Things we know from Transfer Studies

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Why worry about relevance in a mixture workshop?

- There is a growing interest in transfer and persistence studies in the literature in recent years since the ability to profile invisible stains.
- It is easy to suggest that this has little to do with the complexity of mixture deconvolution but I suggest the opposite.
- We know there are varying numbers of genotypes in a mixture.
- Therefore it is arguable more important than ever to consider relevance.
- DNA is, as we all know, is a wonderful material to discriminate one person from another.
- It readily transfers and we have the tools to detect very small quantities of it.
- This later property gives challenges as well as benefits.

HOW CAN WE ENSURE IT IS LINKED TO THE CRIME?
Extensive blood stains
DNA profile matching victim

Mixed profile
Some association with POI

Information that hammer used in attack

Is it reasonable to suggest that we cannot have the same confidence in DNA from each situation? Should we consider alternative propositions?
**Relevance affected by when DNA is transferred to crime samples**

<table>
<thead>
<tr>
<th>Before the crime</th>
<th>Crime Event</th>
<th>Processing the samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Transfers at this stage are the only relevant ones</strong></td>
<td></td>
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</table>

3 Reviews on this topic in the last twelve months


Relevance and issues that need to be considered

Correct samples?  
Sufficient samples?  
Background necessary or useful?  
Damage, degradation or contamination  
Replicated sample - true representation?

DNA persists for weeks out of doors

If POI has access to scene be aware of absence as well as presence

Possible transfer before the crime considered here

Potential for errors to be considered here

Studies re contamination avoidance

Intra and inter-laboratory validation studies

Non-self DNA detected on hands

Relevant transfers

Context in which crime committed

Legitimate access  
On an item for a period of time  
Transfer via another person or thing

collection  
transport  
sampling  
storage  
extraction  
quantification  
amplification  
Separation  
deconvolution

Non-self DNA detected on hands

Studies re contamination avoidance

Intra and inter-laboratory validation studies

If POI has access to scene be aware of absence as well as presence

Possible transfer before the crime considered here

Potential for errors to be considered here

Relevant transfers

Context in which crime committed
Potential sources of DNA which could deposit from the hands

- Cell free DNA
- Fragment-associated residual DNA
- Endogenous nucleated cells
- Anucleate corneocytes
- Transferred exogenous nucleated cells
- Dynamic – transfers in either direction possible


- Method of deposit not agreed
  - Sweat
  - Sebaceous fluid

- Saliva, sneezing, dandruff
Transfer studies - Impact of individual donor

Shedder status – the amount of DNA detected from an individual
Most of publications agree that some people shed more readily than others
Likely to be a continuum rather than strict divide

In spite of variation in the studies, support for the view that some individuals shed more than others

Factors studied
Gender, Age, Sex
Time since hand washing
Activities, Part of hand

References for some of these studies on your slides

Status
• Affects direct transfer
• Affects likelihood of detection of major profile from last handler
• Affects persistence
• Affects detection of non-self on hands
Transfer studies – effect of substrate

DNA transfers affected by
1. type of substrate
2. Moisture
3. pressure

Less transferred to hard non-porous surface but lost more quickly from
Higher amount transferred to soft porous surface but less transferred

Passive, pressure and friction
Increasing amount of transfer
Moisture
Friction to transfer DNA from non-porous to porous the most efficient chain

One Part of a study of Secondary Transfer to Wood Glass and Metal

P1
Door handle
Good source

P2
Nitrile gloves – good vectors

Cloth at crime scene

Transfer via person or object

11ng

10 transfer chains for door handle; average of 55ng deposited on handle; 64% transferred to gloves; 32% transferred to cloth.


Research likely influenced by observations on investigation of Merdith Kercher murder resulting in miscarriage of Justice

Shedder status and Investigation of Self and Non-Self

- 240 handprints deposited by 10 individuals;
- Analyzed for differences in DNA quantity and type of profile at different times on different days;
- Inter-personal variation higher than intra-personal. 0.05-5 ng per deposit;
- Mainly 2 person mixtures or non-interpretable; non-self in 79% Non-self usually the minor component;
- On rare occasion when non-self was major, they were associated with poor depositor/shedder; 7/240 self excluded.

Time since deposit


Profiles obtained out of doors up to two weeks with technology available in 2009


Profiles built up over a period of time in laboratory setting again highlighting need for elimination databases

Fewer systematic persistence studies than transfer studies
Persistence of one user following another

- Original user detected vast majority of experiments
- Varied depending on
  - Duration of use by second person
  - Substrate
  - Original handler – shedder status
  - Activities /action
  - Duration of use

Study with computer and mouse
Original user detected and transferred to second user up to 8 days
Differences in ability to detect initial user reasoned to be due to shedder status

Trend in studies to mimic casework in a broad manner
Experiments with knives

Experiments with knives to check if indirect transfer from person shaking hands with handler is detectable – yes **handler main profile;** 13 /20 5/20 **secondary transfer main profile.**

Is DNA of nearby person detected in stabbing cases and how much is transferred; DNA of person handling knife major or single profile 83%; Profiles too complex 5% ; **Observers profiles not detected.**

Is profile of regular user detected as well as stabber and hand shaker **Regular user persisted for at least a week;** Non-donor DNA co-deposited 5% -declined with time.


Samie, L., Hicks, T., Castella, V. and Taroni, F. (2016)

DNA profiles from laundered semen stains recovered at least 8 months after deposition.
• Micrograms of DNA and full DNA profiles recovered, irrespective of wash conditions.
• No significant decline in DNA quantity and profile quality after multiple washes.
• Both DNA sources detected on laundered T-shirt with semen stains from two donors.
• Laundered semen-stained clothing should be examined in sexual assault cases.


Secondary transfer of DNA from blood following washing but no usable profiles from saliva or epithelial abrasions.

Contamination studies

Possibility of incorrect profile or unnecessary mixtures


At a minimum need elimination samples needed
Care needed to ensure DNA on window frame, the sample profiled in the lab
Recap - we have seen
• Variation in shedder status
• Impact of substrate
• Persistence affected by background DNA as well as environment
• Contamination facilitated by many commonly used vectors

In addition we have major difficulties re standardization which hinders use
Studies not comparable because of
• Changes in technology
• Impact of different extraction and analytical parameters
• Different methods of recording associations

Activity propositions are regularly suggested as way forward
Not the subject of this presentation but ideal framework for raising the correct questions
Tools to address these issues

Case Assessment and Interpretation
Model formulated to deal with trace evidence

• Questions to be addressed arise from investigation and are the drivers behind the formulation of the propositions for the LR
• Later paper describes the effect of different levels of the hierarchy
• “A hierarchy of Propositions: deciding which level to address in casework” R COOK, IW EVETT*, G JACKSON, PJ JONES and JA LAMBERT; Science & Justice 1998; 38: 231-239

Illustration of the CAI model from original paper

Iterative nature is a precursor of the need to reassess WOE of association in light of case circumstances
Hierarchy of Propositions – questions being addressed

**Offense**
Court issues guilt/innocence
Generally not the concern of the forensic scientist

**Activity**
Forensic scientist needs to consider what’s expected in light of different actions; answered such as when or how in addition to who

**Source**
Whether or not two materials share the same source – who
Matching DNA when the cell type is known

**Sub-Source**
DNA when the cell type is not known – generally the case with mixtures and touch

**Sub-sub-Source**
Consider one genotype in a mixture

Activity propositions particularly relevant when transfer and persistence are an issue as in trace/touch

Adding value
<table>
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<tr>
<th>Year</th>
<th>Case</th>
<th>Decision/Findings</th>
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<tbody>
<tr>
<td>2007</td>
<td>Murdoch v The Queen [2007] NTCCA 1</td>
<td>The second issue was contamination. It was decided that the possibility of contamination could be excluded beyond reasonable doubt.</td>
</tr>
<tr>
<td>2007</td>
<td>The Queen v Hillier [2007] HCA 13</td>
<td>The conviction was quashed on the basis that the DNA evidence was considered in isolation from the other evidence. The weight accorded to DNA evidence must be considered in the context of all of the evidence presented by the prosecution.</td>
</tr>
<tr>
<td>2009</td>
<td>R v Jama (Unreported, Supreme Court of Victoria, Court of Appeal, 2009)</td>
<td>A woman was found unconscious in a toilet cubicle. While she did not have any DNA evidence, the case highlights the potential for miscarriages of justice to occur when too much reliance is placed on DNA evidence, or it is the sole evidence in a case.</td>
</tr>
<tr>
<td>2010</td>
<td>Forbes v The Queen [2010] HCA Trans 120</td>
<td>Forbes was convicted of sexual assault. DNA found on the victim’s trousers and bra was the sole evidence linking him to the crime. There was no other evidence linking him to the crime. The conviction was appealed on the basis that the verdict was unreasonable as there were other possible ways the DNA could have been transferred. The DNA evidence was not sufficient to prove guilt beyond reasonable doubt, because there was no information about the circumstances in which the DNA was transferred. The DNA could have been deposited as a result of secondary transfer such as shaking hands with someone who did not participate in the burglary.</td>
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<td>2014</td>
<td>Fitzgerald v The Queen [2014] HCA 28</td>
<td>During a burglary, one victim was murdered and serious brain injuries were inflicted on another. Fitzgerald was convicted of murder after DNA evidence linked him to a didgeridoo at the crime scene. There was no other evidence linking him to the crime. The conviction was appealed on the basis that the verdict was unreasonable as there were other possible ways the DNA could have been transferred. The DNA evidence was not sufficient to prove guilt beyond reasonable doubt, because there was no information about the circumstances in which the DNA was transferred. The DNA could have been deposited as a result of secondary transfer such as shaking hands with someone who did not participate in the burglary.</td>
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Recent developments in DNA evidence
Marcus Smith and Monique Mann
ISSN 1836-2206
© Australian Institute of Criminology 2015
Possible to take the view that continue to report sub-source and leave someone else to figure it out because anything else is too dangerous.

Can not separate knowledge of transfer, contamination risks and error rate when considering the need for robust appropriate findings.

Clinical or analytical chemistry model not appropriate.

Previous slide is not to suggest court determines scientific validity. But if results are useful they must be fit for purpose. Another way of considering is that they need to answer the appropriate questions and if community doesn’t take action risk undermining results anyway.
1. DNA should not be used as the sole evidence in a criminal case.
2. There is a considerable danger if the importance of the DNA evidence is inappropriately afforded greater weight than other evidence.
More recent studies suggest that background needs to be considered more when evaluating DNA findings
Awareness of absence in instances when transfer expected
Consider wider sampling of scenes


Increasing acceptance that approach to DNA needs to be driven by questions raised by the case rather than focus on single result
Impact of information on transfer and persistence

Holistic value from transfer studies information even if incomplete

- Transfer studies can be used to frame the samples to be taken at a scene
- Well known that some areas will be less useful than others
- Efforts to reduce mixtures almost instinctive – avoid door handles and aim for areas connected with crime but not regularly handled
- Information in the studies highlight that we need even more caution

Therefore need mechanisms to impart the information to scene examiners

In laboratory and at scene an awareness of risk of contamination

When reporting or receiving reports

Red flag in situations where only one genotype is recovered from a scene where multiples might be expected

Worth considering areas likely to give rise to culprit profile
Areas grabbed during a crime – work on ankles and armpits
Work of colleagues in NFI – crowd science

Therefore need mechanisms to impart the information to scene examiners

How Science Should Speak to Court – recommended free course from Coursera

https://www.coursera.org/learn/challenging-forensic-science
Some issues being considered

• That the CAI model with Hierarchy of Propositions be used to evaluate DNA except in situations where there is no uncertainty re relevance of source of sample.

• If not possible the report states clearly that the rarity of the profile is not linked to its relevance in the case

• Consideration be given to obtaining background samples ie additional samples from items, in instances where contamination is a possibility ie all sub source sampling.

• In any situation other than stranger rape, DNA findings are evaluated at activity level and possibilities of sperm transferring unto clothing shared in households be considered.

• Anti-contamination measures be put in place in police facilities as well as laboratories

• Elimination databases for police and laboratory personnel are used as well as other relevant people in fixed situations – other householders for example.
Take-away messages

• **Relevance** of sub-source level associations can never be taken for granted in light of information about transfer and contamination
• Therefore need to be aware of what affects transfer
• Information about transfer affects scene, laboratory and reporting/court
• Think of alternatives when examining the findings
• Consider the implication of absence when unexpected
• Be particularly careful when dealing with a single sample in a case
• The findings in a case should form a coherent narrative
• In critical situations ad-hoc tests to replicate proposed scenario is worth considering
• In present state of knowledge it is difficult to extrapolate literature studies to a specific laboratory
Additional references for shedder status and knife experiments


- Samie, L., Hicks, T., Castella, V. and Taroni, F. (2016) 'Stabbing simulations and DNA transfer', *Forensic Sci Int Genet*, 22, pp. 73-80


Thank you very much for your attention