

Fire Investigators Association of Ireland
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The nature of expert opinion and the structure of reports

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Case Assessment and Interpretation (C.A.I.)

Classification of opinion: 'Investigative/Evaluative'

'Hierarchy of issues'

Underpinning, logical framework: **Bayes Theorem**

Formal means of dealing with uncertainty and forming opinion:

Jackson, G, Jones, S., Booth, G., Champod, C. and Evett, I.W. 2006. The nature of forensic science opinion – a possible framework to guide thinking and practice in investigations and in court proceedings. *Science and Justice*. 46: 33-44

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Association of Forensic Science Providers (AFSP)

AFSP. Standard for the formulation of evaluative forensic science expert opinion *Science and Justice* 2009; 49: 161-164

The AFSP standard helps meet the UK Forensic Science Regulator's requirement:
...robust, transparent, balanced and logical interpretation model...

... and it embraces the two key C.A.I. concepts of:

- classification of expert opinion
- hierarchy of issues

Underpinning, logical framework: **Bayes Theorem**

Formal means of dealing with uncertainty and forming opinion:

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Bayes Theorem

- Very long pedigree – idea first proposed by 18th century cleric, mathematician and philosopher, Rev. Thomas Bayes, and later developed by French mathematician, Pierre Simon Laplace.
- Means of reasoning from 'effect' to 'cause' – known as the problem of 'inverse probability'
- Used in a legal context for the first time in the Dreyfus case in 1899 in France.
- First modern applications in forensic science – Finkelstein and Fairley 1970 (USA), Lindley 1977, Evett 1980s (UK)
- Numerous papers now across a wide range of evidence types

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Bayes Theorem

Biedermann A, Taroni F, Delemont O, Semadeni C, Davison, AC.
The evaluation of evidence in the forensic investigation of fire incidents
Part I: an approach using Bayesian networks.
Forensic Science International, 2005; 147: 49-57.

Biedermann A, Taroni F, Delemont O, Semadeni C, Davison, AC.
The evaluation of evidence in the forensic investigation of fire incidents
Part II: practical examples of the use of Bayesian networks.
Forensic Science International, 2005; 147: 59-69.

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How do we form opinions?

Opinion about an uncertain event → Opinion about an uncertain event → Opinion about an uncertain event

Factual evidence 1 → Factual evidence 2 → Factual evid

We adjust our opinion one way or the other given new items of evidence

There's two things to consider

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Bayes Theorem

Tells us how to combine logically new pieces of information (or evidence) to update our opinions about an uncertain event

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Bayes Theorem

Tells us how to combine logically new pieces of information (or evidence) to update our opinions about an uncertain event

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Bayes Theorem

Tells us how to use new pieces of information (or evidence) to update our opinions about an uncertain event

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Bayes Theorem

Tells us how to use new pieces of information (or evidence) to update our opinions about an uncertain event

$Pr[H | E, I] \propto Pr[E | H, I] \times Pr[H | I]$

Pr = 'the probability of ...'
 H = 'the hypothesis' (proposition; allegation; view etc)
 | = 'given ...' (conditioning) I = 'background information'
 E = 'the new evidence' (observations; tests results etc)

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$Pr[H | E, I] \propto Pr[E | H, I] \times Pr[H | I]$

$\frac{Pr[H | E, I]}{Pr[\bar{H} | E, I]} = \frac{Pr[E | H, I]}{Pr[E | \bar{H}, I]} \times \frac{Pr[H | I]}{Pr[\bar{H} | I]}$

Where does the expert sit in this process?
 What is her/his role and contribution?

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Bayes Theorem

... in court:

$\frac{Pr[E | H_p, I]}{Pr[E | H_d, I]}$

A balanced assessment of the value of the scientific findings ...
 ... and the basis of reliable, justifiable, scientific opinion

This is what the expert should be evaluating and communicating

AFSP. Standard for the formulation of evaluative forensic science expert opinion
 Science and Justice 2009; 49: 161-164

Classification of opinion

An example – comparison of hand images

Images courtesy of Prof. Sue Black,
Centre for Anatomy and Human Identification, University of Dundee

Image of the hand of the offender

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Classification of opinion

Offender image

Suspect image

Images courtesy of Prof. Sue Black, Centre for Anatomy and Human Identification, University of Dundee

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Classification of opinion

• The hand that can be seen in the video is the left hand of the defendant

Identification **Individualisation** **Categorical**

• The image of the hand is very likely to be that of the left hand of the defendant

Posterior probability

• The hand seen in the video could be the left hand of the defendant

• The image of the hand is consistent with that of the defendant's

Explanations

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Categorical opinion

The hand in the video is Mr A's left hand.

Benefits

- Takes away all uncertainty
- Authoritative and convincing
- Appears to be a good manifestation of true expertise

Limitations

- Can the categorical answer be justified:
 - is it truly a deductive answer?
 - is it a personal 'conviction'?
- May be implicit use of other information or evidence
- BIAS! (e.g. confirmation bias)

http://www.thefingerprintinquiryScotland.org.uk/inquiry/3127-2.html

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Posterior probability

'The image is very likely to be that of Mr A's left hand'

Benefits

- Provides an apparently strong answer to an important question for the investigation and the court
- Appears helpful
- Appears we are doing our 'job'

Limitations

- A prior view on the uncertain event must have been adopted
- That prior view may be limited or biased; v.likely undeclared
- Risk of 'double-counting' of evidence
- May be a 'transposed conditional' i.e. Prosecutor's Fallacy
- Potentially erroneous and misleading

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Posterior probability

Doheny and Adams
[1997] 1 Cr.App.R. 369

'The scientist should not be asked his opinion on the likelihood that it was the defendant who left the crime stain

The scientist cannot give a reliable view on the likelihood that the semen came from a particular suspect because that likelihood depends not only on the scientific evidence but also on the other, non-scientific evidence.....

..... of which the scientist may be unaware.

This guidance is correct for logical reasons

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... and the logic applies to all forms of expert evidence!

'The scientist should not be asked his opinion on the likelihood that it was the defendant who left the crime stain

'The scientist should not be asked his opinion on the likelihood that the glass fragments came from the window

the accused kicked the victim

the defendant's shoe left the mark

the recovered hair came from the victim

the image is that of Mr A's left hand

the shoes had probably been in contact with petrol

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Explanations

The image could be that of Mr A's left hand.

The findings are consistent with the image being that of Mr A's left hand.

Benefits

- Useful 'first stage' conclusion
- Can provide options for the investigation

Limitations

- Applies to rare as well as common features and materials
- No assessment of investigative helpfulness or evidential value
- There may be 'better' conjectures
- Could be argued for prosecution or for defence
- Potential to mislead

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Explanations

The image could be that of Mr A's left hand.

The findings are consistent with the image being that of Mr A's left hand.

Kaufman Commission Report 1998

R v Puaca [2005] EWCA 3001

The State of Western Australia –v- Dair [2006] WADC 157

'Strengthening Forensic Science in the United States: A Path Forward' NAS 2009

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Association of Forensic Science Providers (AFSP)

Likelihood ratio

AFSP. Standard for the formulation of evaluative forensic science expert opinion *Science and Justice* 2009; 49: 161-164

The degree of correspondence observed between the image of the hand in the video and the known image of Mr A's left hand is far more probable (OR, e.g., approx 100 times more probable) if the video image were truly that of Mr A's left hand rather than of the hand of some other, unknown, person

The degree of correspondence ... provides (qualifier) support for a view that the video image is that of Mr A's left hand rather than of the hand of some other, unknown, person

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'The findings are approximately 100 times more probable if...'

Likelihood ratio

'The findings provide moderate support for the view that ...'

Benefits

- Logical, balanced and robust, if based on appropriate propositions and on sound knowledge and understanding
- Allows combination of different pieces of evidence
- Helps in assessing whether sensible use of resources

Limitations

- Is it comprehensible to lay people, lawyers and police?
- Not liked by some - insufficient certainty; too 'wishy-washy'
- Are there sufficient data/knowledge to help assign probabilities?

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Classification of opinion

Most opinions can be classified in this way

There are benefits and limitations to each of these

However, some opinions are difficult to classify:

- ... provides strong evidence of a link
- ... significant finding ...
- ... no significant findings ...
- ... evidence of association ...
- ... evidence of contact ...

Likelihood ratios

Explanations

Posterior probabilities

Categorical

...except in a category of 'meaningless'?

and possibly misleading!

Avoid using!

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Classification of opinion

Investigative

Evaluative

Explanations

$[H_1 | E, I], [H_2 | E, I] \dots [H_n | E, I]$

Likelihood ratios

$\frac{\Pr[E | H_p, I]}{\Pr[E | H_d, I]}$

Posterior probabilities

$\Pr[H | E, I]$

These formulations have implications for report-writing

Categorical

$\Pr[H | E, I] = 1$
 $\Pr[H | E, I] = 0$

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Classification of opinion

Investigative

Explanations

$[H_1 | E, I], [H_2 | E, I] \dots [H_n | E, I]$

Ensure readers are aware of

- aspects of the case circumstances (i.e. background information, I) that we have used to generate the explanation
- the absence of any assessment of probability for the explanation
- the open-ended nature of explanations

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Classification of opinion

Investigative

Posterior probabilities

$\Pr[H | E, I]$
 $\propto \Pr[E | H, I] \times \Pr[H | I]$

Ensure readers are aware of

- the initial hypotheses and the prior probabilities
- the background information and expert knowledge (all part of 'I') that we have used to help generate hypotheses and inform their prior probabilities
- the background information and expert knowledge (all part of 'I') that we have used to assign values for probabilities of the evidence (E)

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Classification of opinion

Investigative

Categorical

$\Pr[H | E, I] = 1$
 $\Pr[H | E, I] = 0$

Ensure readers are aware of

- the initial hypotheses and the prior probabilities
- the background information and expert knowledge (all part of 'I') that we have used to help generate hypotheses and inform their prior probabilities
- the background information and expert knowledge (all part of 'I') that we have used to assign values for probabilities of the evidence (E)
- the justification of probabilities of zero somewhere for the evidence (E)

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Classification of opinion

Investigative

Categorical

$\Pr[H | E, I] = 1$
 $\Pr[H | E, I] = 0$

Ensure readers are aware of

- the initial hypotheses and the prior probabilities
- the background information and expert knowledge (all part of 'I') that we have used to help generate hypotheses and inform their prior probabilities
- the background information and expert knowledge (all part of 'I') that we have used to assign values for probabilities of the evidence (E)
- the justification of probabilities of zero somewhere for the evidence (E)

Can the categorical answer be justified? Is it truly a deductive answer? Is it a personal 'conviction'?

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Classification of opinion

$\frac{\Pr[E | H_p, I]}{\Pr[E | H_d, I]}$

Evaluative

Likelihood ratios

Ensure readers are aware of

- the propositions given to you by the prosecution and defence
- the relevant background information (I) that we have used to inform probabilities of the evidence (E) given the two propositions
- the magnitude of the ratio of those two probabilities
- where that magnitude sits on verbal scale, if used
- the vital importance of the background information (I) and its influence on probabilities of the evidence
- on what basis (expert knowledge) we have assigned values for the conditional probabilities of E

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'Hierarchy of issues'

Specifying the questions we can address as forensic scientists may be one of the most important activities we do.....

... and perhaps one of the most difficult aspects of forensic science.

The 'Hierarchy' provides a guiding structure

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What type of question is being asked?

Evaluative
... in a judicial context

Did he commit the **offence**?

Did he do the **activity**?

Is he/his item the **source** of the trace material?

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What type of question is being asked?

Evaluative
... in a judicial context

Did he commit **arson**?

Did the defendant **pour petrol** from the can?

Is the petrol at the scene the **source** of the 'trace' on the shoes?

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What type of question is being asked?

Investigative

What **offence** committed?

What **activity** took place?

What is the **source** of the trace material?

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What type of question is being asked?

Investigative

Was it **arson**?

Was flammable liquid **poured** through letter-box?

What is the **source** of the 'trace' at the scene?

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Hierarchy of issues

Requires dialogue between scientist and client on which are the most important, the most useful, issues for the scientist to address to help resolve uncertainties for the police, lawyers, defendant, court.

After agreement on the issues to be addressed, propositions and their alternatives can be developed from those issues

Hierarchy of issues → Hierarchy of propositions

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This hierarchical approach to the issues in a case, together with the investigative/evaluative model, provides clarity on the issues being **addressed**.....

.....and therefore helps clarify and communicate the **purpose** of the scientific examination

For example, if **evaluative** :

The purpose of my examination has been to help address the issue of whether Mr A was the person who poured petrol through the letter-box.

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This hierarchical approach to the issues in a case, together with the investigative/evaluative model, provides clarity on the issues being **addressed**.....

.....and therefore helps clarify and communicate the **purpose** of the scientific examination

For example, if **investigative** :

The purpose of my examination has been to answer the question of whether flammable liquid was poured through the letter-box

The purpose of my examination has been to provide suggestions for the type of flammable liquid used at the scene

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Structure of reports and statements maps over from the basic principles, reflecting the flow of a logical process

- What have I been told? **HEADINGS**
- What items have I been given? **Circumstances**
- What am I trying to achieve? **Receipt of items**
- What techniques am I going to use; what might I find? **Purpose**
- What have I done; what have I found? **Technical issues**
- What do the results mean? **Examination results**
- What's the bottom line? **Interpretation**
- Conclusion**

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Structure of reports and statements maps over from the basic principles, reflecting the flow of a logical process

- Explicit statement of those elements of the case circumstances (I) that are relevant to specifying the issues, to selection of items/tests and to interpretation **Circumstances**
- Specification of the issues to be addressed - 'investigative' or 'evaluative'; if evaluative, also a description of the propositions that are being addressed **Purpose**
- If 'evaluative', the probability of the findings, given the truth of each of the propositions, is explained. If 'investigative', alternative explanations are listed and, if giving posterior probabilities, the priors adopted will be explained **Interpretation**
- The conclusions should link directly with the purpose **Conclusion**

Evett IW, Jackson G, Lambert JA and McCrossan S. *The impact of the principles of evidence interpretation on the structure and content of statements.* Science and Justice 2000; 40: 233-239

Circumstances

Include those, and only those, pieces of background information that:

- help specify the issues (**investigative** and/or **evaluative**) and the propositions
- influence our probability assignments for $\Pr[E|H_p, I]$ and $\Pr[E|H_p, \bar{I}]$ and, if **investigative**, our priors

State clearly that our assessment and interpretation rely critically on these pieces of information (I)

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Circumstances

State clearly that assessment and interpretation rely critically on these pieces of information (I)

e.g. *This is the information I used to determine the examination strategy for this case and on which I relied when interpreting the results of the examinations. If any part of that information is wrong, or if any new information comes to light, I will need to reappraise my interpretation and conclusions.'*

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Examples of 'Purpose'

Evaluative

The purpose of my examination has been to help address the issue of whether Mr A was the person who poured petrol through the letter-box.

Investigative

The purpose of my examination has been to answer the question of whether flammable liquid was poured through the letter-box

The purpose of my examination has been to provide suggestions for the type of flammable liquid used at the scene

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Interpretation

- If **evaluative**, set out the propositions addressed and discuss probabilities for the observations: $Pr[E|H_p,I]$ and $Pr[E|H_D,I]$
- If **investigative**, present all feasible 'explanations' $[H_1|E,I]$, $[H_2|E,I]$... $[H_n|E,I]$ OR ...
 - WHERE APPROPRIATE, discuss $Pr[E|H_1,I]$, $Pr[E|H_2,I]$... $Pr[E|H_n,I]$ together with priors $Pr[H_1,I]$, $Pr[H_2,I]$... $Pr[H_n,I]$ and posteriors $Pr[H_1|E,I]$, $Pr[H_2|E,I]$... $Pr[H_n|E,I]$
- Opportunity for the expert to lead the readers/users through their thinking, share their knowledge in order to help them form their own views and reach their own conclusion

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Conclusion

- Simple summary of result of interpretation
- Relate to 'Purpose'
- If **evaluative**, express the magnitude of the likelihood ratio
- If **investigative**, express as 'explanations or as "best conjectures", i.e. highest posterior probabilities

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Conclusion

Evaluative

'The findings provide very strong support for the view that it was Mr A, rather than some other person, who poured petrol through the letter-box.

Investigative

In my opinion, it is very likely that flammable liquid was poured through the letter-box

Types of flammable liquid that could have been used at the scene include ...

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Report extracts kindly provided by Dennis McAuley

REPORT 1.

Introduction

On 16 November 2011, [REDACTED] examined a "40 foot" shipping container and contents at [REDACTED]. Fire damage had apparently been discovered inside the container on 8 November 2011 during unloading of the contents at [REDACTED]. At the time of discovery, the fire appeared to have self-extinguished. I understand that the seals on this "customs bonded" container were found to be intact before the unloading procedure commenced.

Purpose of my Examination

To determine the cause of the fire which damaged the contents of the shipping container.

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REPORT 1.

Examination

Exterior of shipping container

There were two areas of fire damage on the exterior of one side-wall of the yellow painted steel container (photos 1 & 2). These irregular shaped areas were located at/near the bottom rail of the side-wall, approximately 9m from the door-end of the container.

The lowermost area of fire damage, approximately size 320mm x 290mm, comprised a central region of bare metal, bordered by pink coloured scorched paint. This damage straddled the joint between the container side-wall and the bottom rail (extending 110mm below the joint – photo 3). An area of paint on the underside of the upper lip of the bottom rail had also been burnt away (photo 4).

The upper area of fire damage was comprised of a pink coloured scorch mark, approximately size 200mm x 120mm, located 60mm above and to the left of the lower damage.

Examination of the underside of the plywood floor of the shipping container revealed an area of heat blistered black paint adjacent to the fire damaged region of the bottom rail (photo 5). A nail hole was also present in this area of the floor (photo 6).

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REPORT 1.

Examination
Contents of shipping container
 The container was fully packed with cardboard boxes, each approximately size 112cm x 73cm x 69cm. These were loaded, broad-side first, in rows of two columns, across the container (photo 7). Each column was stacked three boxes high. The boxes contained tightly packed leaf tobacco and bore labels which included the information "Gross 215kgs". Six of the boxes had been partly burnt (photo 8). These boxes had formed two columns in adjoining rows and had been located end-on to the fire damaged region of the container side-wall.

The outer end of the bottom box in each of the two columns had been partly burnt (photo 9). Further burning had occurred between the adjoining broad-sides of these boxes and into their contents (photos 10 – 12). The fire had also spread upwards between both columns of boxes, though the upper damage was less severe.

Interior of shipping container
 An area of burnt and blackened brown paintwork, approximately size 360mm x 300mm, on the interior of the container side-wall referred to above, corresponded to the lower fire damage observed on the exterior of the side-wall (photo 13). An oily black plume of combustion products extended from the edge of this area, up the side-wall to the underside of the container roof (photos 14 – 16).

The original positions of the fire damaged cardboard boxes within the container could be determined, due to smoke having been deposited on the floor in the gaps between the bottom boxes (photo 17). A linear shaped burnt area, approximately size 260mm x 120mm x 20mm, was present on the wooden floor where there had been a gap between the bottom boxes of the two fire damaged columns (photos 18 & 19). This burnt floor area was adjacent to the fire damaged region of the container side-wall (photo 20).

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REPORT 1.

Conclusion
 The pattern of fire damage to the cardboard boxes of the shipping container indicated that the origin of the fire was near the lowest outer edges of the two fire damaged columns of boxes. The fire then developed between the two adjoining sides of the bottom boxes and into the contents of these boxes. The fire also spread upwards between both columns of boxes. After an initial free flaming stage, the fire became smouldering in nature.

In my opinion, the fire was caused by the external application of heat (probably from a welding torch) to the lower regions of the side-wall of the shipping container. The resultant "hot-spot" on the inner surface of the side-wall (coincident with the lower area of external fire damage) ignited the cardboard box closest to this high temperature source.

Pr[H | E, I] = high
 Posterior probability

Categorical Pr[H | E, I] = 1
 Pr[H_{EXT Welding torch} | E, I] = high
 Pr[H_{EXT} | E, I] = 1
 Pr[H_{All Other Causes} | E, I] = 0

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REPORT 1.

In reaching this conclusion, I have also considered the following propositions:-

- (i) That the fire was caused by "self-heating" of the tobacco within at least one of the cardboard boxes. H_{SELF}
- (ii) That the fire was caused by a lit cigarette, carelessly discarded within the shipping container at the time the boxes were loaded. H_{CIG}
- (iii) That the fire was caused by some other external means than that concluded above. $H_{O.EXT}$

E = location and pattern of burning; absence of burning elsewhere

Pr[E | H_{EXT}, I] = very _ high
 Pr[E | H_{SELF}, I] = ?
 Pr[E | H_{CIG}, I] = ?
 Pr[E | H_{O.EXT}, I] = ?

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REPORT 1.

In my opinion, there is no support for the fire having been caused by "self-heating" of the tobacco, given that the origin of the fire was at the edge of the boxes rather than at the centre of a box. There was also no evidence of any "self-heating" having occurred in other parts of the cargo.

'No support' is not in the original verbal scale of qualifiers for the strength of support provided by the evidence.

E = location and pattern of burning; absence of burning elsewhere

Pr[E | H_{SELF}, I] = ?

Does 'no support' mean: Pr[E | H_{SELF}, I] = very _ low
 Or is it meant to imply: Pr[H_{SELF} | E, I] = very _ low

Fallacy of the transposed conditional

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REPORT 1.

The proposition that a carelessly discarded cigarette caused the fire is highly unlikely, given that the double thickness cardboard boxes would not be susceptible to ignition by a cigarette. There was also no evidence of any cigarette butts within the container.

E = location and pattern of burning

Pr[E | H_{CIG}, I] = ?

As stated, this opinion is a post. prob: Pr[H_{CIG} | E, I] = v.Low

But, logically, posterior probability can only come from combining the prob. for the evidence { Pr[E | H_{CIG}, I] = ? } and the prior probability for the event { Pr[H_{CIG} | E, I] = ? }

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REPORT 1.

Pr[H_{O.EXT} | E, I] = 0

Given that the shipping container was sealed and intact on arrival at [redacted], no means of directly igniting the container contents from the exterior was possible.

E = ? What is the scientific evidence?

Pr[E | H_{O.EXT}, I] = ? Pr[E | H_{O.EXT}, I] = 0?

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Case Study – Suspicious death and fire

Case circumstances

- Fire Brigade called to a fire in a small, fenced-off yard late in the late evening
- Because of difficult access to the yard from the roadway, officers removed one concrete fence panel and directed jet of water to the fire among a small 'pile of rubbish'
- Officers then became aware that the pile was a body

- Body was that of a 12-year old, local female, last seen about 18.45 that evening with a girlfriend
- Had been with her 17-year old boyfriend about 16.00 that day
- He says that was last time he saw her

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Case Study – Suspicious death and fire

Samples available

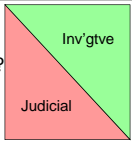
- Debris from under body
- Debris from second seat of fire
- Hair from near second seat of fire
- Remains of clothing from deceased

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Case Study – Suspicious death and fire

What are the questions/issues?

- What was the sequence of events?
- Was a flammable liquid used; if so, what type?
- Who did what?



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Was a flammable liquid used; if so, what type?

Investigative $Pr[H | E, I] \propto Pr[E | H, I] \times Pr[H | I]$

- Specify the question
- List all realistically possible hypotheses
- Estimate prior probabilities
- Consider prob. of observing the various outcomes of tests
- Do tests
- Multiply priors by the (previously estimated) probability of the test result
- Normalise to arrive at posterior probability

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Was a flammable liquid used; if so, what type?

	Priors	Pr[E H,I]	Prior x Pr[E H,I]	Posteriors
H1 Petrol				
H2 White spirit				
H3 Paraffin				
H4 Lighter fuel				
H5 Diesel				
H6 Something else				
H7 No accelerant				
	1			1

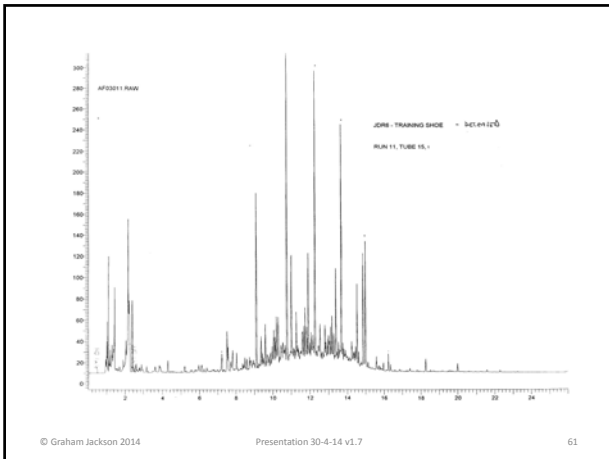
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Was a flammable liquid used; if so, what type?

	Priors	Pr[E H,I]	Prior x Pr[E H,I]	Posteriors
H1 Petrol	0.4			
H2 White spirit	0.2			
H3 Paraffin	0.1			
H4 Lighter fuel	0.08			
H5 Diesel	0.001			
H6 Something else	0.001			
H7 No accelerant	0.218			
	1			1

- Values for prior probabilities are for illustrative purposes only and would not necessarily reflect the assignments of an expert

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Was a flammable liquid used; if so, what type?

	Priors	Pr[E H,I]	Prior x Pr[E H,I]	Posteriors
H1 Petrol	0.4			
H2 White spirit	0.2			
H3 Paraffin	0.1			
H4 Lighter fuel	0.08			
H5 Diesel	0.001			
H6 Something else	0.001			
H7 No accelerant	0.218			
	1			1

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Was a flammable liquid used; if so, what type?

	Priors	Pr[E H,I]	Prior x Pr[E H,I]	Posteriors
H1 Petrol	0.4	0.03		
H2 White spirit	0.2	0.04		
H3 Paraffin	0.1	0.95		
H4 Lighter fuel	0.08	0.01		
H5 Diesel	0.001	0.015		
H6 Something else	0.001	0.01		
H7 No accelerant	0.218	0.01		
	1			1

• Values for probabilities of evidence are for illustrative purposes only and would not necessarily reflect the assignments of an expert

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Was a flammable liquid used; if so, what type?

	Priors	Pr[E H,I]	Prior x Pr[E H,I]	Posteriors
H1 Petrol	0.4	0.03	0.012	
H2 White spirit	0.2	0.04	0.008	
H3 Paraffin	0.1	0.95	0.095	
H4 Lighter fuel	0.08	0.01	0.0008	
H5 Diesel	0.001	0.015	0.000015	
H6 Something else	0.001	0.01	0.00001	
H7 No accelerant	0.218	0.01	0.00218	
	1		0.118005	1

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Was a flammable liquid used; if so, what type?

	Priors	Pr[E H,I]	Prior x Pr[E H,I]	Posteriors
H1 Petrol	0.4	0.03	0.012	0.102
H2 White spirit	0.2	0.04	0.008	0.068
H3 Paraffin	0.1	0.95	0.095	0.805
H4 Lighter fuel	0.08	0.01	0.0008	0.007
H5 Diesel	0.001	0.015	0.000015	<0.001
H6 Something else	0.001	0.01	0.00001	<0.001
H7 No accelerant	0.218	0.01	0.00218	0.018
	1		0.118005	1

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Who did what?

- Police believe that someone squirted BBQ lighter fuel over girl and ignited it by flicking lit matches at her; they suspect the boyfriend
- Boyfriend denies this and states he spilt turps on his shoes the day before
- Shoes taken 5 hours after incident

Judicial/Evaluative

- Identify the issue
- Set out the proposition and alternative
- Consider probability of observing all the various outcomes of the tests used (pre-assessment)
- Do the work
- Evaluate the likelihood ratio for the test outcome
- Convey the magnitude of the LR

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Identify the issue: Did he squirt the fuel over her?

Judicial/Evaluative $\frac{\Pr[E | H_P, I]}{\Pr[E | H_D, I]}$

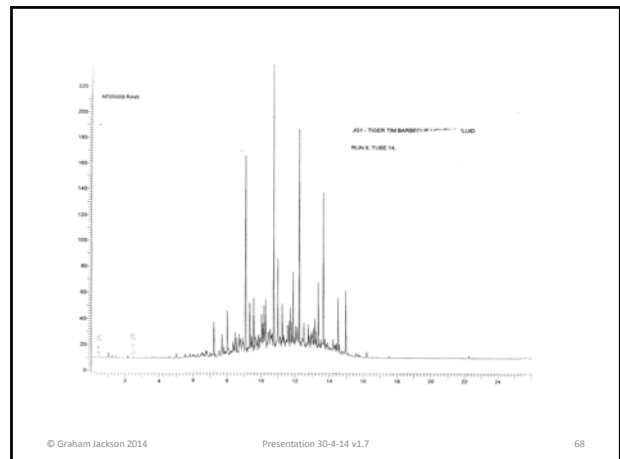
Develop the proposition and alternative:

H_p He squirted the fuel over her

H_D He did not squirt fuel; he spilt turps...

Set out probabilities for all outcomes of headspace analysis on shoes

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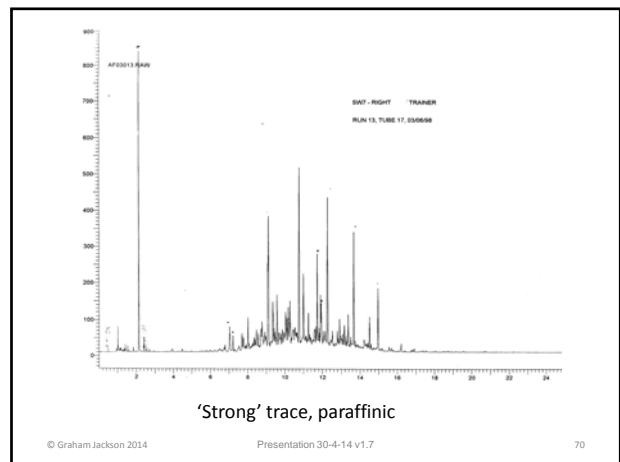


Set out probabilities for all outcomes of the test

	$\Pr[E H_p]$	$\Pr[E H_D]$	LR
No trace	0.005	0.005	1
'Weak' trace, paraffinic	0.25	0.01	25
'Strong' trace, paraffinic	0.7	0.005	140
Any other trace	0.045	0.98	1 / 22
	1	1	

• Values for probabilities for the evidence are for illustrative purposes only and would not necessarily reflect the assignments of an expert

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'Strong' trace, paraffinic	0.7	0.005	140
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Judicial/Evaluative $\frac{\Pr[E | H_P, I]}{\Pr[E | H_D, I]}$

H_p He squirted the fuel over her

H_D He did not squirt fuel; he spilt turps...

$$\frac{\Pr[E | H_P, I]}{\Pr[E | H_D, I]} = \frac{0.7}{0.005} = \frac{0.7}{0.005} = 140$$

The findings provide moderately strong support for the view that he squirted the fuel over her rather than he did not (and.....)

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In summary

The principles of interpretation, including the use of the 'hierarchy of issues' and a scheme to classify expert opinion, help provide ...

- clarity to the role and contribution of an expert
 - ... that can be explained to, and developed with, users
- clear guidance on the data and knowledge required for each type of opinion
- the means with which to test and challenge opinions!
- pointers to the structure and content of reports

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Thanks for your attention
Hope you found it interesting and useful

