Forensic Genetics

Module 16 – Session 6

Reporting and Presenting LRs

- Formulating Propositions
  - Hierarchy of propositions
  - Guidelines
  - Issues

- Communicating LRs
  - Verbal scales
  - Bias

- Fallacies
  - Prosecutor's fallacy
  - Defendant's fallacy
  - Uniqueness fallacy
  - Association fallacy

Hierarchy of Propositions

Evett & Cook (1998) established the following hierarchy of propositions:

Level	Scale	Example
III	Offense	H_p: The suspect raped the complainant. H_d: Some other person raped the complainant.
II	Activity	H_p: The suspect had intercourse with the complainant. H_d: Some other person had intercourse with the complainant.
I	Source	H_p: The semen came from the suspect. H_d: The semen came from an unknown person.
0	Sub-source	H_p: The DNA in the sample came from the suspect. H_d: The DNA in the sample came from an unknown person.

Number of Contributors

What about the number of contributors?

This is an important component of mixture interpretation. Most approaches assume that the NoC is known.

- The MAC method does not always work (e.g. when we have four alleles, but the POI is homozygous).
- Multiple LR_n values may be calculated for varying number of contributors n and the most conservative one is usually presented.
- Machine learning approaches have been proposed to assess the NoC[1].

[1] PACE: Probabilistic Assessment for Contributor Estimation - A machine learning-based assessment of the number of contributors in DNA mixtures (Marciano & Adelman, 2017).

Number of Contributors

Another option is to calculate a weighted average[1]:

$$\mathsf{LR} = \sum_{n=1}^{N} \mathsf{LR}_n \Pr(\mathsf{NoC} = n),$$

where prior independence is assumed:

$$\Pr(\mathsf{NoC} = n|H_p) = \Pr(\mathsf{NoC} = n|H_d)$$

The ISFG also recognizes that there may be situations where different number of contributors in H_p and H_d are needed. Non-equivalence of the prior seems a rare event and may be difficult to interpret.

[1] Contributors are a nuisance (parameter) for DNA mixture evidence evaluation (Slooten & Caliebe, 2018).

Number of Contributors

- Underestimating the NoC is usually conservative (minor contributors may be incorrectly excluded).

- Overestimating the NoC may not be conservative (non-contributors may not be excluded).

- For major contributors the NoC has little effect on the LR.

Verbal Scales

A verbal scale for evidence interpretation, applied to the prosecution proposition:

Likelihood Ratio	**Verbal Equivalent**
$1 < \text{LR} \leq 10$	Limited support (for H_p)
$10 < \text{LR} \leq 100$	Moderate support (for H_p)
$100 < \text{LR} \leq 1\,000$	Moderately strong support (for H_p)
$1\,000 < \text{LR} \leq 10\,000$	Strong support (for H_p)
$10\,000 < \text{LR} \leq 1\,000\,000$	Very strong support (for H_p)
$1\,000\,000 < \text{LR}$	Extremely strong support (for H_p)

The equivalent for H_d is given by taking the reciprocal.

→ The association of words with numbers is subjective and arbitrary!

Presenting Evidence

- How forensic evidence is presented is at least as important as what is presented.

- It is not only what forensic experts say, but how they say it that must be considered

Valid probabilistic reasoning is not easy, so people often use various tricks, rules of thumb, habits, etc., to reason in daily life. These are called heuristics.

Heuristics may suffice for most practical situations, but can lead to systematic error in probabilistic reasoning (i.e. fallacies).

Case Study 1

Quickly read/say the colors of the word:

Case Study 1

Quickly read/say the colors of the word:

RED
ORANGE
YELLOW
GREEN
BLUE
PURPLE

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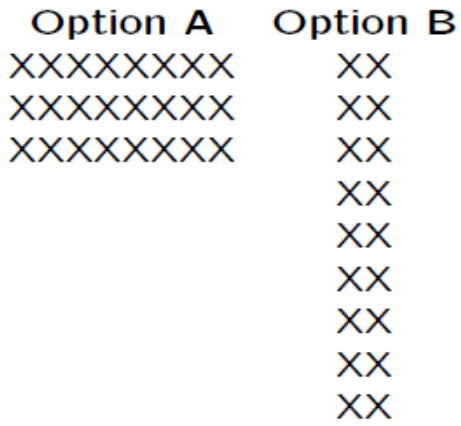
Automatic cognitive processes are unintentional and involuntary, and occur outside awareness, probably controlling us more than we want to admit.

Case Study 2

Which option has the most paths? What is the difference?

Option A	Option B
XXXXXXXX	XX
XXXXXXXX	XX
XXXXXXXX	XX
	XX
	XX
	XX
	XX
	XX
	XX

Case Study 2



The number of paths is the same for both options:

$$8^3 = 2^9 = 512$$

In a study (Tversky and Kahneman) 85% of respondents found more paths in option A (median: 40) than in option B (median: 18).

This is an example of *availability heuristic*, i.e. the likelihood of an event is estimated as the ease with which examples of such events can be retrieved from memory.

Case Study 3

An unusual disease is expected to kill 600 people. Two alternative programs to combat the disease have been proposed:

- If program A is adopted, 200 people will be saved.
- If program B is adopted, there is a 1/3 chance that all 600 people will be saved and a 2/3 chance that nobody will be saved.

Which program would you choose?

Case Study 3

An unusual disease is expected to kill 600 people. Two alternative programs to combat the disease have been proposed:

- If program C is adopted, 400 people will die.
- If program D is adopted, there is a 1/3 chance that nobody will die and a 2/3 chance that all 600 people will die.

Which program would you choose?

Case Study 3

All four programs have the same expected outcome: 200 people will live, 400 will die.

When framed in terms of gains, 72% choose program A (risk-averse). When framed in terms of losses, 78% choose program D (risk-taking).

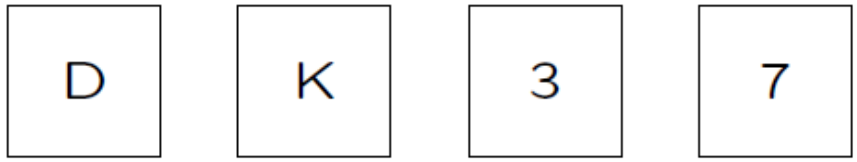
Certain gain is preferred over possible gain, while possible loss is preferred over certain loss.

This is an example of the *framing effect*.

Case Study 4

Four cards, each with a letter on one side and a number on the other, are placed on a table. The following hypothesis is proposed:

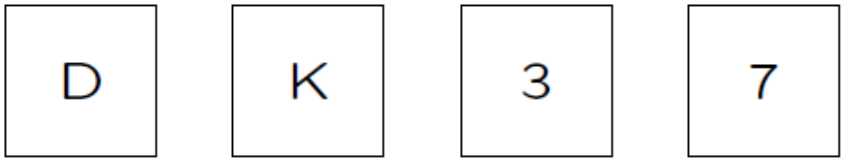
Every card that has a D on one side has a 3 on the other.



Which card(s) need to be turned over to determine whether the hypothesis is true?

Case Study 4

Hypothesis: *Every card that has a D on one side has a 3 on the other.*



The correct answer is D and 7. Selecting D and 3 is indicative of *confirmation bias*, i.e. the tendency to search for or interpret information in a way that confirms one's preexisting beliefs or hypotheses, but $\Pr(3|D) \neq \Pr(D|3)$.

Case Study 5

Estimate the number resulting from the following expression:

$$2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$$

Case Study 5

Estimate the number resulting from the following expression:

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2$$

Case Study 5

Estimate the number resulting from the following expression:

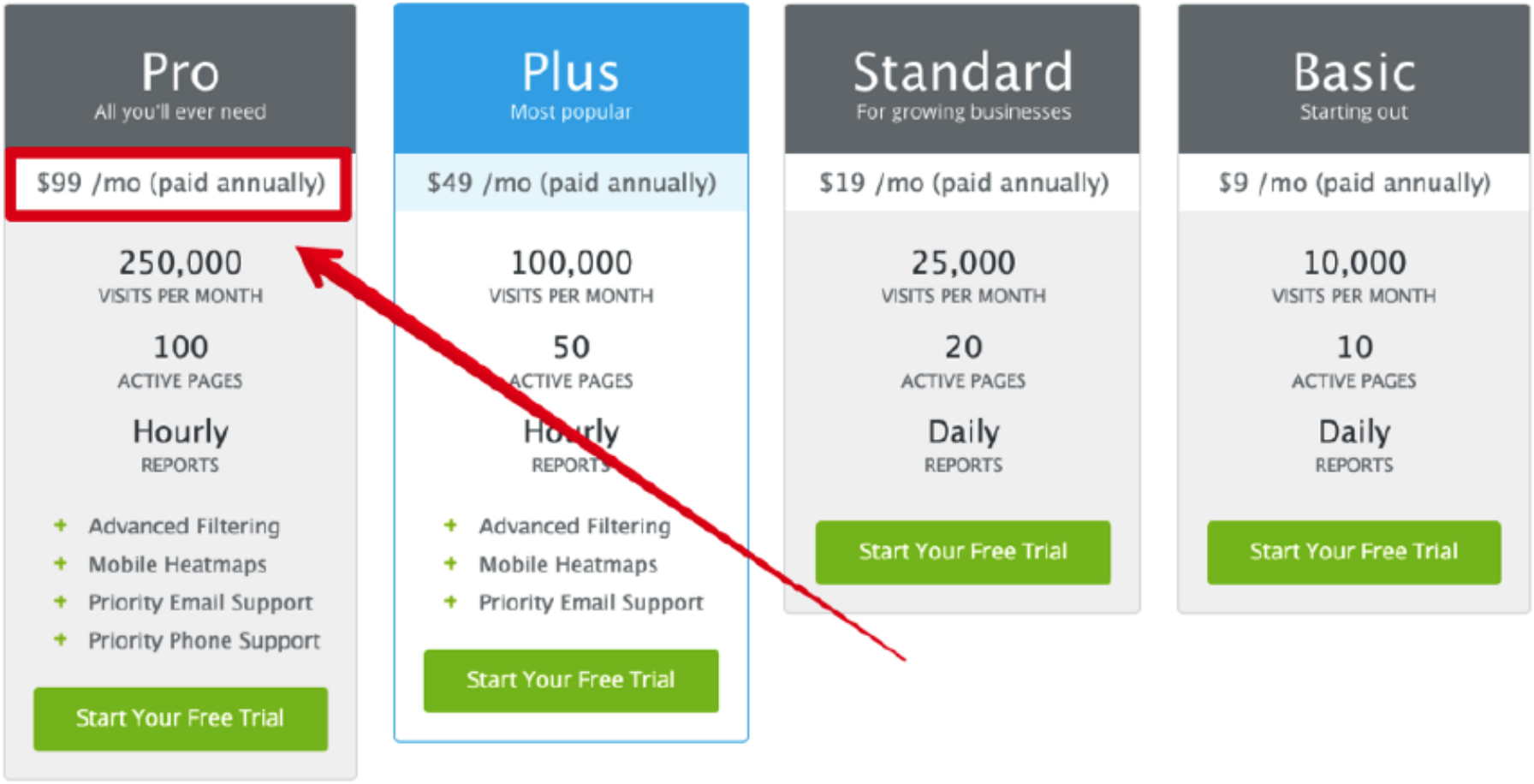
$$2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$$

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2$$

Subjects gave a median estimate of 512 in the first case, while the second case had a median of 2 250. The true answer is of course $8! = 40\,320$.

This is an example of *anchoring*, i.e. estimates may depend too much on an initial number.

Case Study 5


Pro
All you'll ever need
$99 /mo (paid annually)
250,000
VISITS PER MONTH
100
ACTIVE PAGES
Hourly
REPORTS
+ Advanced Filtering
+ Mobile Heatmaps
+ Priority Email Support
+ Priority Phone Support
Start Your Free Trial
Plus
Most popular
$49 /mo (paid annually)
100,000
VISITS PER MONTH
50
ACTIVE PAGES
REPORTS
+ Advanced Filtering
+ Mobile Heatmaps
+ Priority Email Support
Start Your Free Trial
Standard
For growing businesses
$19 /mo (paid annually)
25,000
VISITS PER MONTH
20
ACTIVE PAGES
Daily
REPORTS
Start Your Free Trial
Basic
Starting out
$9 /mo (paid annually)
10,000
VISITS PER MONTH
10
ACTIVE PAGES
Daily
REPORTS
Start Your Free Trial

Case Study 6

- Of the women complaining of painful hardening of the breast, 1% have a malignant tumor: $\Pr(C) = 0.01$.

- The accuracy ($+$ or $-$) of a mammography is 90%: $\Pr(+|C) = \Pr(-|C') = 0.9$.

- Estimate $\Pr(C|+)$ to decide whether or not to order a biopsy.

Case Study 6

Most physicians estimate $\Pr(C|+) \approx 0.75$, while the correct answer is:

Representativeness leads people to neglect the base rate, by assessing a conditional probability by the 'degree of similarity' ($\Pr(A|B) \neq \Pr(B|A)$). This is known as the *base rate fallacy*.

Bias in Forensic Science

What about probabilistic genotyping software?

- Interpretation software can reduce variation in interpretation among examiners.
- It does *not* make interpretation bias free;
- Subjectivity is also involved in software development (and underlying modeling).
- Different software can show LRs varying over 10 logs for the same DNA profiles.

Probabilistic Genotyping

What about the consistency between software programs when they examine the same evidence?

Method	Sample A	Sample B	Sample C
LRmix Studio	1.29	1.85×10^{14}	0.0212
Lab Retriever	1.20	1.89×10^{14}	0.0241
DNA·VIEW	1.09×10^{-14}	4.66×10^{11}	2.24×10^{8}
Combined	Inconclusive	Support to H_p	Inconclusive

Another example can be found in the *People v. Hillary* (NY) case: TrueAllele reported no statistical support for a match ($LR < 0$), whereas STRmix inculpated the defendant with a likelihood ratio of 360 000. The evidence consisted of an LTDNA sample with an extreme mixture ratio.

Source: An alternative application of the consensus method to DNA typing interpretation for Low Template-DNA mixtures (Garofano et al., 2015).

Fallacies

Biases can lead to potential fallacies in the courtroom, and may even lead to a miscarriage of justice[1].

- Prosecutor's fallacy
- Defendant's fallacy
- Uniqueness fallacy
- Association fallacy

[1] See also Misleading DNA Evidence (Gill, 2014).

State v. Phillips

From the South Carolina Supreme Court report (June, 2020):

The court then asked her, "Well, are you saying that Billy Phillips' DNA is on the weapon," to which she responded, "It is."

'Cannot be excluded' means the same thing as can be included."

person does not touch an item he will be excluded. She stated, for example, "If you don't touch it, you are automatically excluded. One hundred percent excluded." She

> By not conducting a *Daubert/Council* hearing, the trial court left itself without a meaningful opportunity to exercise its discretion. The State failed to establish the "assist the trier of fact" element, and the probative value of the DNA evidence is substantially outweighed by danger the evidence would confuse the issues and mislead the jury. We reverse Phillips' convictions and remand for a new trial.

Miscarriage of Justice - Example

Adam Scott was arrested, accused of rape and incarcerated on the basis of a DNA profile match, which was eventually traced back to a contamination incident.

> *"It is estimated that the chance of obtaining matching DNA components if the DNA came from someone else unrelated to Adam Scott is approximately one in 1 billion. In my opinion the DNA matching that of Adam Scott has most likely originated from semen. [. . .] In my opinion these findings are what I would expect if Adam Scott had some form of sexual activity with [the victim]. In order to assess the overall findings in this case I have therefore considered the following propositions:*
>
> - *Adam Scott had vaginal intercourse with [the victim]*
> - *Adam Scott has never been to Manchester and does not know [the victim]"*

Source: Misleading DNA Evidence (Gill, 2014).

Miscarriage of Justice - Example

- The perpetrator DNA was absent (hidden perpetrator effect and false inclusion error).
- The DNA match was falsely associated with the presence of sperm (association fallacy).
- The 'presence' of sperm was associated with sexual intercourse (association fallacy).
- Exculpatory evidence was ignored (base rate fallacy and confirmation bias).

Different biases/effects resulted in a *compounded error* or *snowball effect*.