THE INVESTIGATION INTO A COST EFFECTIVE METHOD FOR RETRIEVING BAREFOOT PRINT CONTROL SAMPLES FOR THE DEVELOPMENT OF A BAREFOOT PRINT DATABASE

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BARE FOOTPRINT IDENTIFICATION:

BACKGROUND TO PROJECT
PODIAATRISTS’ APPROACH TO BARE FOOTPRINT IDENTIFICATION

• Analysis: The independent assessment of questioned and reference bare footprints, looking to describe size, form and recognisable features

• Comparison: Of the size, form and recognisable features of questioned and reference bare footprints

• Evaluation: Of the comparisons made – what aspects of size form and feature matched, what mismatched and what was the significance of the matched and mismatched features in relation to commonality?

• Verification: Independent working through, checking and (hopefully) confirmation of the above conclusions
EXAMPLES OF BARE FOOTPRINT ANALYSIS

Images courtesy of Prof Vernon
INTERPRETATION OF BARE FOOTPRINTS

• In the UK, the likelihood ratio approach is then used to suggest the levels of individuality represented by these features

• Size, form and features considered need to be independent variables

• Published works, survey data, personal experience used to inform/support the derived opinion
SO HOW INDIVIDUAL IS THE HUMAN FOOT?

Cassidy (1987) - Observed 1:90
Bodziak (2000) - Distinguished 1:1,000
Freedman et. al. (1945) - Observed 1:6,700
Rossi et. al. (1983) – Observed 1:6,800
Kennedy (2005) – Distinguished 1:24,000
Kennedy et. al. (2003) – Statistically suggested probability of a chance match >1:1.27 billion
LIMITATIONS OF CURRENT DATA/SURVEYS

Current data

Populations
- Limited analysis of some features
- Non-representative

Expensive
- One-off surveys
- Time consuming
- Collection methods
- Potential repetition

Quality Control
- Different protocols being utilised
- Limited parity across collections
In the absence of further information how do we know whether the sizes, forms and features we are interested in during casework relate to the person or the population type (i.e. whether they represent general features of the Caucasian, Afro-Caribbean, Asian, Germanic etc. populations?)
COULD A BARE FOOTPRINT DATABASE AID INTERPRETATION?
Court of Appeal for England and Wales rejected the testimony of an expert who had used likelihood ratios to assess the probative value of shoe-print evidence.

Basis for the judgment was the reliance on an insufficiently large database, the FSS’s Footwear Database.

Reliability of such databases need identifying.

Data needs to be deemed as ‘sufficient’
NEED FOR A BARE FOOTPRINT DATABASE

- Need for data collection for interpretation of bare footprint impressions in order to create a more robust interpretation

- Need for extensive database of different populations to interpret particular case scenarios

- Not for identification purposes but could be used for intelligence
CURRENT CHALLENGES IN DATABASE PRODUCTION

**Database Requirements**
- Robust data
- Representative
- Able to be easily contributed to
- Inexpensive to populate and maintain
- Samples fit-for-purpose

**Challenges**
- Limited number of forensic podiatrists
- Expensive method for obtaining control prints
- Varied methods of collecting samples in custody

**Possible solutions**
- Engage forensic science students/podiatrists
- Develop SOP’s and proficiency test schemes
- Develop fit-for-purpose and inexpensive collection method
PROJECT AIMS

1. To identify a robust, reliable and cheap method for the continued collection of bare footprint impressions

2. To design a database that allows bare footprint impressions to be analysed and qualitative and quantitative measurements to be searched against.

3. To develop quality assurance procedures for people contributing data to the database

4. To query the collected data so as to determine intra and inter variability within different populations of bare footprints.
THE CURRENT PRACTICES FOR COLLECTING BARE-FOOTPRINT(S) SAMPLES

Inkless Shoeprint Kit
Inkless Shoeprint Kit Inc.
Treated Paper
Podiatrist to observe the gait
and position the Inkless pad and treated paper
20ft or 6 metres walkway
Require minimum of 6 good prints

Fingerprint Ink & Paper
Fingerprint Ink
Ink roller
Kraft paper (brown or white)
THE CRÈME AND THERMOCHROMIC PAPER (AKA FAX) IN FINGER-MARKS DEVELOPMENT

CRÈME AND THERMOCHROMIC PAPER

Leuco dye embedded in thermo chromic paper reacts

- Contact with solvents e.g., Butylene glycol
- Sunlight (Ultra Violet)
- High temperatures

(Bond 2013)
AIMS OF CRÈME/FAX PAPER STUDY

• To identify whether the new crème and thermochromic paper method;
  – is easy to use
  – is comparable to extant methods
  – is more cost effective for large sample collection
• To identify optimum crème development and storage conditions
• To ascertain the extent of variation within sampling procedure and analyst measurement technique
Creating the Optimum Crème and Thermo-chromic Paper System
MATERIALS FOR CRÈME DEVELOPMENT

500mL Triple distilled water
200mL Glycerol
30g Glyceryl stearate
200mL Glycerol
30g Glyceryl stearate
35g Cetearyl alcohol
45mL Butylene glycol
Hot plates x2
Thermometers x2

(Bond 2013)
METHOD FOR CRÈME DEVELOPMENT

Creating an emulsion of the water phase and oil phase

Incorporation of the desired quantity of the protic solvent (Butylene glycol)

Temperature 80°C

(Bond 2013)
TESTING THE CRÈME ON THERMO-CHROMIC PAPER

Increase by 5ml/150ml

(Bond 2013)
METHOD FOR TESTING OPTIMUM TEMPERATURES

- 6x pieces of Roltech Fax paper measuring +/- 6 cm x 6 cm: Thermal Paper 1 (TP1), Thermal Paper 2 (TP2) etc.
- Thermo Scientific Laboratory oven, equipped with a temperature regulator switch. Temperature is increased by 6ºC for each sample from 22ºC to 52ºC.
- Fingerprint sample created and placed immediately in the oven and observed at 5 minute intervals.
OPTIMUM TEMPERATURE RESULTS

Time vs Temperature

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1/22°C</td>
<td>180</td>
</tr>
<tr>
<td>TP2/28°C</td>
<td>40</td>
</tr>
<tr>
<td>TP3/34°C</td>
<td>30</td>
</tr>
<tr>
<td>TP4/40°C</td>
<td>20</td>
</tr>
<tr>
<td>TP5/46°C</td>
<td>10</td>
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<tr>
<td>TP6/52°C</td>
<td>5</td>
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</tbody>
</table>
STORAGE

7 days after contact of crème and thermo-chromic paper

90 days after contact of crème and thermo-chromic paper
CRÈME COLLECTION
CONCLUSIONS

• Ratio of ingredients needs to be altered for use with bare-footprints
• Optimum temperature depends upon type of fax paper
• Will fade but this can be overcome by scanning asap after collection
COMPARING THE CRÈME SYSTEM TO EXTANT METHODS

Is it fit-for purpose?
**QUANTITATIVE & QUALITATIVE ANALYSIS**

**Crème on thermo-chromic paper vs Inkless ink on treated paper vs Fingerprint Ink on paper**

**Bare-footprints**
- Static bare-footprints recorded on all conditions from one participant
  - (i) 1x Cream on Thermo-chromic paper
  - (ii) 1x Inkless ink on treated paper
  - (iii) 1x Fingerprint ink on paper

**Qualitative observations**
- Contrast
- Complete footprint outline
- Characteristics that include creases, humps, toe index, phalange marks etc.
- Presence of smudges or slippage that might affect quality

**Controlled Sampler**
- Mild Steel flat plate
- Weight = 2.2 kg
- L = 195 mm W = 100mm T = 10mm

**Quantitative Analysis**
- Controlled repeated measures experiment on all conditions
  - (i) 20x Crème on thermo-chromic paper
  - (ii) 20x Inkless ink on treated paper
  - (iii) 20x Fingerprint ink on paper
QUANTITATIVE & QUALITATIVE ANALYSIS

Metal plate control sampler

Control Sampler measurements
Computer Hardware Requirements for Data Storage & Software for Analysis

**Hardware**

- Laptop or computer with new generation processors
- Flatbed Scanner with optical resolution 150dpi (Set default to RAW or TIFF format to prevent image alteration)
- Camera equipped with a 50mm lens (DiMaggio & Vernon. 2011)
- At least 2gb camera memory card
- At least 250gb storage to cope with large image files or to start with.

**Computer Software**

- Gimp GNU Image manipulator (open source software), (Reel 2012).
- Adobe Photoshop.
- Clic Morphometrics software (Borstler 2014).
- TPS dig, Geometric Morphometrics software (Domjanic et al 2013).
STATISTICAL ANALYSIS OF QUANTITATIVE MEASUREMENTS

Statistical analysis

Descriptive
- Mean
- Mode
- Minimum and maximum
- Range
- Standard deviation

Test for normal distribution & Significance testing.
- Kolmogorov – Smirnov Test
- Histograms for observing skew and distribution
- Significance testing (Wilcoxon sign rank test, Paired T-test)
QUALITATIVE RESULTS

- Cream on Thermo-chromic paper
- Inkless ink and Treated paper
- Fingerprint Ink and Paper
QUANTITATIVE RESULTS

Table 1. Descriptives Statistics of experimental conditions (Crème on Thermo-chromic Paper vs Inkless on Treated Paper vs Fingerprint Ink on Paper vs Control Sampler.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mean</th>
<th>SD</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampler Ctr-TR</td>
<td>219.13</td>
<td>0.1218</td>
<td>219.3</td>
<td>218.9</td>
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<tr>
<td>Crème_TR-FP</td>
<td>219.11</td>
<td>0.1119</td>
<td>219.3</td>
<td>218.9</td>
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<tr>
<td>Finger_TR-P</td>
<td>219.125</td>
<td>0.1552</td>
<td>219.6</td>
<td>218.9</td>
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<tr>
<td>Inkless_TR-TP</td>
<td>218.575</td>
<td>0.2613</td>
<td>219</td>
<td>217.9</td>
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<tr>
<td>Sampler Ctr-TL</td>
<td>219.045</td>
<td>0.0999</td>
<td>219.2</td>
<td>218.9</td>
</tr>
<tr>
<td>Crème_TL-FP</td>
<td>219.06</td>
<td>0.0883</td>
<td>219.2</td>
<td>218.9</td>
</tr>
<tr>
<td>Finger_TL-P</td>
<td>219.03</td>
<td>0.175</td>
<td>219.2</td>
<td>218.4</td>
</tr>
<tr>
<td>Inkless_TL-TP</td>
<td>218.695</td>
<td>0.474</td>
<td>219.7</td>
<td>218</td>
</tr>
</tbody>
</table>

n=20
INVESTIGATING VARIATION IN ANALYST MEASUREMENTS

- 3 x static bare footprints from one donor obtained using crème – each of varying quality; low, medium, high

- Each scanned image measured 25x by same analyst across different periods of the day using GIMP
### Table 2. Descriptive Statistics of the Precision of Measurement Method (High, Medium and Low Quality of Static Bare-footprints Measurements)

<table>
<thead>
<tr>
<th>Quality</th>
<th>Mean</th>
<th>SD</th>
<th>Max</th>
<th>Min</th>
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<tbody>
<tr>
<td>High_TL1</td>
<td>251.44</td>
<td>0.2566</td>
<td>252</td>
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<td>Medium_TL1</td>
<td>256.464</td>
<td>0.4405</td>
<td>257.2</td>
<td>255.4</td>
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<tr>
<td>Low_TL1</td>
<td>252.62</td>
<td>0.3</td>
<td>253.1</td>
<td>252</td>
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<tr>
<td>High_TL2</td>
<td>247.292</td>
<td>0.2272</td>
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<td>246.9</td>
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<tr>
<td>Medium_TL2</td>
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<td>0.3984</td>
<td>248.8</td>
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<tr>
<td>Low_TL2</td>
<td>247.08</td>
<td>0.2255</td>
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<tr>
<td>High_TL3</td>
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<td>High_TL5</td>
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<tr>
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<td>0.5585</td>
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<td>Medium_HB</td>
<td>54.968</td>
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<td>54.3</td>
</tr>
</tbody>
</table>

n=25
CAN WE USE THE CRÈME AND THERMAL PAPER?

• Results indicate that;
  – Qualitatively the crème/thermal paper are comparable to extant methods and deemed better than inkless pad/treated paper
  – Quantitatively, all of the methods show slight differences to the sampler

If creation of impressions is comparable to extant methods, what other factors should be considered before choosing which method?

• analysts method of measurement – some variability seen
• Reproducibility of sampler
COST BENEFITS

Ink/Paper
- 7.9p/sample, $0.12/sample, € 0.11/sample
- Approx £1.58/$2.48/€2.24 per individual
- Unlimited shelf life, no storage issues.

Treated paper/Inkless Pad
- 70p/sample, $1.10/sample, € 0.99/sample
- Approx £14/$22/€20 per individual
- 1 year shelf life

Crème/Thermal Paper
- 7.4p/sample, $0.12/sample, € 0.11/sample
- Approx £1.48/$2.32/€ 2.10 per individual
- Unlimited shelf life but careful storage

Exchange rate as of 19/8/15
THE MESS!
NEXT STEP FOR BARE-FOOTPRINT DATABASE PRODUCTION & PROJECT

• Crème system to be utilised
• Create an SOP for the use of the crème that is fit-for-purpose for obtaining controls from suspects/participants.
  – Survey of current international practices
• Initially, 6 population groups (minimum of 25 participants/group
• Investigate data for correlations in features within and between groups
• Creation of a sustainable database
THANK YOU FOR LISTENING

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