies, proficiency testing and collaborative exercises.

Laboratories should attempt to identify the potential sources of uncertainty during examinations, as stipulated in paragraph 5.4.6 of the ISO 17025 standard. Potential sources of uncertainty examiners may encounter during the examination of materials includes, but is not limited to, the following:

- Sample size: the quantity of imagery available for analysis and comparison may impact upon the strength of the evaluation. If the observations made during the examination are limited to a single frame there may be less information available compared to using multiple images or moving video.
- Quality of imagery: Image quality depends on a myriad of inter-related factors including resolution, compression and occlusion of features. These factors will have an intrinsic impact on the results of any examination. See Appendix B for examples of factors affecting facial appearance.

- Human error: At each stage of the examination the actions of the human examiner are critical to result. Human error may introduce uncertainty and should be countered using processes such as the following:
- Structured training
- Ongoing competency testing
- Adhering to standard operating procedures
- Using validation methods
- Structured examinations (e.g. ACE-V)
- Independent verification of findings
- Fact checking and critical finding checks (peer-review)
- Participation in collaborative exercises and proficiency testing

7. PROFICIENCY TESTING

Proficiency tests should be used to test and assure the reliability of FIC processes. ENFSI Guidance on the conduct of Proficiency Tests and Collaborative Exercises [9] provides information on the organisation and frequency of proficiency tests. ENFSI also maintains a list of proficiency test and collaborative exercise providers that may be consulted. When developing proficiency tests providers should be aware of relevant scientific literature concerning the testing of human performance [10].

ISO 17025 accreditation requires laboratories to perform at least one proficiency test per year [29].

8. HANDLING ITEMS

Media containing digital data should be handled in accordance with the ENFSI BPM for Forensic Information Technology [31]. Analogue media, such as VHS cassettes, should be stored in a safe and secure environment to prevent degradation of the material. Submissions requiring more than one type of work should follow laboratory SOPs for dual submissions. If the type of work requested will be impacted by the facial comparison examination (e.g. DNA profiling, fingerprint enhancement) the examiner should consult with the investigator to determine which examination should take place first.

9. INITIAL ASSESSMENT

Prior to the formal submission of imagery for FIC the laboratory may consider providing an initial triage service to assess the suitability of the imagery and the proportionality of the request. For example, if the quality of the imagery is likely to only provide weak or inconclusive results or there is substantial other evidence in the investigation FIC may not be appropriate. It is likely at this stage only a sample of the imagery will be triaged for quality assessment. If the request is proportionate and the sample of imagery sufficient for examination a full examination should be conducted. Triaging cases can be an effective way of managing caseloads and ensuring operational effectiveness. It also manages the expectations of the investigator regarding how beneficial facial comparison will be to their case.

10. PRIORITISATION AND SEQUENCE OF EXAMINATIONS

A FIC examination can be broadly separated into technical processes and subjective examination [32]:

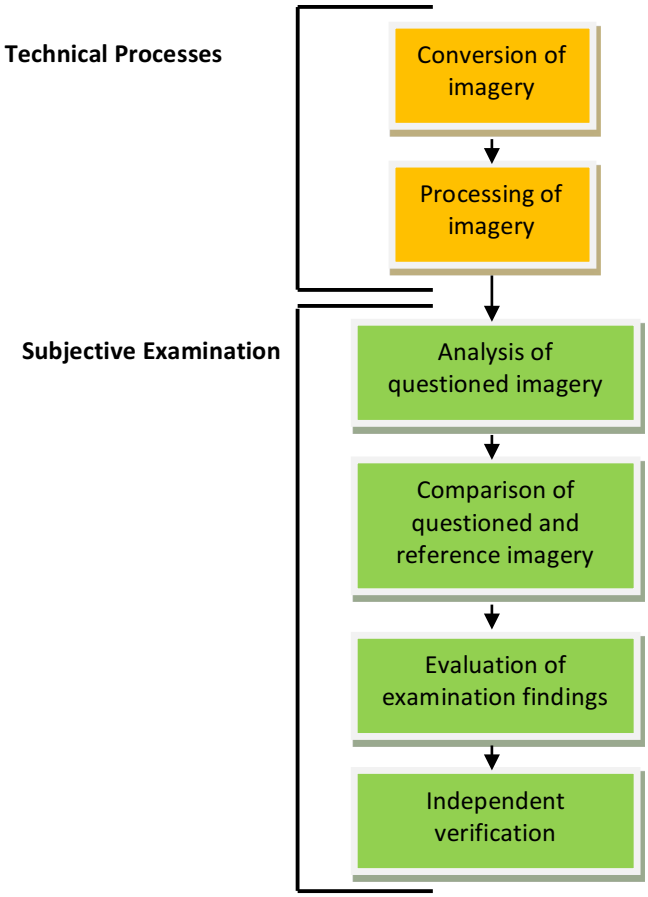


Figure 2 – Overview of the FIC examination process

Depending upon laboratory organisation, the facial examiner may undertake the technical processing of imagery or this may be undertaken by a specialist in image processing then passed onto the facial examiner. In either arrangement it is necessary to ensure that staff undertaking any task are competent to do so and have sufficient training and knowledge in that field. A clear chain of continuity must be maintained throughout all stages of the examination, particularly if material is moving between different departments.

The subjective examination of FIC should be undertaken within a structured ACE-V workflow. Although ACE-V is described as a linear workflow examiners should not necessarily work completely in a linear fashion, e.g. processing of the imagery may occur during any stage of the subjective examination or a feature within the questioned imagery may only be observed during the comparison stage. This is acceptable as long as the examiner can justify their deviation from a linear workflow.

11. RECONSTRUCTION OF EVENTS

When sourcing reference material of a subject for FIC, in addition to high quality reference imagery, attempts should be made to recreate, insofar as possible, the capture conditions of the questioned imagery, as discussed in Section 4.5.

12. EVALUATION AND INTERPRETATION

The ENFSI Guideline for Evaluative Reporting in Forensic Science [3] provides forensic examiners with a framework for formulating evaluative reports and contains an example of evidence evaluation from a FIC examination. This guideline should be consulted for specific guidance on formulating logical, evaluative opinions. This BPM provides details of some of the factors that can influence evaluation in FIC and should be read in conjunction with the ENFSI Guideline.

During the evaluation stage the observed similarities and differences from the comparison are evaluated by the examiner, resulting in a conclusion that states the evidential weight as a level of support for one of the competing propositions. FIC is a subjective process and currently it is not possible to assign a quantitative probability to the examination findings. Therefore the conclusions will be based upon the training, knowledge and experience of the examiner.

The findings should be expressed as a level of support for one of the propositions, for example:

- The findings from the examination support the view that the person indicated on the CCTV still is the person in the reference images (level +2), rather than that the individual is another adult male [3].
- The examination findings provide strong support for the proposition that Subject A is another individual, rather than the defendant.

The propositions under consideration will depend on the circumstances of the case and should be established prior to undertaking the FIC examination.

Support levels are typically reported using a graded scale. At present there is not a universally accepted scale for reporting FIC conclusions and there is a wide range in scales used by different agencies. Whichever way the conclusions of a FIC examination are reported should be validated to ensure that it is applicable to the type of imagery encountered in casework and produces repeatable, reliable and accurate results.

Due to the lack of empirical data regarding the frequency of occurrence of facial features within the population, it is recommended that statements of absolute certainty are not used when reporting FIC conclusions.

If using a graded scale to report conclusions the following factors should be considered:

- The scale should include degrees of support for identity correspondence and degrees of support for exclusion
- The scale should contain an inconclusive level (0) in which the facial examiner can express their opinion as offering no support to either proposition
- The number of support levels used in the scale should be sufficient to provide a meaningful range of opinions whilst still ensuring repeatability between different examiners. This should be established through validation studies and competency testing

Evaluating the strength of the examination findings is complex and dependant on a number of interacting factors, such as:

- The extent to which facial features can be observed in the imagery
- The number of facial features visible within the imagery
- How common the observed facial features are (this will primarily be based upon subjective knowledge and experience)
- The transience/permanence of the observed facial features
- The quantity and nature of the similarities or differences observed
- If the similarities or differences are readily explainable as resulting from image quality factors
- The correspondence in imaging conditions between the questioned and reference imagery (e.g. resolution, lighting, camera angle, occlusion)
- The difference in time between the capture of the questioned imagery and the capture of the reference imagery

Each of these factors should be addressed as a condition that impacts the level of support that can be offered for one of the propositions. For example, if only a small number of poorly resolved facial features are observed to be similar and the images are captured at non-matching angles the findings may only offer limited or weak support to the proposition the images depict the same person. If there are differences observed in the detailed features of the face and in some fine feature detail (such as facial marks), the images have been captured at a similar time and under similar conditions then the findings may offer the strongest levels of support for the proposition that the images depict different individuals.

Examiners should be aware of issues concerning the interpretation of conclusion scales by lay audiences reported in the literature [33].

Examiners conducting the evaluation stage should be trained and competent to do so with specialised knowledge relevant to this task.

13. PRESENTATION OF EVIDENCE

The overriding duty of those providing expert testimony is to the court and to the administration of justice. As such, evidence should be provided with honesty, integrity, objectivity and impartiality.

Evidence can be presented to the court either orally or in writing. Only information which is supported by the examinations carried out should be presented. Presentation of evidence should clearly state the results of any evaluation and interpretation of the examination. Written FIC reports should include all the relevant information in a clear, concise, structured and unambiguous manner as required by the relevant legal process. Written reports must be peer reviewed.

Expert witnesses should resist responding to questions that take them outside their field of expertise unless specifically directed by the court, and even then a declaration as to the limitations of their expertise should be made.

If an evaluative conclusion is made based on relevant population data the source of the data should be made clear in the written or oral evidence. If the evaluative opinion is based upon subjective knowledge, training and experience this should be stated also. Further details on reporting evaluative conclusions in FIC can be found in the ENFSI Guideline for Evaluative Reporting in Forensic Science.

14. HEALTH AND SAFETY

Which health and safety considerations are relevant to be considered regarding FIC examinations will depend upon the operational requirements of the agency or organisation for whom the examiner works and the types of casework undertaken. Laboratory SOPs should address working with hazardous material and/or material of an indecent or disturbing nature if applicable. When viewing imagery for prolonged periods examiners should take regular screen breaks.

15. REFERENCES

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16. AMENDMENTS AGAINST PREVIOUS VERSION

Not applicable (first version).

APPENDIX A: EDUCATION AND TRAINING GUIDELINES FOR FACIAL EXAMINERS

The purpose of this guideline is to provide a training outline for persons involved in delivering facial comparison training courses, and to assist in developing a uniform formal training program for facial image examiners.

This training guideline is specific to **facial examiners** conducting facial comparison examinations, defined as follows:

> 'The task of facial examination includes, but is not limited to, a rigorous one-to-one analysis, comparison, and evaluation of controlled and uncontrolled images for the purpose of effecting a conclusion. Examiners in this situation have to draw on a larger foundation of knowledge, skill, and ability to accurately reach their conclusions. Additionally, the articulation of the scientific and legal basis for the expression of conclusions for many forensic, intelligence, or law enforcement purposes requires an even more advanced level of training to include an expanded set of knowledge, skills, and abilities above the level of basic concepts.'[1]

Facial comparison is an innate ability and performance varies significantly across different individuals[2]. The laboratory should implement a facial comparison testing programme to gauge examiner ability before training. There is a wide range in innate ability when comparing unfamiliar faces, such a testing scheme can be used to highlight individuals with high innate performance for recruitment as facial examiners and enrolment in subsequent training and mentoring.

Throughout training regular testing and evaluation of trainee performance should be conducted using ground truth facial comparison tasks. These tasks should cover the range of imagery that will typically be encountered in casework. Empirical research has demonstrated that providing trainees with feedback on facial comparison tests improves trainee ability[3].

IMPORTANT NOTE

This guide is designed to provide a comprehensive list of training topics relevant to forensic facial comparison. Not all topics will be relevant to every agency or organisation and not all topics are required to become a competent facial examiner.

Which topics are required to achieve competency will depend upon the operational requirements of the agency or organisation and the types of casework undertaken.

Throughout this document the terms awareness, knowledge and ability are used in the context of the following definitions:

- **Awareness**: The trainee should have a general acquaintance with the relevant major elements of a given method or technology to include specific capabilities and limitations.

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1 Guidelines and Recommendations for Facial Comparison Training to Competency (Section 3), FISWG, Version 1.1

2 White et al. 2010, The Glasgow Face Matching Test, *Behavior Research Methods*, 42 (1), 286-291

3 White et al. 2014, Feedback training for facial image comparison, *Psychon Bull Rev*, 21 (1), 100-106

- **Knowledge**: The trainee should have an in-depth knowledge of the topic and how the subject relates to their discipline, acquired through education, training and experience.
- **Ability**: The trainee should have the necessary capability to carry out a particular skill or process, acquired through training, proficiency testing and experience. The trainee should also be aware of the limitations of the process.

Facial comparison training programmes should aim to provide knowledge and ability in the following:

Knowledge of:

- Principals of image comparison
- Psychology of image comparison (e.g. innate ability vs. training)
- Principals of digital image and video capture and recording and effect on quality (including resolution, compression, interlacing etc.)
- Principals of proprietary video (e.g. CCTV)
- Different illumination in video and images
- Analogue media
- Principals of image processing using global and local filters and their limitations and pitfalls
- ACE-V process: Analyse – Compare – Evaluate – Verify
- Methods of comparison and their limitations
- Cognitive Bias
- Methods of Evaluation
- Facial anatomy and the commonality of facial features
- Age-related and environmental changes to facial features
- Forensic Reporting
- Legislation
- Procedures applied in the laboratory and in the scene of crime, including chain-of-custody, as well as procedures related to law (court testimony)
- Relevant health and safety considerations (e.g. working with hazardous material or material of an indecent or disturbing nature)
- Quality management systems and working practices at the laboratory

Ability in:

- Extracting still images from video and maintaining image quality
- Digitising analogue media and minimising image quality loss
- Transcoding images without degradation in quality
- Identifying original recordings
- Replaying proprietary video (e.g. CCTV)
- Using enhancement techniques in images and video
- Image resizing, cropping and rotation
- Assessing imagery for comparison
- Following the appropriate method for comparison and documenting that process
- Describing and comparing facial features observed in an image
- Determining age related and environmental differences between images
- Determining the likely cause of similarities and differences observed between two images
- Determining the commonality of facial features observed in an image and evaluating the significance of observations, using either population data or subjective knowledge
- Correct interpretation of the results obtained
- Case management, reporting, communication of analytical findings, presentation and defending them in court
- Peer-review of critical findings

1. OVERVIEW

1.1 Fundamentals of Facial Image Comparison

1.1.1. Objectives

- Knowledge of the principles of comparison
- Knowledge of standard terminology
- Awareness of the limitations of image comparison as a method of identification
- Knowledge of the different processes of facial identification (i.e. facial image comparison, automated facial recognition, human cognitive facial recognition)
- Knowledge of the psychology of facial identification (e.g. innate ability vs. trained ability and own-race effect)

1.1.2. Modes of Instruction – Training Aids

- Studying of suggested references
- Classroom based learning
- Review of example cases
- Clarification on questions
- Discussion

1.1.3. References

- “Facial Comparison Overview (Section 2)” FISWG
- “Forensic Image Comparison and Interpretation Evidence: Guidance for Prosecutors and Investigators” GOV.UK
- “Guidelines for Facial Image Comparison Methods (Section 6)” FISWG
- “Best Practices for Forensic Photographic Comparison (Section 16)” SWGIT
- “Best Practices for Forensic Video Analysis (Section 7)” SWGIT
- “Digital and Multimedia Evidence Glossary” SWGIT/SWGDE
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1.1.4. Assessment

- Quick decision facial comparison test with normalised test data (to determine innate ability)
- Study questions (oral, written)
- Critical review of case examples

2. IMAGING FACTORS

2.1 Image capture and recording

2.1.1. Objectives

- Awareness of interlacing
- Awareness of proprietary file formats (e.g. digital CCTV)
- Awareness of common types of digital image and video compression algorithms (e.g. JPEG, H.264)
- Awareness of different types of noise and its impact on image quality

- Knowledge of digital image capture
- Knowledge of the types, causes and impact of lens distortion
- Knowledge of the impact of scene illumination by different light sources (including near infrared) and camera white balance settings on imagery
- Knowledge of common image resolutions
- Awareness of different image interpolation algorithms and their impact on image quality
- Knowledge of the relationship between storage aspect ratio (SAR), pixel aspect (PAR) and display aspect ratio (DAR) and their impact on image appearance
- Knowledge of the impact of compression on image quality

- Ability to determine if a file is an original recording
- Ability to extract still images from video and maintain quality
- Ability to transcode digital video and maintain quality
- Ability to determine if a video is interlaced or progressive

2.1.2. Modes of Instruction – Training Aids

- Studying of suggested references
- Classroom based learning
- Practical demonstrations

2.1.3. References

- “Fatal Flaws: Uncertainty in the Interpretation of Colour in CCTV Images”, L. W. MacDonald, Annals of the BMVA Vol. 2007, No. 7, pp 1−11 2007
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- “Best Practices for Forensic Video Analysis (Section 16)” SWGIT
- “Issues Relating to Digital Image Compression and File Formats (Section 19)” SWGIT
- “Digital Imaging Procedure” Home Office Scientific Development Branch
- The Principles and Practice of CCTV 3rd Ed. - Online version
- Cambridge in Colour Tutorials

2.1.4. Assessment
- Study questions (oral, written)
- Practical test

2.2 Analogue Media

2.2.1. Objectives
- Awareness of common types of analogue media
- Awareness of different printing techniques and how these affect the choice of scanning procedure and filtering
- Awareness of the effect of different hardware on replay quality
- Knowledge of the correct storage and handling of analogue media to prevent degradation
- Ability to digitise analogue media and minimise image quality loss
- Ability to scan printed documents at sufficient resolution and lossless compression to minimise image quality loss
- Ability to apply image adjustments in the analogue domain prior to digitisation

2.2.2. Modes of Instruction – Training Aids
- Studying of suggested references
- Classroom based learning
- Practical demonstrations

2.2.3. References
- “Best Practices for Forensic Video Analysis (Section 16)” SWGIT
- The Principles and Practice of CCTV 3rd Ed. - Online version

2.2.4. Assessment
- Study questions (oral, written)
- Practical test

2.3 Image Processing

2.3.1. Objectives
- Awareness of colour space conversions
- Knowledge of different image file formats and advantages and disadvantages
- Knowledge of image histograms and RGB colour values
- Knowledge of colour channel separation
- Knowledge of the advantages and limitations of relevant image filters and adjustments and their impact upon image quality
- Knowledge of image enhancement workflows and the impact of the ordering of filters on image quality
- Ability to work lossless/uncompressed to maintain image quality
- Ability to apply basic image adjustments and filters such as levels, contrast, sharpening, de-blurring and noise reduction
- Ability to crop, rescale and rotate images using different interpolation algorithms
- Ability to sufficiently document image processing steps applied to an image

2.3.2. Modes of Instruction – Training Aids
- Studying of suggested references
- Classroom based learning
- Practical demonstrations

2.3.3. References
- “Best Practices for Forensic Video Analysis (Section 16)” SWGIT
- Cambridge in Colour Tutorials
- ENFSI BPM for Forensic Image and Video Enhancement (ENFSI-BPM-DI-02)
- ASTM E2825 − 12 Standard Guide for Forensic Digital Image Processing

2.3.4. Assessment
- Study questions (oral, written)
- Practical test

3. IMAGE COMPARISON METHODS AND EVALUATION

3.1 Methods

3.1.1 Objectives

- Knowledge of the Analyse, Compare, Evaluate and Verify (ACE-V) process for comparison
- Knowledge of the morphological approach and use of feature checklists and associated limitations
- Knowledge of feature classification and associated limitations
- Knowledge of photo anthropometry and associated limitations
- Knowledge of superimposition and overlays and associated limitations
- Knowledge of the benefits of independent verification and peer-review of observations

- Ability to follow a reliable, repeatable and transparent process for the comparison of images
- Ability to sufficiently document the process of comparison to ensure transparency
- Ability to assess the suitability of an image or video for image comparison

3.1.2 Modes of Instruction – Training Aids

- Studying of suggested references
- Classroom based learning
- Review of example cases
- Supervised casework
- Clarification on questions
- Discussion

3.1.3 References

- “Best Practices for Forensic Photographic Comparison (Section 16)” SWGIT
- “Facial Comparison Overview (Section 2)” FISWG
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- “Facial Image Comparison Feature List for Morphological Analysis” FISWG

3.1.4 Assessment
- Study questions (oral, written)
- Critical review of case examples
- Proficiency tests
- Test examinations and mock trial

3.2 Contextual and Cognitive Bias

3.2.1 Objectives
- Awareness of the difference between contextual and cognitive bias

- Knowledge of the various sources of contextual and cognitive bias
- Knowledge of the impact of bias on forensic examinations
- Knowledge of strategies to mitigate bias, such as ACE-V and sequential unmasking

- Ability to effectively manage contextual case information to mitigate bias

3.2.2 Modes of Instruction – Training Aids
- Studying of suggested references
- Classroom based learning
- Review of example cases
- Clarification on questions
- Discussion

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3.2.4 Assessment
- Study questions (oral, written)
- Critical review of case examples

3.3 Evidence Evaluation

3.3.1. Objectives
- Awareness of distributions (i.e. Gaussian distribution, binomial distribution)
- Awareness of population data and sampling

- Awareness of Statistics (e.g. probability and calculating mean, median and typical value)

- Knowledge of the Frequentist and Bayesian approach to evidence evaluation and their associated limitations
- Knowledge of hypothesis testing
- Knowledge of evidence evaluation and various pitfalls (e.g. prosecutors and the defenders fallacy, independence assumption and another match error)

- Ability to choose the most suitable approach for evidence evaluation on a case by case basis
- Ability in presenting the level of conclusion from a comparison and any associated error-rate
- Ability in establishing appropriate hypotheses and testing them in case work

3.3.2. Modes of Instruction – Training Aids

- Studying of suggested references
- Classroom based learning
- Review of example cases
- Clarification on questions
- Discussion

3.3.3. References

- ENFSI Guideline for Evaluative Reporting in Forensic Science, Strengthening the Evaluation of Forensic Results across Europe (STEOFRAE), Approved Version 3.0
- Introduction to Statistics for Forensic Scientists, Lucy, D. 2005, John Wiley and Sons LTD
- Jackson, G. et al. Communicating the Results of Forensic Science Examinations (November 8, 2015); Penn State Law Research Paper No. 22-2015. Available at SSRN: http://ssrn.com/abstract=2690899
- Communicating and Interpreting Statistical Evidence in the Administration of Criminal Justice 1. Fundamentals of Probability and Statistical Evidence in Criminal Proceedings - Royal Statistical Society
- Communicating and Interpreting Statistical Evidence in the Administration of Criminal Justice 3. The Logic of Forensic Proof: Inferential Reasoning in Criminal Evidence and Forensic Science - Royal Statistical Society
- Communicating and Interpreting Statistical Evidence in the Administration of Criminal Justice 4. Case Assessment and Interpretation of Expert Evidence - Royal Statistical Society

3.3.4. Assessment

- Study questions (oral, written)
- Critical review of case examples
- Proficiency tests
- Test examinations and mock trial

4. FACIAL ANATOMY AND FEATURES

4.1 General anatomy

4.1.1. Objectives

- Awareness of the bones of the skull and how they affect facial appearance
- Awareness of the genetic components relating to facial appearance, including variation between populations and familial similarity (e.g. identical twins)
- Awareness of the muscles of expression
- Awareness of common types of marks and blemishes
- Awareness of the commonality of features within and between relevant populations
- Awareness of the variation of features between males and females (sexual dimorphism)
- Awareness of acquired features such as scars, piercings and tattoos

- Knowledge of how facial expression affects the appearance of facial features and causes wrinkles
- Knowledge of the appearance of facial features (e.g. ears, mouth, nose and eyes) and associated sub-features (e.g. tragus, antihelix and helix of the ear)
- Knowledge of the impact of pose and perspective on facial appearance

- Ability to describe and compare features of the face observed in an image
- Ability to determine the commonality of a face including acquired features

4.1.2. Modes of Instruction – Training Aids

- Studying of suggested references
- Classroom based learning
- Practical demonstrations
- Supervised case work

4.1.3. References

- Forensic Anthropology Training Manual, 2nd Ed. Burns, K. R. 1999. Pearson Prentice Hall
- Forensic Art and Illustration, Taylor, K. T. 2000. CRC Press
- Claes, P. et al. 2014, Modelling 3D Facial Shape from DNA. PLoS Genetics, 10 (3)
- Human Anatomy and Physiology 6th Ed. Marieb, E. N. 2004. Pearson
- “Anatomy of the Human Body”, Gray, H. 20th Ed.
- Anatomy of the Face and Neck, Prendergast, P. M. in: Cosmetic Surgery, Shiffman, M. A. and Di Giuseppe, A. (eds), 2012, Springer-Verlag
- Dermatology, Braun-Falco, O. 2000, Springer Science and Business Media
- Nurhudatiana A. et al. 2015, Relatively Permanent Pigmented or Vascular Skin Marks for Identification: A Pilot Reliability Study, Journal of Forensic Science
- “Facial Image Comparison Feature List for Morphological Analysis” FISWG

4.1.4. Assessment

- Study questions (oral, written)
- Practical test
- Test examinations

4.2 Ageing and environmental changes

4.2.1. Objectives
- Awareness of the facial changes related to juvenile development
- Awareness of the facial changes related to adolescence
- Awareness of the facial changes related to degenerative ageing
- Awareness of facial changes due to environmental (extrinsic) factors e.g. weight, lifestyle, diet, drug use
- Awareness of acquired features e.g. scars, tattoos
- Knowledge of the permanence and transience of different facial features over time
- Ability to determine age related and environmental differences between facial images

4.2.2. Modes of Instruction – Training Aids
- Studying of suggested references
- Classroom based learning
- Practical demonstrations
- Supervised case work

4.2.3. References

- Farkas, J. P. et al. 2013, The Science and Theory behind Facial Aging, PRS GO
- Farkas, J. P. et al. 1992, Growth Patterns of the Face: A Morphometric Study, Cleft Palate-Craniofacial Journal, 29 (4)
- Albert, A. M. et al. 2007, A review of the literature on the aging adult skull and face: Implications for forensic science research and applications, Forensic Science International, 172, 1-9
- The Anatomic Basis of Midfacial Aging, Wulc, A. E. et al. in: Midfacial Rejuvination, Harston, M. E. (eds), 2013, Springer Business and Media
- Guyuron, B. et al. 2009, Factors Contributing to the Facial Aging of Identical Twins, Plastic and Reconstructive Surgery, April, 1321-1331
- Rexbye, H. et al. 2006, Influence of environmental factors on facial ageing, Age and Ageing, 35, 110-115

4.2.4. Assessment
- Study questions (oral, written)
- Practical test
- Test examinations

5. COURTROOM TESTIMONY

5.1 Objectives
- Awareness of the environment of a courtroom and the functions of a criminal proceeding
- Knowledge of the requirements of an expert witness presenting evidence in court
- Ability to present expert testimony and defend findings
- Ability to present evidence as an impartial expert witness and assist the court

5.2 Modes of Instruction – Training Aids

- Observation of court testimonies by experienced experts
- Practical exercise (min-mock trials) based on case-studying
- Clarification on questions
- Discussion

5.3 References

- National legislation
- Relevant case law

5.4 Assessment

- Study questions
- Practical exercise in a simulated environment of a courtroom testimony:
- Direct questioning
- Cross-examination

APPENDIX B: FACTORS AFFECTING FACIAL APPEARANCE

Digital imagery comes from a wide range of sources, such as CCTV, smart devices and social media. Imagery from uncontrolled sources is frequently used for facial image comparison (FIC), which may not be of optimal quality. Image quality factors can impact significantly on the reliability of FIC. This appendix will explain some of these factors and the impact they have on facial appearance. The assessment of image quality is currently a subjective process and the factors that affect the quality of one image may not be significant in another image, therefore examiner should consider multiple factors when determining whether an image is suitable for FIC.

Image factors
Image factors that can alter facial appearance include, but are not limited to:

- Image resolution/distance from camera
- Image compression
- Aspect ratio
- Lighting
- Occlusion
- Camera angle
- Image/lens distortions
- Number of available images
- Date an image was captured

The suitability of an image for FIC may be impacted by one, some or all of the above factors. The examiner should consider each factor individually and then determine the combined impact of all the factors on facial appearance. The image quality factors described in this document are not exhaustive. The examiner may observe artefacts or anomalies in an image that are not described here.

Note: Facial comparison and facial recognition are two distinct human processes. Often it is possible to recognise a known face from a low quality image that is unsuitable for facial comparison. Examiners should be aware of the difference between comparison and recognition and consider this when assessing the suitability of an image for facial identification (recognition or comparison).

Image Resolution
The resolution of an image is determined by the number of pixels within that image, the greater the number of pixels the higher the resolution. Images of a higher resolution will generally contain more detail than low resolution images, therefore image resolution is the significant factor affecting facial detail.

If there is insufficient detail to determine the basic shape of facial features that image may be unsuitable for any method of facial identification.

Enlarging an image beyond its full resolution will not add any more detail to the image, instead the resulting image may appear blocky or blurry depending upon the method of enlargement used (e.g. nearest neighbour or bilinear interpolation respectively).

Examiners should consider the resolution of the face in an image rather than only the resolution of the entire image; i.e. if the subject of interest is a substantial distance from the camera in a very high resolution image the number of pixels that occupy the face will be low causing a lack

of facial detail, conversely if the subject of interest is very close to the camera in a low resolution image facial feature detail may still be discernible.

Figure B1 A low resolution image enlarged to give a blocky result (left) and a blurred result (centre) compared to the higher resolution original (right)

Questions to consider:

- Can only the basic shape and outline of facial features be determined?
- Does the image appear visibly blocky or blurry due to a lack of pixels?

If the answer is yes to either of the above questions the image may be of limited use for FIC.

Compression

Compression refers to any method used to reduce the data size of a file. Compression may be lossless, whereby the original file can be recovered and no data is lost (e.g. TIFF files) or lossy, whereby file sizes can be reduced significantly but may result in a loss of image detail (e.g. JPEG, MP4). This loss of detail cannot be recovered. Compression can significantly reduce facial detail even in high resolution images. Highly compressed images will have visible compression artefacts such as macroblocks or edge artefacts. Compression algorithms may also subsample colour information leading to chromatic aberrations within an image. Examiners should be aware of the impact of image compression on facial detail. Resaving imagery in a compressed format such as a .JPG or .MP4 file will recompress the image and potentially further reduce facial detail. Where possible images should be resaved in a lossless (e.g. TIFF) or uncompressed format (e.g. bitmap).

Figure B2 Example of a high resolution image (left) recompressed as a JPEG (right) - note the visible macroblocks and loss of detail (e.g. creases and marks)

Questions to consider:

- Are compression artefacts visible and contributing to a loss of facial detail?

If the answer is yes to the above question the image may be of limited use for FIC.

- Has the imagery been converted from its original format?

If the answer is yes to the above question the original imagery should be sought as this may be of a higher quality.

Aspect Ratio

Display aspect ratio refers the proportions of an image as shown on a monitor. It is typically reported as ratio of the width of the image in proportion to its height (e.g. 4:3, 16:9). Distortions to the aspect ratio of an image can significantly impact facial proportions. Correct display aspect ratio can be hard to determine if an image is cropped.

Distortion to video can also occur due to an incorrect pixel aspect ratio. Certain sources of video, such as standard definition CCTV video, require rectangular, non-square pixels to be viewed at the correct display aspect ratio. Computer monitors typically display video using square pixels which will result in the video appearing slightly squashed horizontally. For example, if standard definition PAL CCTV is displayed using square pixels the display aspect ratio will be 5:4 rather than the correct 4:3. A correction to the resolution of the imagery is required to achieve a display aspect ratio of 4:3. Without the correction the proportions and size of facial features may appear distorted.

Figure B3 Standard definition with a 5:4 display aspect ratio (left) compared to the same image shown at the correct 4:3 display aspect ratio (right)

Questions to consider:

- Does the aspect ratio of the image appear distorted?

If the answer is yes to the above question the examiner should attempt to correct the aspect ratio if the native resolution of the image is known.

- Is the imagery a copy of the original and/or cropped?

If the answer is yes to the above question the original imagery should be sought as this may be at the correct aspect ratio.

Exposure

The lighting within a scene may significantly impact the visibility of facial detail. If an image is too bright (overexposed) areas of the face may be burnt out and unrecoverable. If an image is too dark (underexposed) there may be poor contrast limiting facial detail. Adjustments to

brightness and contrast may recover detail in some circumstances. Image processing, such as brightness and contrast adjustment should be performed by competent examiners.

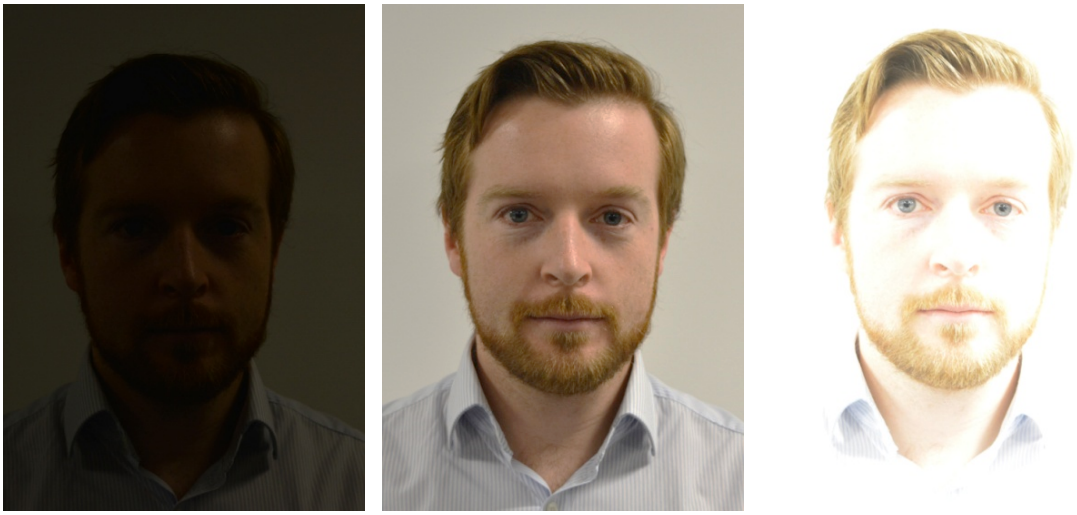

Figure B4 Examples of an underexposed image (left), well exposed image (centre) and overexposed image (right) - note the loss of detail in the dark and light areas

Questions to consider:

- Are parts of the face underexposed and/or overexposed?

If the answer is yes to the above question the image may be of limited use for FIC. Competent examiners should attempt to recover detail by image processing.

Light Sources

Different light sources emit light in different wavelengths of visible light and may introduce colour casts into an image. Cameras must have a correctly calibrated white balance to display colour correctly in captured imagery. If the white balance is not calibrated correctly the skin tone of a subject may not be accurately represented. Examiners should avoid attempting to correct the colour of uncontrolled imagery as the results may not be accurate if the original capture conditions are not known. Examiners should also be cautious in assessing skin colour from uncontrolled imagery due to variation under different light sources.

Figure B5 Images of the same individual captured under fluorescent lighting with different camera white balance settings

Near infrared light sources are commonly used in CCTV systems to record video in low light conditions. Under near infrared light some facial marks, such as freckles, and fine creases may not be visible and the texture of the skin may appear smoother.

Figure B6 Images of the same individual captured under a visible light source and a near infrared light source

Figure B7 Images of the right eye of the same individual captured under a visible light source and a near infrared light source

Occlusion
Facial features may be occluded/obscured from view by other objects within an image, such as clothing. The higher the number facial features occluded from view the less reliable the image may be for FIC.

Questions to consider:

- Is there occlusion of facial features in the image?

If a high number of facial features are occluded the image may be of limited use for FIC.

Camera Angle and Pose

Uncontrolled imagery such as CCTV is frequently captured at various angles. In some imagery (e.g. elevated cameras at an acute angle) facial features may be obscured from view by the angle of the camera, limiting the suitability of the imagery for FIC. Orientation of the subject head within the image may also vary, which may also occlude features from view. The questioned and reference imagery should be at as closely matching pose and camera angle as possible. For substantial differences in camera angle, such as between a frontal image and profile image, or pose, facial comparison may not be possible.

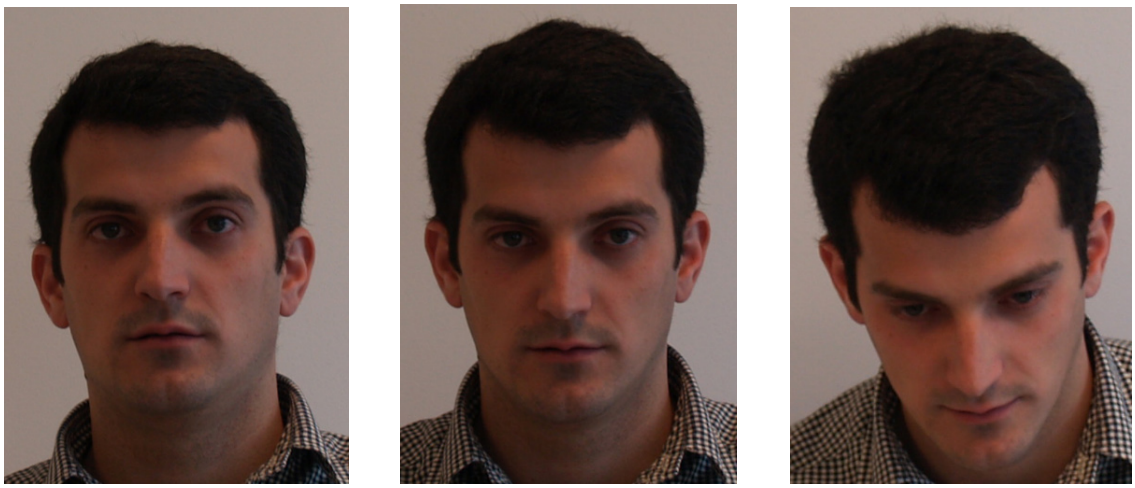

Figure B8 The same individual captured at different camera angles

Figure B9 Right ear of the same individual captured at a different pose

Questions to consider:

- Is the camera angle or pose obscuring facial features from view?

If the answer is yes to the above question the image may be of limited use for FIC. If the image is taken from moving footage the examiner should examine the video to look for additional imagery.

- Are the images being compared captured at a significantly different camera angle or pose?

If the answer is yes to the above question the image may be of limited use for FIC. The examiner should seek additional imagery at a better comparative angle.

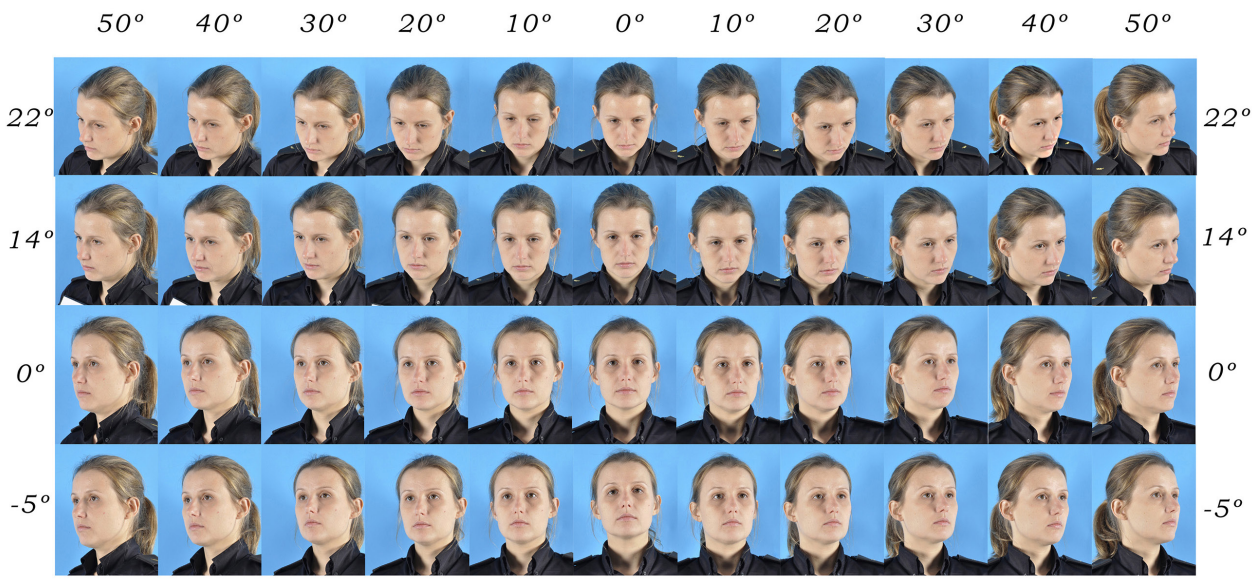

Figure B10 Variation in the appearance of the same individual at different camera angles

Blur

Blur is present in almost all imagery to some degree. If an image is sufficiently blurred facial feature detail will be distorted or may not be visible, which will negatively impact on a FIC examination. Image processing methods can be used to sharpen a blurred image by increasing contrast at edges or by attempting to deconvolve the original blurring process. However these techniques frequently introduce artefacts into an image that may be misleading during comparison. Blur can occur due to an improperly focussed camera lens (focal blur) or due to motion of the subject or a low shutter speed (motion blur).

Figure B11 The same individual captured with increasing focal blur

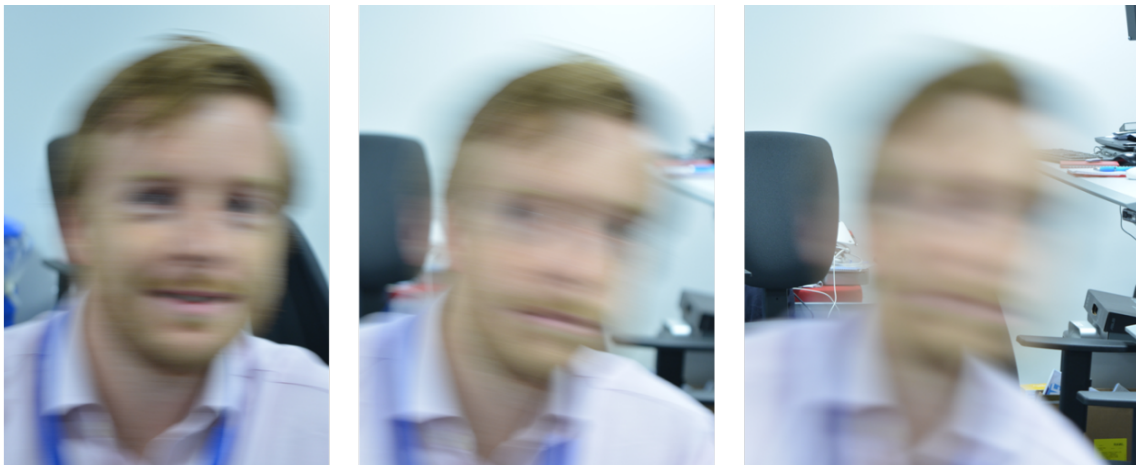

Figure B12 The same individual captured with increasing motion blur

Questions to consider:

- Is blurring within the image affecting the appearance of facial feature detail?

If the answer is yes to the above question the image may be of limited use for FIC. Competent examiners should attempt to recover detail by image processing.

Perspective/Lens Disortion

Images captured when the subject is close to the camera can distort the relative size and position of facial features. This distortion causes features at the centre of the image to appear magnified in relation to features at the edge of the images, for example in a facial image the nose and distance between the eyes may appear larger and the ears may appear smaller.

Figure B13 Images of the same individual captured at different distances from the same camera

Distortion can also be caused by the camera lens. A common example is lens barrelling which can occur with wide angle lenses. With lens barrelling there may be a pronounced curvature to features at the edge of the image, this curvature will diminish towards the centre of the image. If imagery suffers from lens barrelling images used for FIC should be selected when the subject is in the centre of the image.

Figure B14 Example of lens barrelling distortion in an image

Questions to consider:

- Is distortion within the image affecting the appearance of facial feature detail?

If the answer is yes to the above question the image may be of limited use for FIC. If the distortion is caused by the camera lens competent examiners may attempt to recover detail by image processing.

Expression

The features of the face are dynamic and can be temporarily altered by expression and contraction of the underlying musculature of the face. Facial expression may distort the size and shape of facial features, obscure fine feature detail, like marks, from view and cause temporary/ permanent creases at areas of repeated use.

Questions to consider:

- Is there a difference in facial expression between the questioned and reference imagery?

If the answer is yes to the above question the imagery may be of limited use for FIC. Additional imagery should be sought with similar facial expression.

Growth and Ageing

As individuals grow and age facial features can change significantly. The growth of juveniles is a relatively controlled process as the features of face and skull adapt to accommodate functional changes e.g.:

- Early growth of the cranium to accommodate increases in brain size
- Later growth of the mid face and mandible to accommodate the teeth and growth of the tongue

During growth facial features can change significantly over a short space of time.

Adult ageing follows a similar general pattern but the rates of ageing vary significantly between different individuals and can be influenced by environmental factors (e.g. alcohol consumption, smoking, UV exposure). Adult ageing occurs at a slower rate than juvenile growth. Some common consequences of aging processes are:

- Hair loss and changes in hair pigmentation
- Sagging of soft tissues
- Increased number and depth of facial lines at areas of repeated muscle use and facial fat pad junctures
- Decrease in density of fatty tissue under and descent of facial fat pads
- Increased number of hyper pigmented spots

Questions to consider:

- Is there a significant difference in time between the questioned and reference imagery?

If the answer is yes to the above question the imagery may be of limited use for FIC. Additional imagery should be sought within a closer age range. The length of time where significant differences occur will generally be less for juveniles than adults.

Environmental Differences (e.g. weight change, cosmetic surgery, illnesses etc.)

The appearance of facial features can be strongly influenced by environmental factors, including, but not limited to: weight change, cosmetic surgery, dietary changes, disease, injury, surgery etc.

Questions to consider:

- Is there evidence of environmental factors altering the appearance of facial features?

If the answer is yes to the above question the imagery may be of limited use for FIC. Additional questioned and/or reference imagery should be sought within a closer time frame, or additional relevant information concerning the subject's medical history or lifestyle.

APPENDIX C: OVERVIEW OF COMPARISON METHODS

Holistic Face Processing

Holistic comparison is the process by which we naturally identify people. This process is highly accurate when the faces belong to familiar people (e.g., friends, colleagues, celebrities), but highly inaccurate when the faces belong to unfamiliar people[4]. Results from unfamiliar face matching tasks show large individual differences for holistic face processing– some people perform remarkably well, whereas others can perform at chance levels[5,6]. Given that only unfamiliar faces are encountered in forensics, holistic comparison is only recommended where other more effective methods are not available (e.g. in quick decision, high throughput environments such as border crossings), and when the observer has demonstrated suitable proficiency on unfamiliar face identification tasks. Even when using other facial comparison methods it is not possible to completely disengage holistic processing.

Photo Anthropometry

Photo anthropometry is a metric approach to facial image comparison. Various soft tissue landmarks are identified on the face and lines are overlaid onto the images at the determined location of the landmarks. The distances between the various landmarks are then compared between the two facial images to determine the level of similarity or dissimilarity. This may be determined simply by visual inspection or the ratios of the distances between the landmarks may be compared. Although photo anthropometry is described as a metric technique it is subjective in nature. The landmarks are often located by eye, which can cause issues when the imagery is limited in terms of resolution and lighting and can have poor repeatability between different individuals. Also the threshold for what constitutes a similar or dissimilar measurement is arbitrary as other factors such as camera angle, resolution, expression and pose may introduce differences in the facial proportions of the same individual. Empirical studies[7,8] have demonstrated this technique is unreliable with poor repeatability. Photo anthropometry is not recommended for FIC using uncontrolled imagery.

Superimposition

Superimposition is the combining of two facial images to highlight potential similarities or dissimilarities. The images may be combined by using a reduced opacity overlay, combining certain parts of the face within another facial image (chimeric images) or blinking quickly between two images. The level of agreement/disagreement is determined subjectively by the examiner. Studies[9,10] have demonstrated that the use of chimeric, blinked and overlaid images

[4] Bruce, V., Henderson, Z., Newman, C., & Burton, A. M. (2001). Matching identities of familiar and unfamiliar faces caught on CCTV images. *Journal of Experimental Psychology: Applied, 7*(3), 207-218.

[5] Burton, A. M., Wilson, S., Cowan, M., & Bruce, V. (1999). Face recognition in poor-quality video: Evidence from security surveillance. *Psychological Science, 10*(3), 243-248.

[6] Bruce, V., Henderson, Z., Greenwood, K., Hancock, P. J. B., Burton, A. M., & Miller, P. (1999). Verification of face identities from images captured on video. *Journal of Experimental Psychology: Applied, 5*(4), 339-360.

[7] R. Moreton and J. Morley, “Investigation into the use of photoanthropometry in facial image comparison,” *Forensic Sci. Int.*, vol. 212, no. 1–3, pp. 231–237, 2011.

[8] K. F. Kleinberg and P. Vanezis, “Variation in proportion indices and angles between selected facial landmarks with rotation in the Frankfort plane.,” *Med. Sci. Law*, vol. 47, no. 2, pp. 107–16, 2007

[9] A. Strathie, A. Mcneill, and D. White, “In the Dock: Chimeric Image Composites Reduce Identification Accuracy,” *Appl. Cogn. Psychol.*, vol. 26, no. 1, pp. 140–148, 2012.

[10] A. Strathie and A. McNeill, “Facial Wipes don’t Wash: Facial Image Comparison by Video Superimposition Reduces the Accuracy of Face Matching Decisions,” *Appl. Cogn. Psychol.*, vol. 30, no. 4, pp. 504–513, 2016.

reduced matching accuracy compared to full facial images. The studies also found that chimeric images created a bias towards false positives and made differences less apparent, indicating that superimposition can potentially be misleading. Superimposition is not recommended for FIC using uncontrolled imagery.

Morphological Comparison
Morphological comparison is a subjective process where facial features and/or regions of the face are observed and compared to determine apparent differences and similarities. Typically a pre-determined list of features is used in order to structure and document the comparison. There are two approaches to morphological facial comparison; feature classification and feature comparison.

Feature Classification
Feature classification involves classifying facial features according to pre-defined categories (e.g., round face shape, almond eyes, bulbous nose etc.), and basing an identification decision on the correspondence of these categorisations. However, facial features are not discrete variables but continuous, so classifying facial features in this way discards an enormous amount of potentially useful information. Research demonstrates that this technique does not improve accuracy, is unreliable and can be misleading[11,12]. Feature classification is not recommended for FIC. Terminology used in feature classification can be useful for describing observations in feature comparison (see below) but examiners should not base decisions solely upon an assigned category or classification.

Feature Comparison
Feature comparison is a form of morphological analysis whereby facial images are compared feature by feature methodically using a feature checklist and observations are made as to the similarity/dissimilarity of the individual features. As for feature classification there is no standardised list of facial features however FISWG have developed a detailed facial feature checklist document, which if widely adopted by the community will provide some degree of standardisation in examinations. The features (described as “components”) are each broken down detailed sub-component characteristics. Empirical research has shown that conducting a systematic feature-by-feature comparison improves identification accuracy when the facial images are a true match, compared to results from participants who reached a decision without a feature list (see above for holistic comparison)[13]. The study also found that for forensic examiners, the ears, nose, and scars and blemishes were most diagnostic of whether the faces showed the same person or different people. The results also confirm reports by facial comparison examiners that ears are often the most useful feature for comparison. Given the evidence in support of this comparison method, feature comparison is recommended for FIC. It is also recommended that the FISWG facial feature checklist be used in such analyses.

For all comparison methods, including morphological analysis, laboratories should conduct their own validation studies of their method using ground truth material that represents the type(s) of imagery commonly encountered in casework. Laboratory staff should also undertake scheduled proficiency testing or inter-laboratory testing to evaluate their performance.

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[11] A. Towler, D. White, and R. I. Kemp, “Evaluating training methods for facial image comparison: The face shape strategy does not work,” *Perception*, vol. 43, no. 2–3, pp. 214–218, 2014.

[12] S. Ritz-Timme *et al.*, “A new atlas for the evaluation of facial features: Advantages, limits, and applicability,” *Int. J. Legal Med.*, vol. 125, no. 2, pp. 301–306, 2011.

[13] A. Towler, D. White, R. I. Kemp, A. Towler, D. White, and R. I. Kemp, “Evaluating the Feature Comparison Strategy for Forensic Face Identification,” *J. Exp. Psychol. Appl.*, 23 (1), 2017.

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