

Forensic match information: exact calculation and applications

10th International Conference on
Forensic Inference and Statistics
September, 2017
Minneapolis, Minnesota

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Genotype LR & RMP



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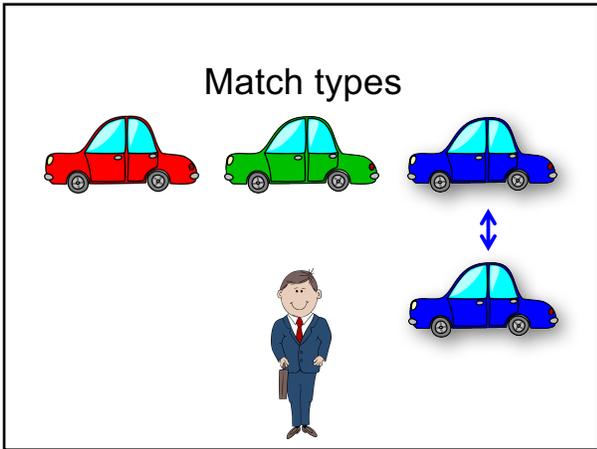
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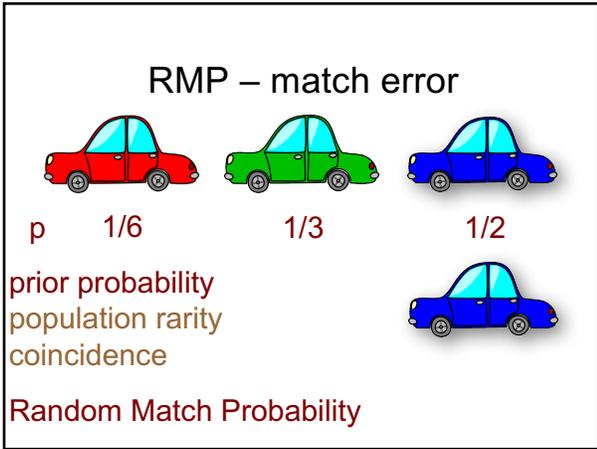
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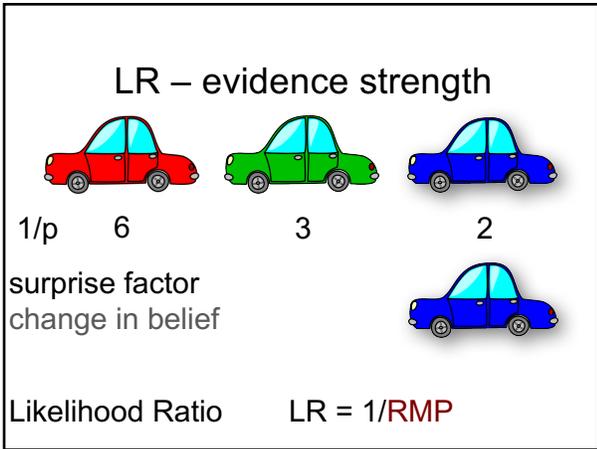
Genotype likelihood ratio distributions
and random match probability:
Generalization, calculation and application

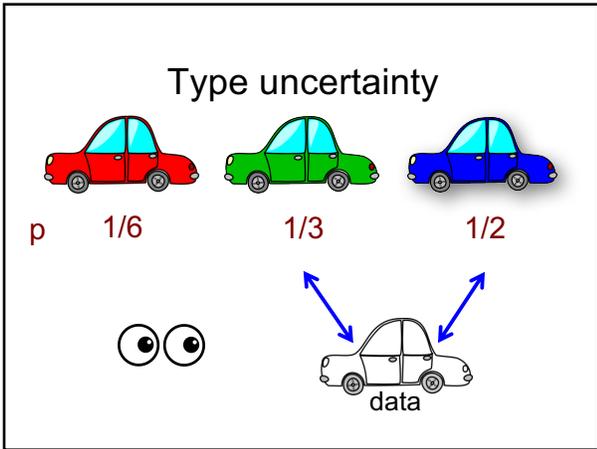
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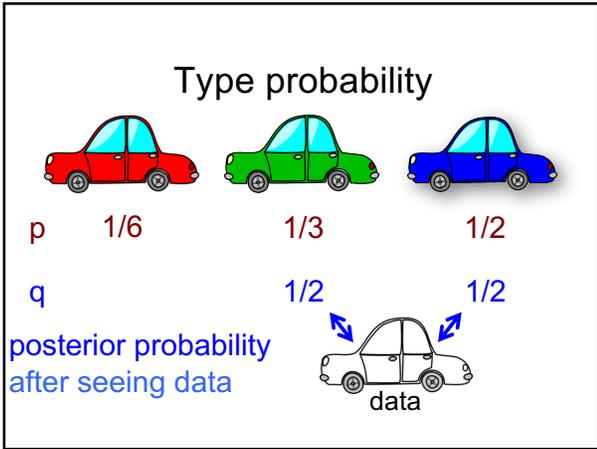


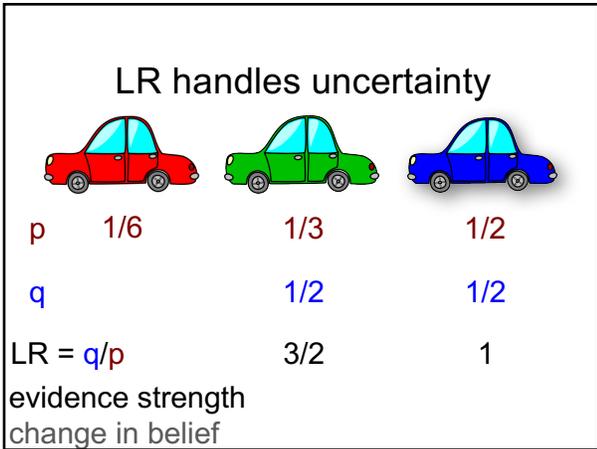


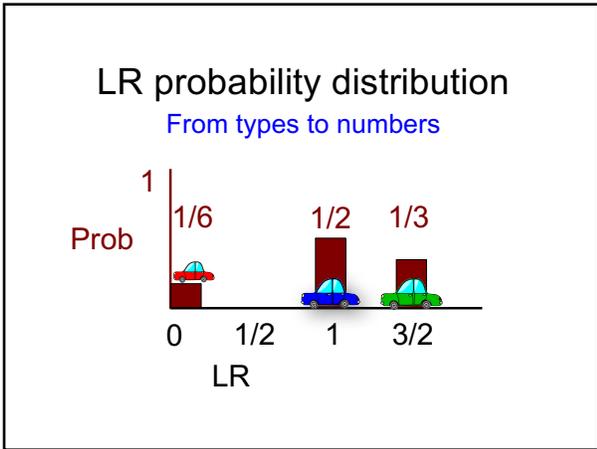


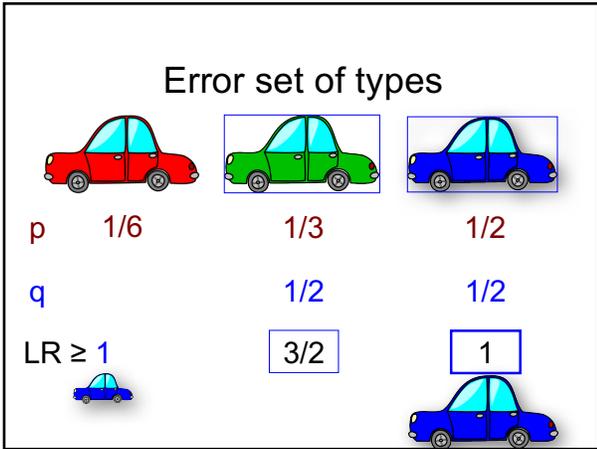


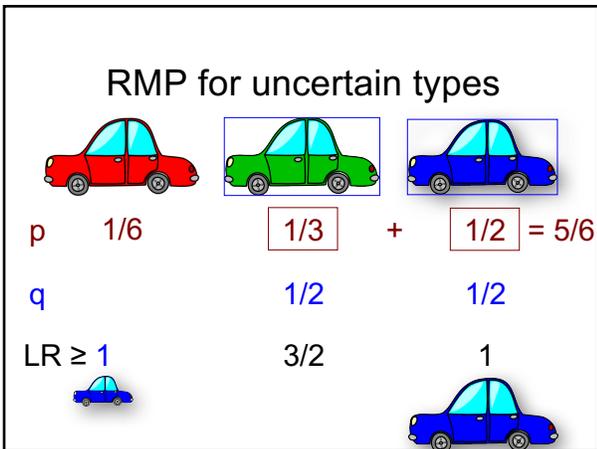


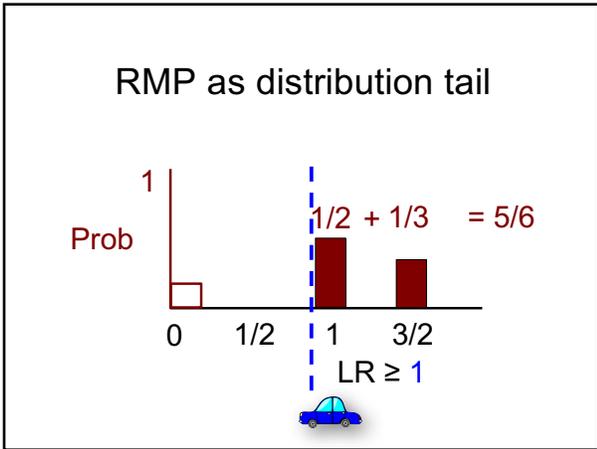




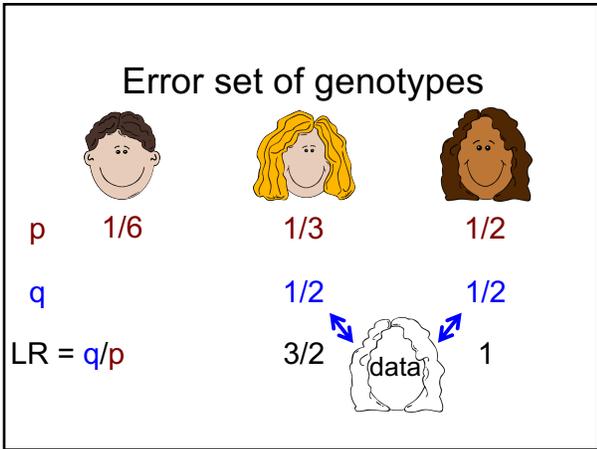


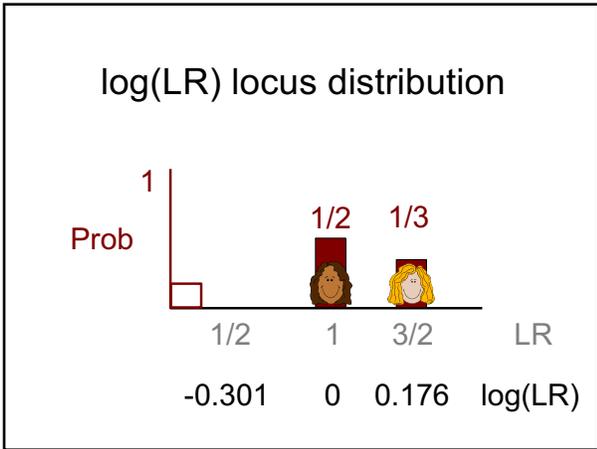






- ### General RMP properties
- DNA mixture analysis
LR error = RMP
- Thorough (Bayesian) probabilistic inference
 - Separated (unmixed) contributor genotypes
 - Rapid calculation from prior and posterior
 - Extreme set contains the matching genotype
 - In set: LR of evidence \geq matching genotype
 - Smallest RMP sum containing matching genotype
 - Singleton set reduces to ordinary RMP
 - Chance of false positive for innocent person



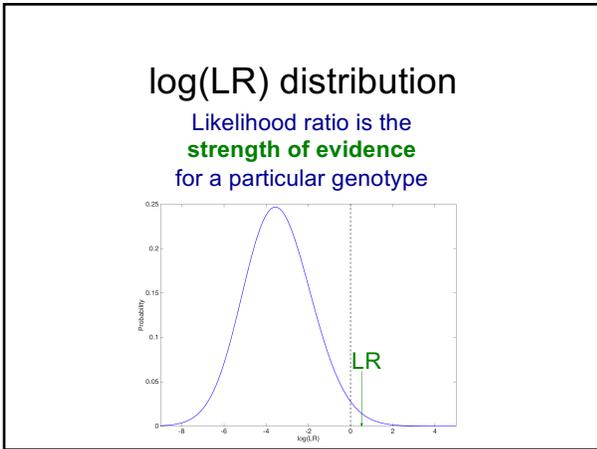


Combine independent tests

$\log(LR) = \log(LR_1 \times \dots \times LR_L)$
 $= \log(LR_1) + \dots + \log(LR_L)$

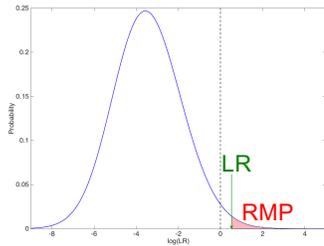
Distribution of independent **sums**
is the **convolution** of their distributions

Fast calculation



RMP

Random match probability is the **chance of error** – same DNA evidence against innocent people





Case example

A homeless man took a woman into an alleyway and sexually assaulted her. He stole her phone so she couldn't call for help.

He threatened her, saying, "Don't tell anyone about this or I will kill you" and "You are never going to see your mother again."

Fearing for her life, she followed him across a bridge and into a downtown Pittsburgh park. He sexually assaulted her again, but she screamed and ran toward a hotel.

Hotel workers came to her aid, and chased after him. Police officers caught him a few blocks away.



Crime lab DNA analysis

The Allegheny County Medical Examiner's Office developed informative DNA data from the evidence.

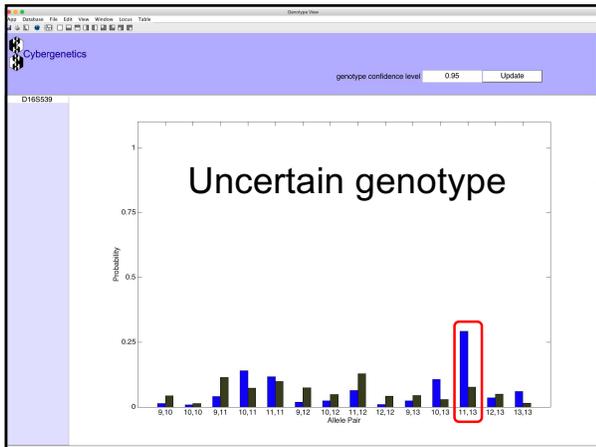
Using limited DNA mixture interpretation methods, the lab said that **no conclusion can be made** due to **insufficient data on some items**, and the **complexity of the data on others**.

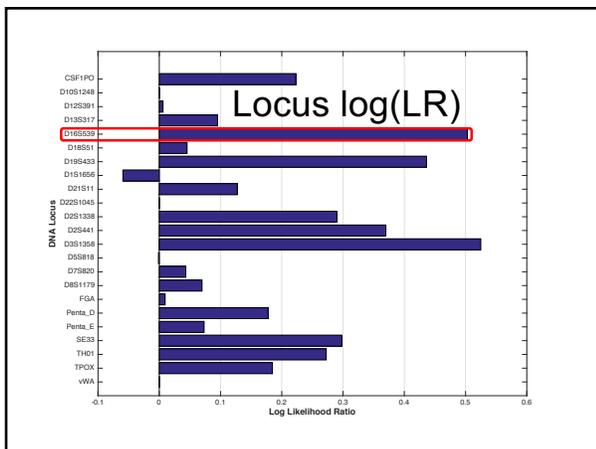
They did not report DNA match statistics.

TrueAllele[®] interpretation

Description	log(LR)	
	Victim	Suspect
non-sperm rectal swabs	16.06	25.81
sperm rectal swabs		3.69
right hand fingernails	30.72	21.31
left hand fingernails	29.97	16.30

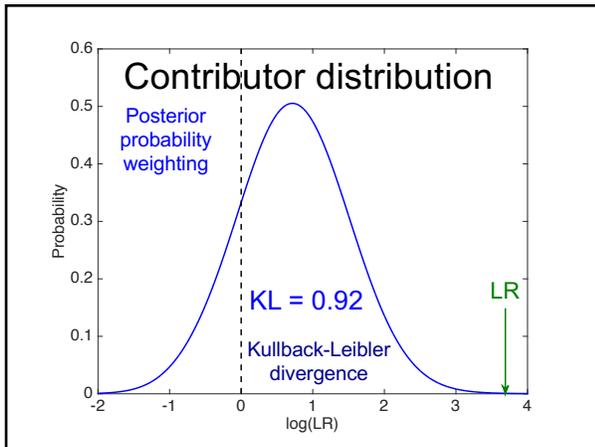
LR values range from thousands to nonillions

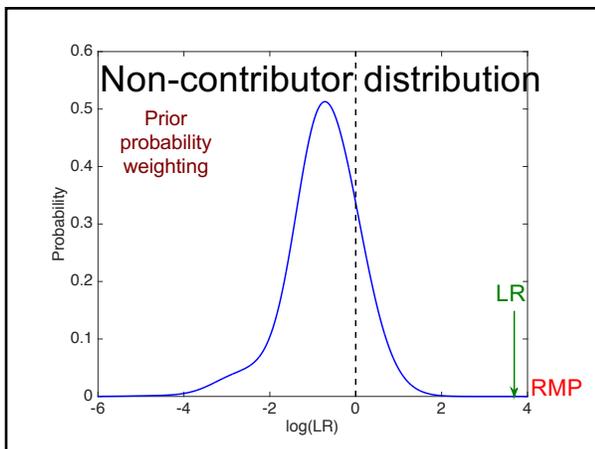




Evidence statement (LR)

A **match** between the rectal swabs
and the defendant
is **4.89 thousand** times more probable than
a **coincidental** match
to an unrelated (ethnic group) person





Error statement (RMP)

Question

What is the chance that someone who didn't contribute their DNA to the rectal swabs has an LR of at least 4.89 thousand?

Answer

One in 28.7 million for an (ethnic group) person.

Related RMP methods

- approximate the LR distribution
- Monte Carlo simulation for LR tail
- branch and bound for small sets
- divide and conquer for larger sets
- don't report any error measure
- give generic $RMP \leq 1/LR$ bound

RMP much less than 1/LR

$$\begin{aligned} rmp &= csum/alr \\ &= (1/lr)*(lr/alr)*csum \\ &= (1/4893)*(1/2.400)*(1/2448) \\ &= (1/4893)*(1/5873) \\ &= 1/28736000 \end{aligned}$$

alr average LR on NCD tail
csum sum over right CD tail
lr likelihood ratio
rmp random match probability

Statistics & Law

- RMP as probability of observing misleading statistical evidence
- Evidence & uncertainty are different
- LR for evidence, RMP for uncertainty

- Initial **presumption of innocence** (null hypothesis), defendant not contributor
- More evidence increases LR
- RMP as "p-value" for false positives
- Reduce error **beyond reasonable doubt**

Conclusions

- **LR** summarizes **DNA evidence**
 - **RMP** gives the **error** probability
- RMP x population size =
number of innocent people with DNA
evidence as strong as for defendant
- LR (evidence) & RMP (error)
both help the trier of fact
understand DNA evidence

DNA identification science

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