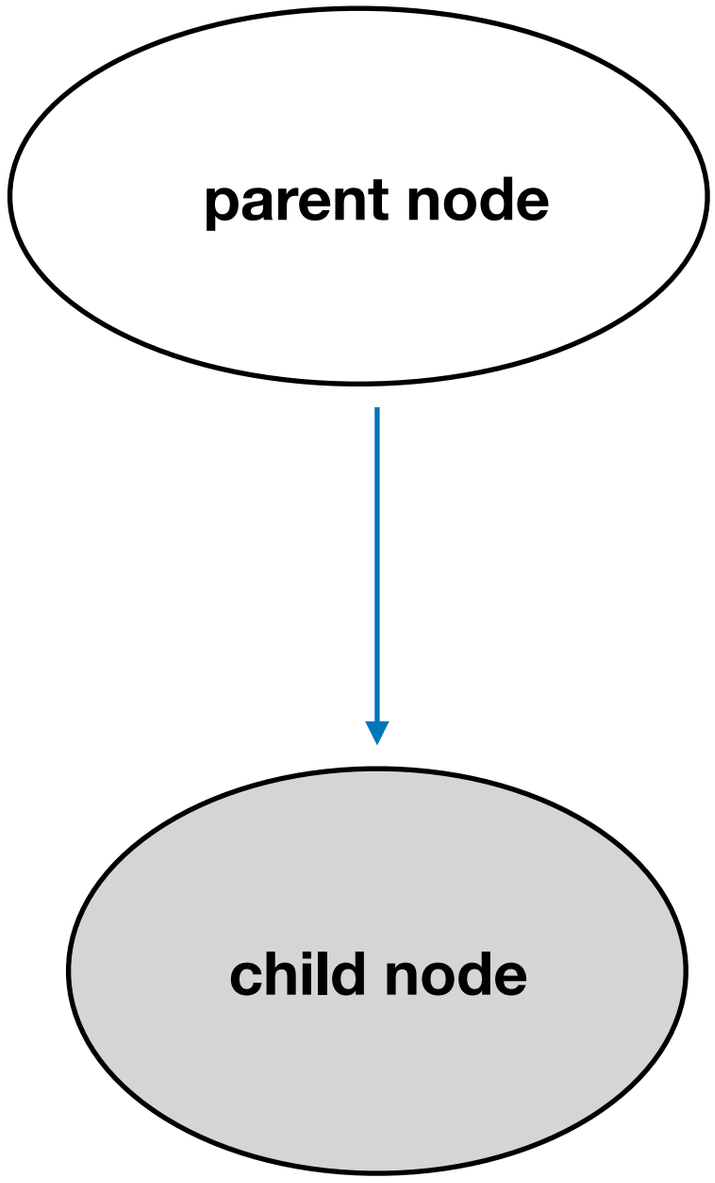
Evaluating Bayesian Networks

using agent-based modelling


parent node
child node

I’m nervous for a presentation

I watch too much Youtube beforehand

I'm nervous for a presentation

	nervous	not nervous
	0.9	0.1

I watch too much Youtube beforehand

nervous	too much Youtube	not (too much youtube)
TRUE	0.75	0.25
FALSE	0.2	0.8

I'm nervous for a presentation

Bayes Law

I watch too much Youtube beforehand

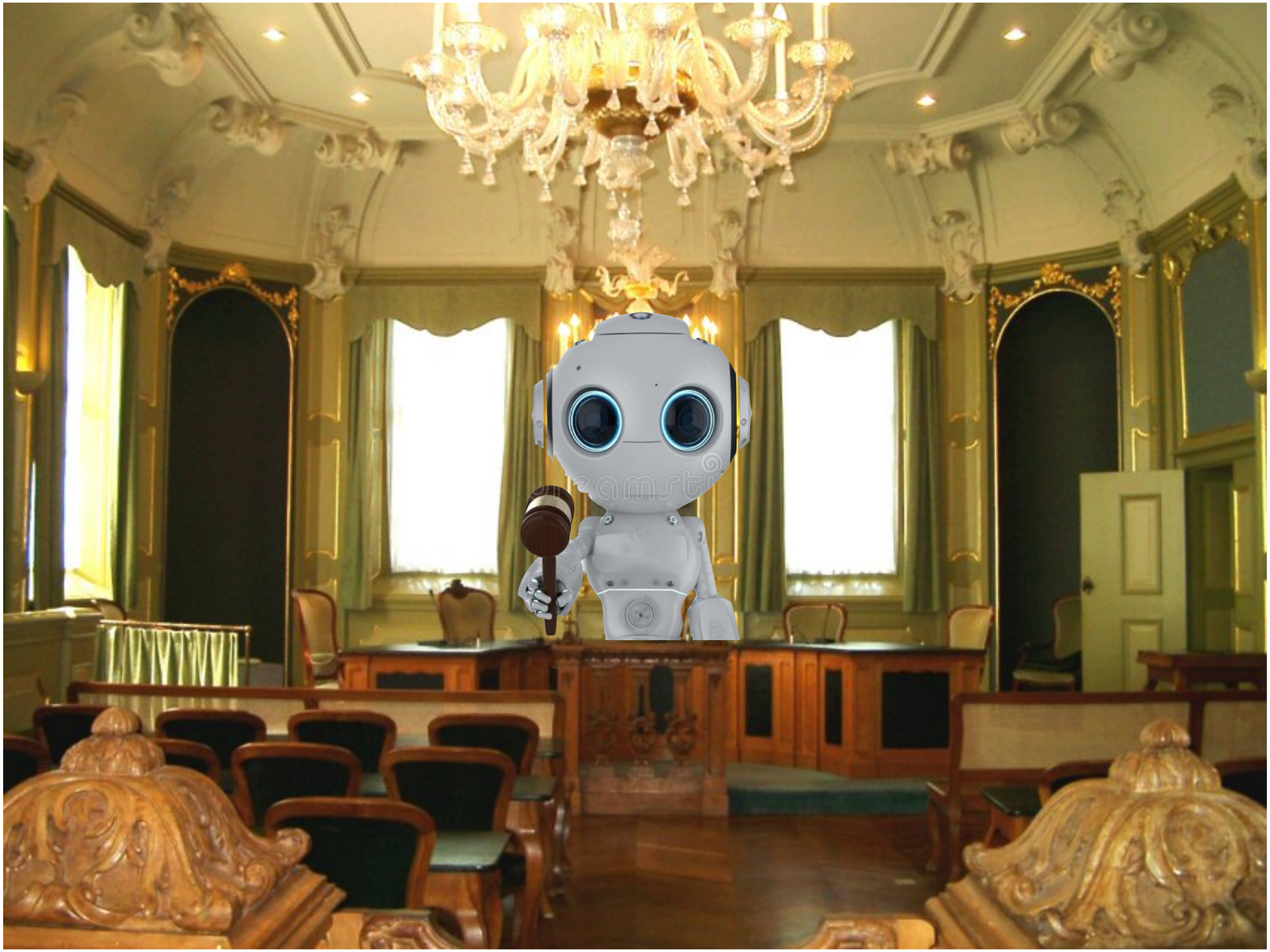
I'm nervous for a presentation

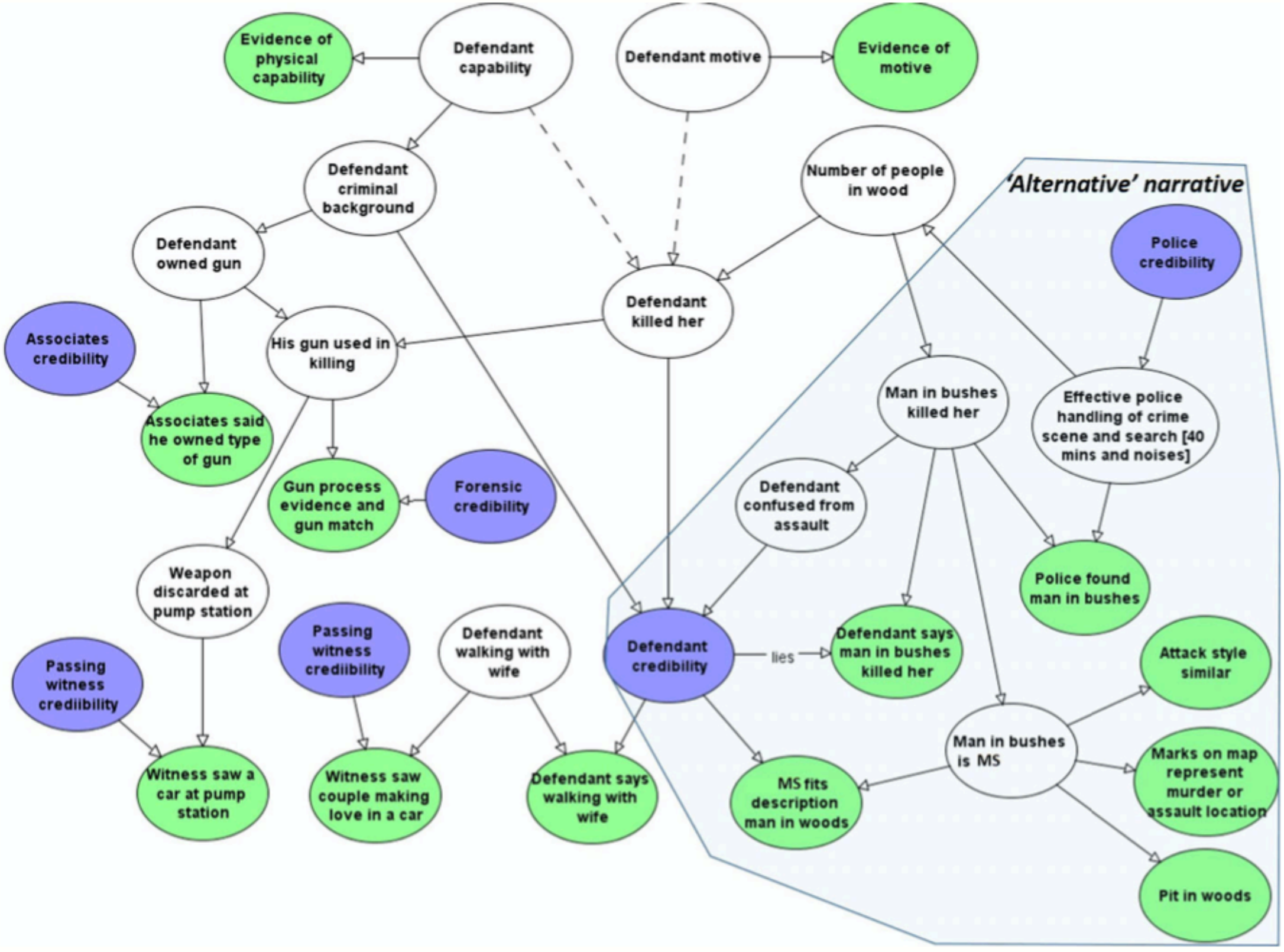
Bayes Law

I watch too much Youtube beforehand

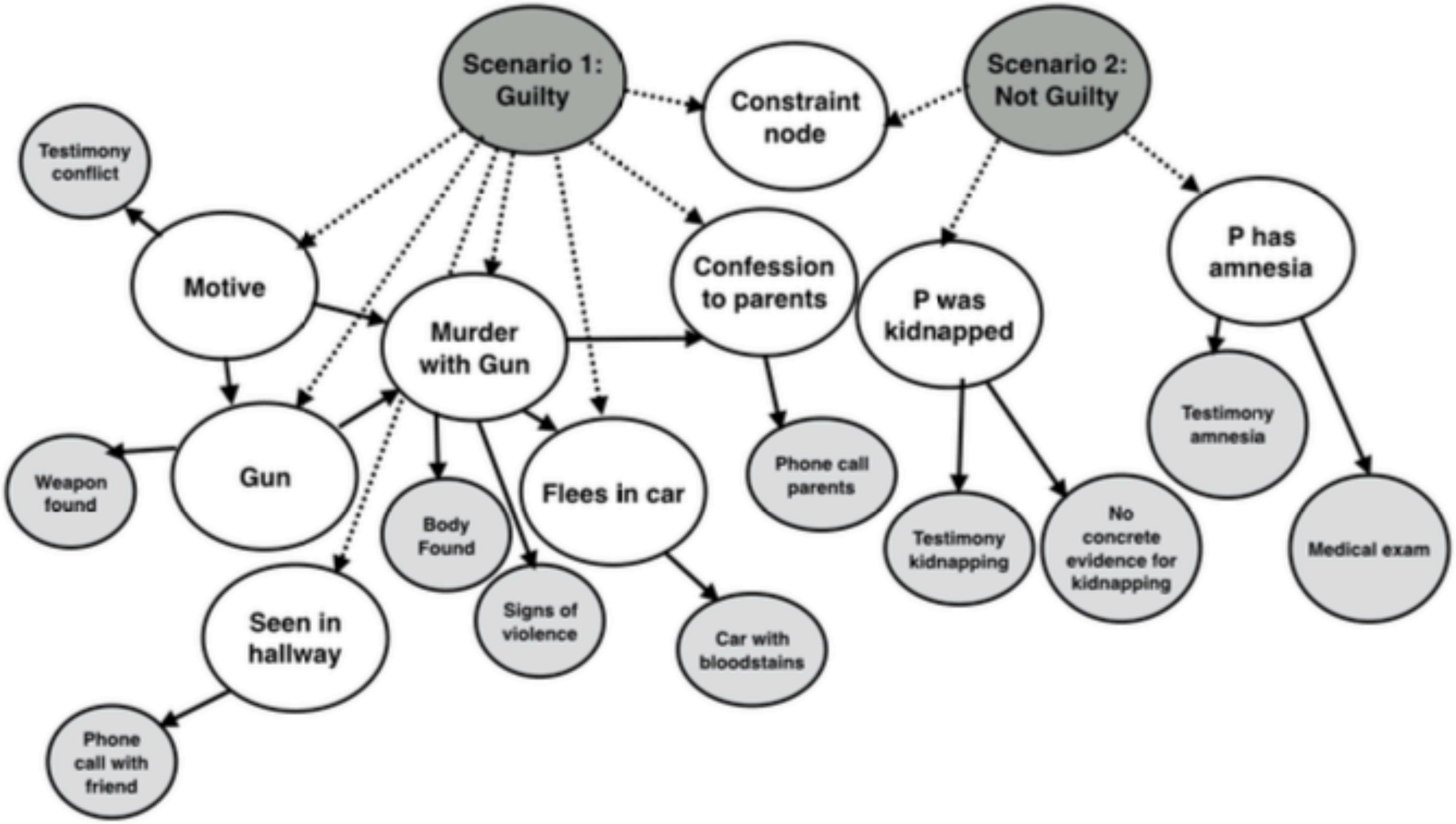
Updated on evidence:

	nervous	not nervous
	0.97	0.03




Evidence of physical capability
Defendant capability
Defendant motive
Evidence of motive
Defendant criminal background
Number of people in wood
'Alternative' narrative
Police credibility
Defendant owned gun
Defendant killed her
Associates credibility
His gun used in killing
Man in bushes killed her
Effective police handling of crime scene and search [40 mins and noises]
Associates said he owned type of gun
Gun process evidence and gun match
Forensic credibility
Defendant confused from assault
Police found man in bushes
Weapon discarded at pump station
Passing witness crediibility
Passing witness crediibility
Defendant walking with wife
Defendant credibility
lies
Defendant says man in bushes killed her
Attack style similar
Man in bushes is MS
Marks on map represent murder or assault location
Witness saw a car at pump station
Witness saw couple making love in a car
Defendant says walking with wife
MS fits description man in woods
Pit in woods

Fenton, 2020


Scenario 1: Guilty
Constraint node
Scenario 2: Not Guilty
Testimony conflict
Motive
Murder with Gun
Confession to parents
P was kidnapped
P has amnesia
Weapon found
Gun
Body Found
Flees in car
Phone call parents
Testimony amnesia
Testimony kidnapping
No concrete evidence for kidnapping
Medical exam
Seen in hallway
Signs of violence
Car with bloodstains
Phone call with friend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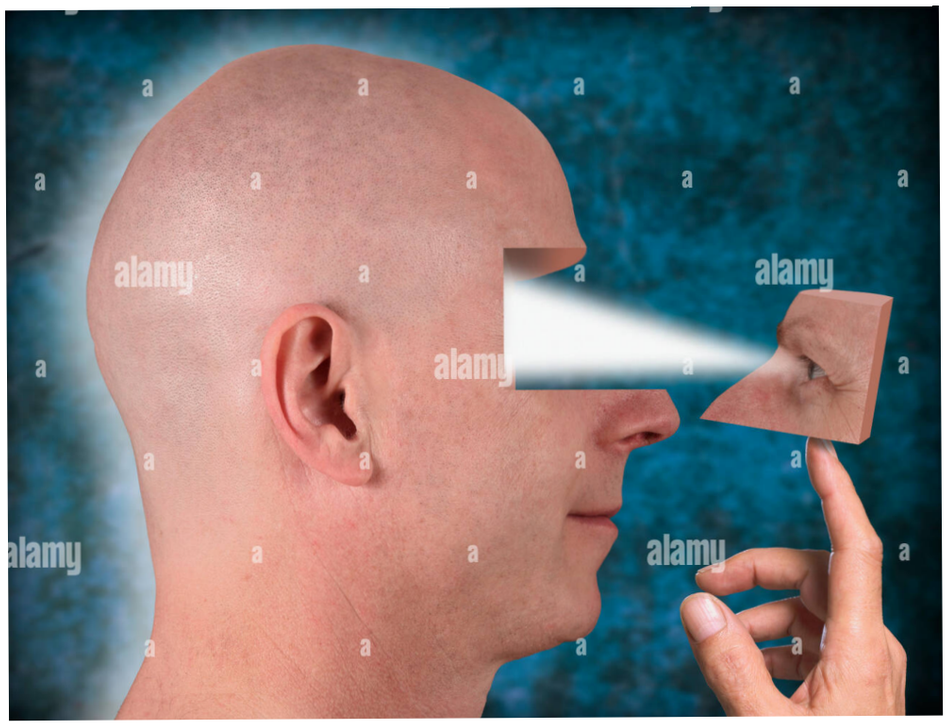
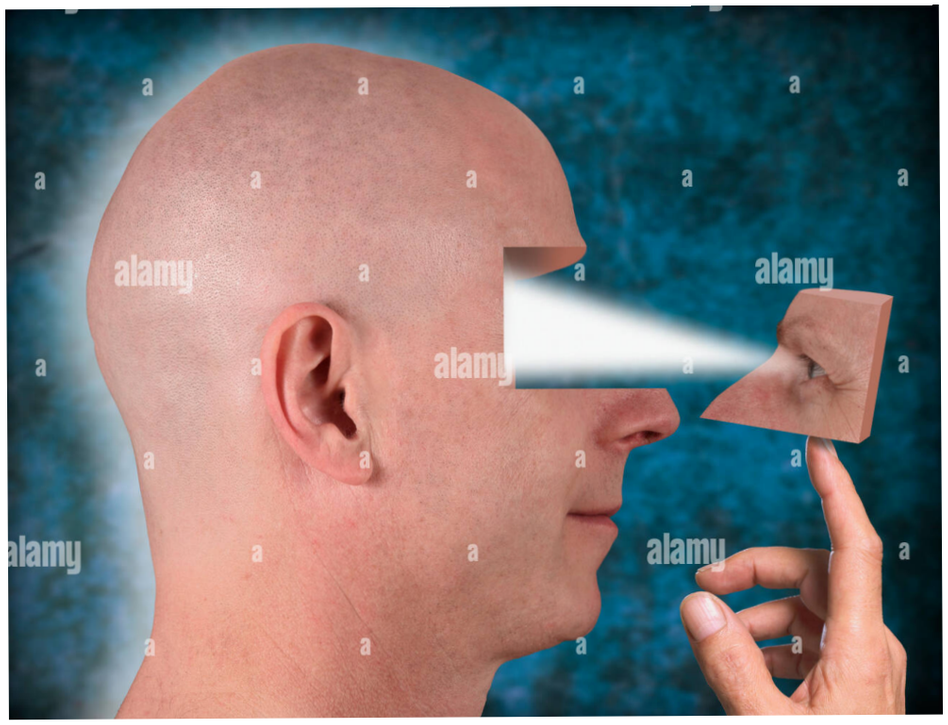
Motive	Gun	not (gun)
TRUE	?	?
FALSE	?	?



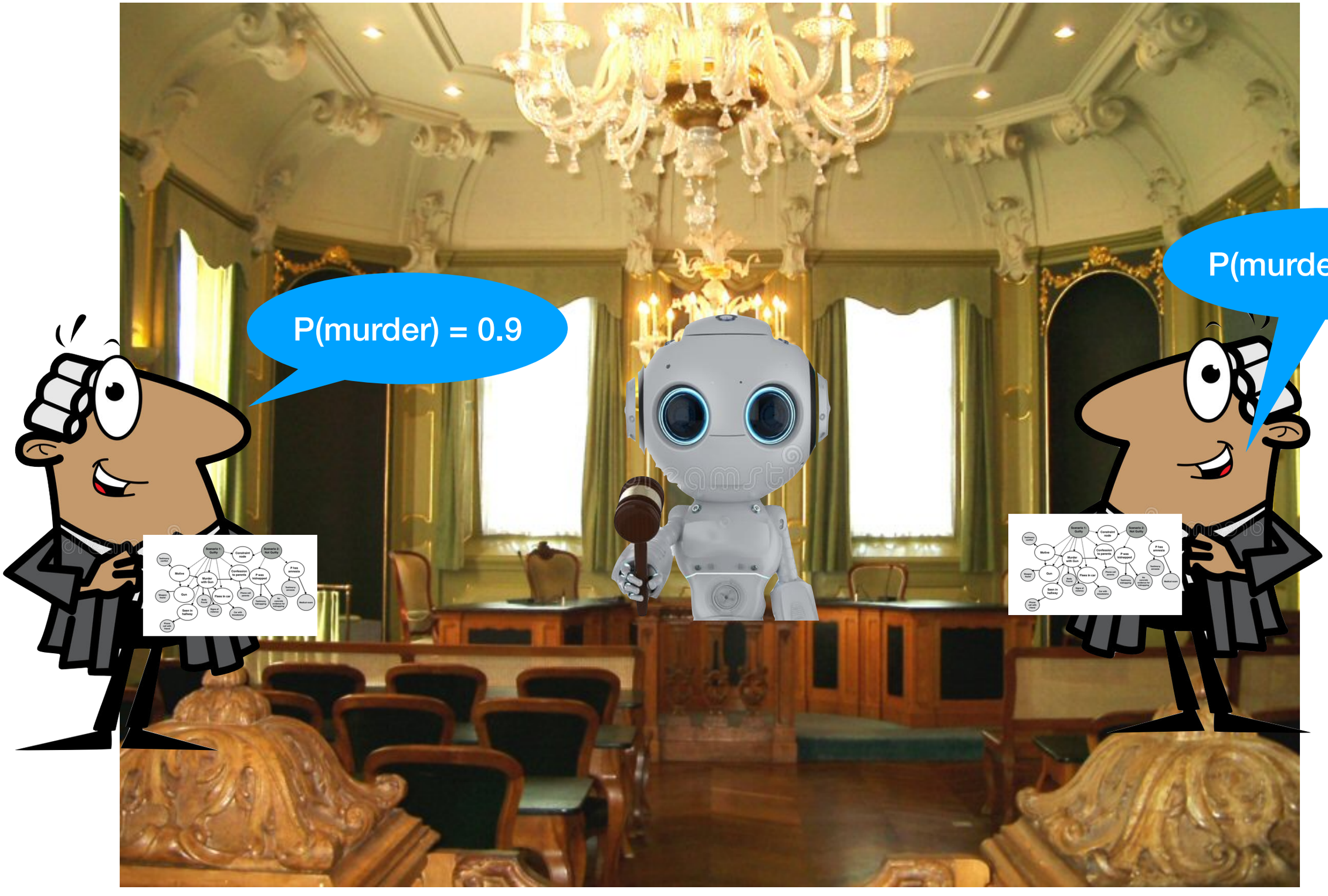
Motive	Gun	not (gun)
TRUE	?	?
FALSE	?	?

introspection, probability elicitation and collaborative discussion, to establish **subjective probabilities**



subjective probability =

just making implicit assumptions explicit


P(murder) = 0.9
P(murder) = 0.1

Is there a way to mitigate the subjective probability?

The existing approaches focus on building the network, but not on evaluating them.

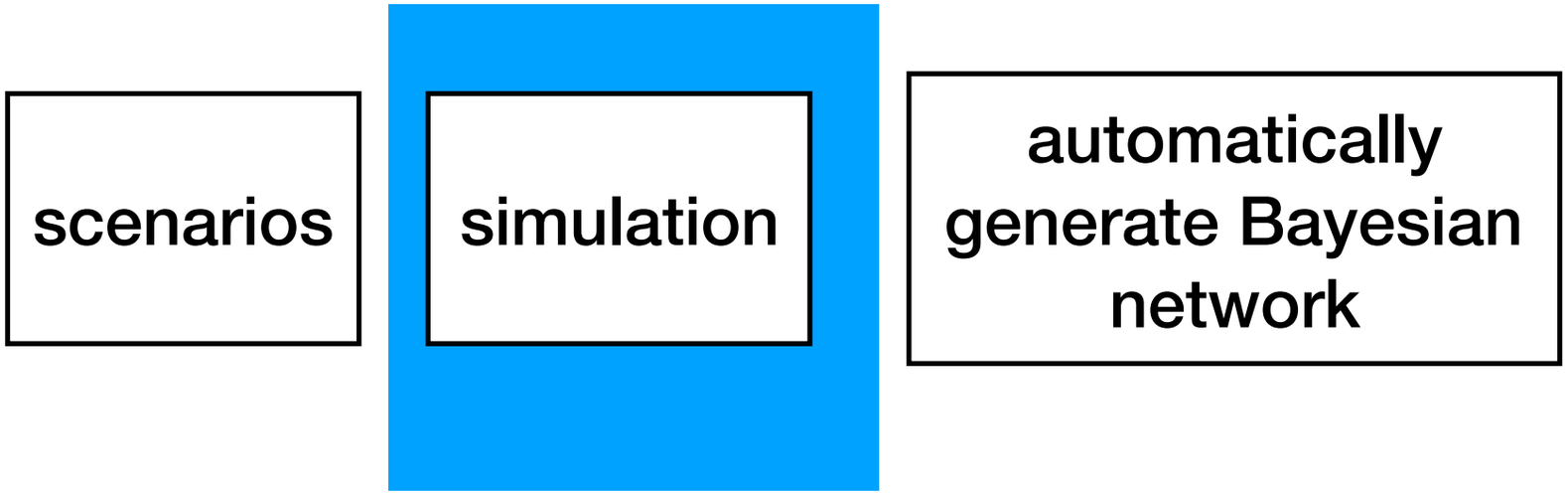
Methods of evaluation that are used:

- **cumulative evidence**
  - Turning one set of nodes off and on

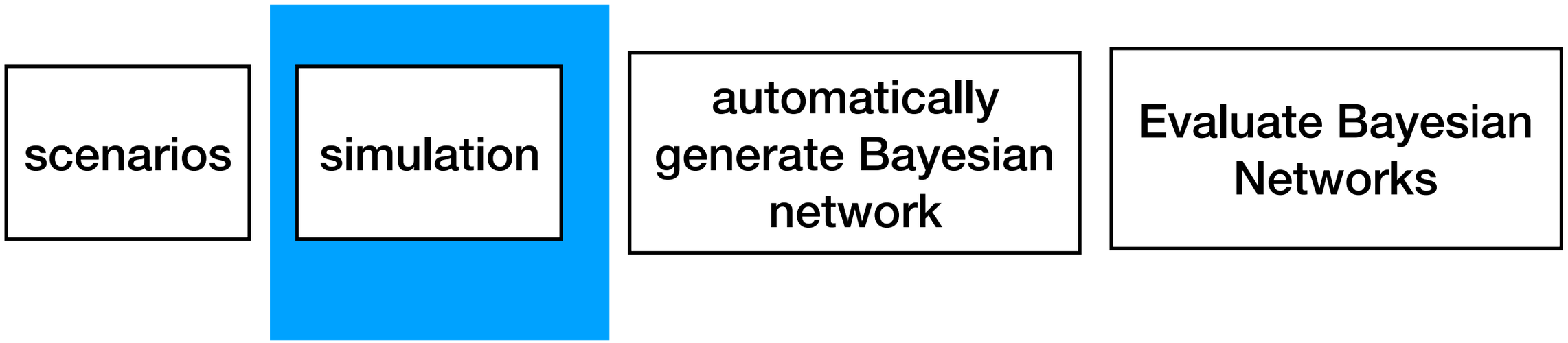
- **sensitivity analysis**
  - Small changes in CPTs to see effects

these methods are not satisfactory

The aim of this project



The aim of this project



RQ: Do Bayesian Networks work as a tool for rationally dealing with evidence?

Do Bayesian Networks work as a tool for rationally dealing with evidence?

Criteria discussed here…

- Can we create a BN that reflects the probabilities of the simulation?

- Does this BN respond ‘rationally’ to all possible combinations of evidence?

- Is it plausible that this method generalises to real life?

Building a Simulation

Scenario: Robbery on Grote Markt

scenario 1

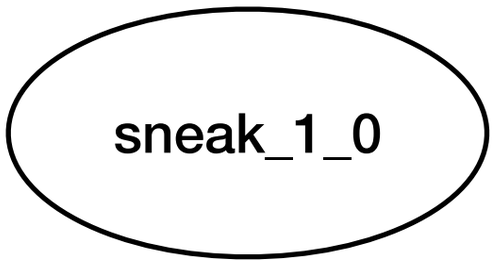
scenario 2

street robbery

accidentally losing

We represent all relevant events in the simulation

In the network, we call the thief 1, and the old lady 0



means: Agent 1 sneaks up on Agent 0

scenario 1

motive_1_0

sneak_1_0

steal_1_0

evidence

psych report 1

camera 1

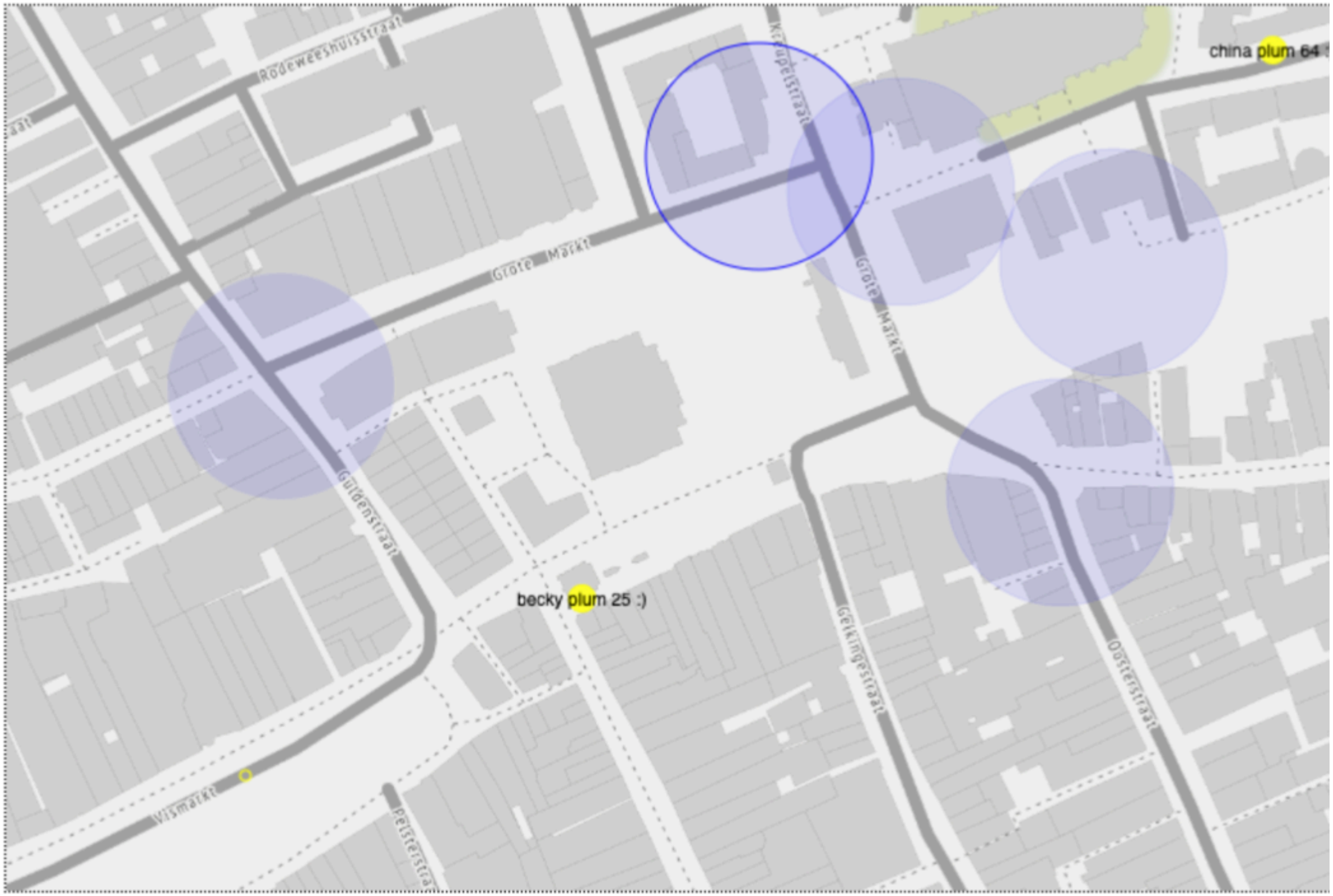
camera seen stealing

object gone

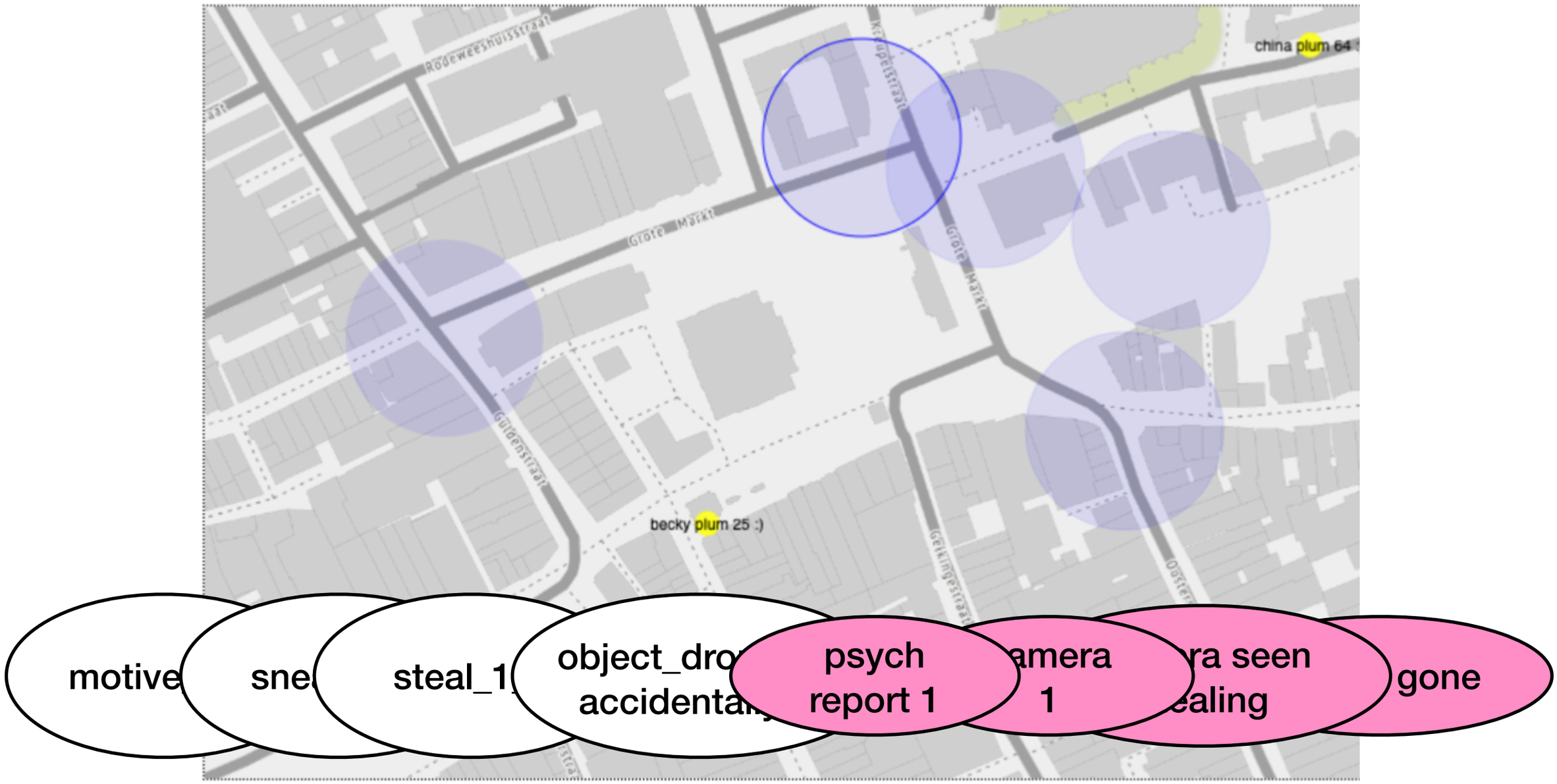
scenario 2

object_dropped_ accidentally_0

Agents


china plum 64
becky plum 25 :)
Rodeweeshuisstraat
Grote Markt
Grote Markt
Guldenstraat
Gelkingestraat
Oosterstraat
Vismarkt

In every run, we collect data through random variables in code



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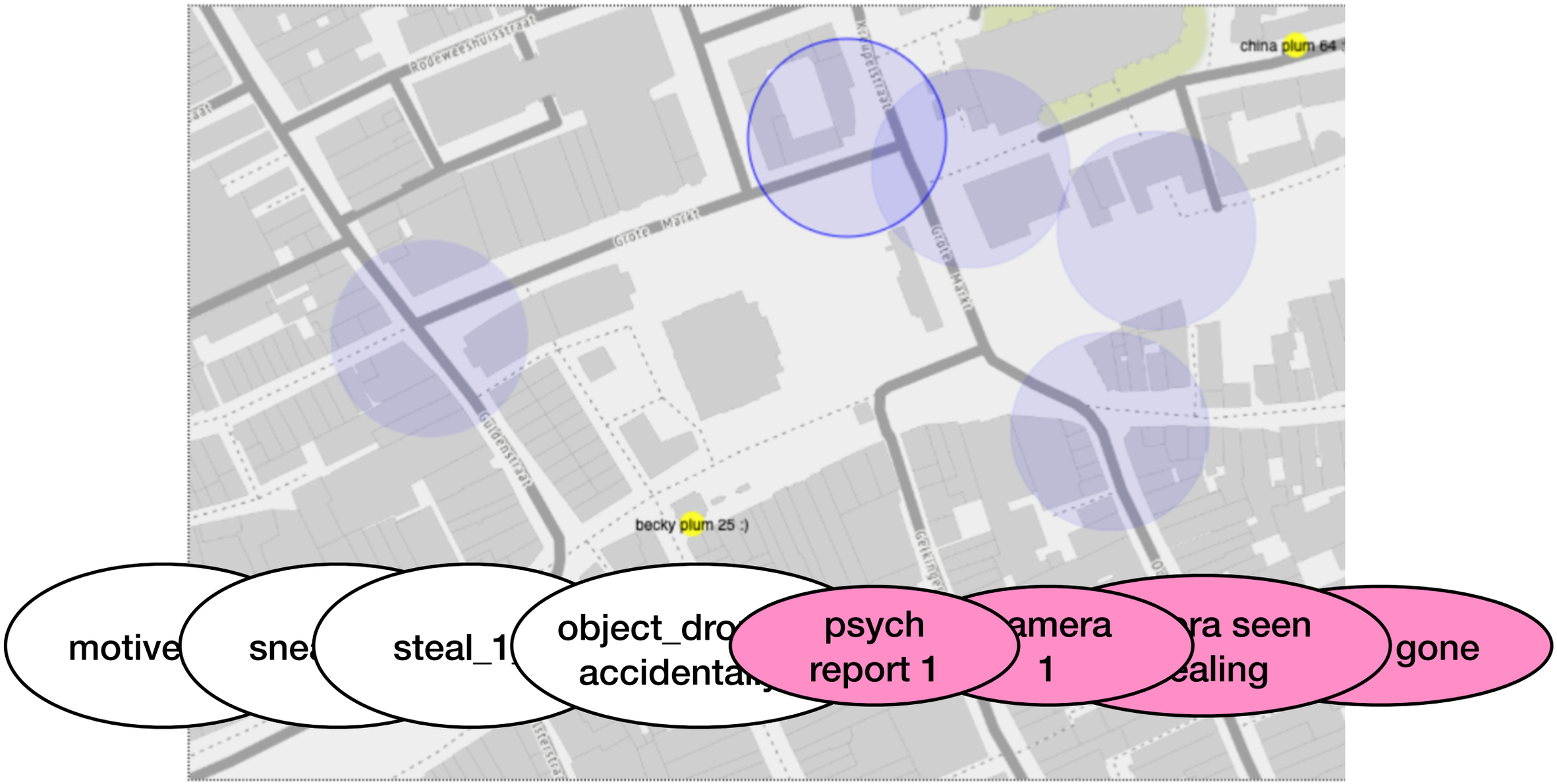
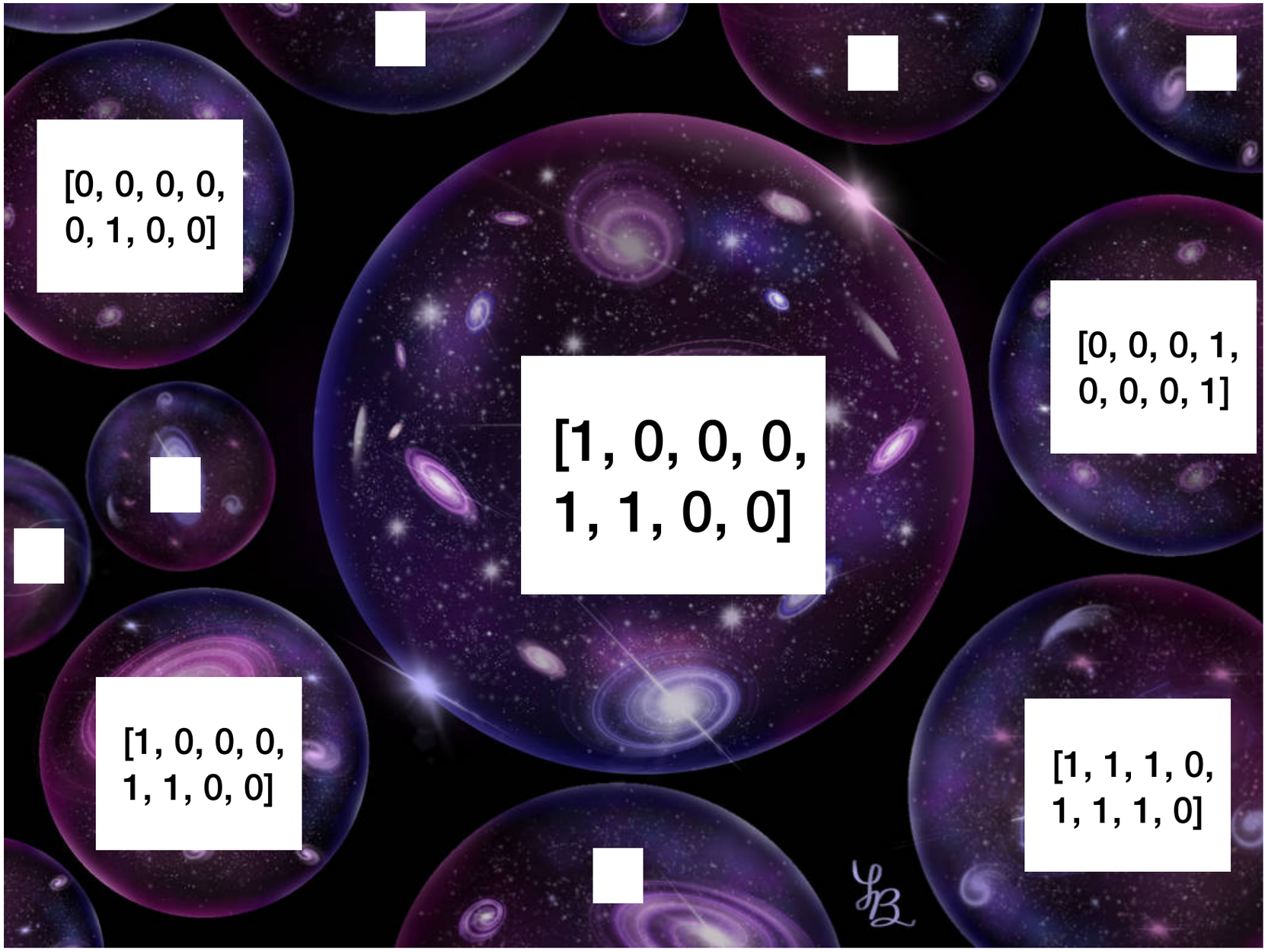
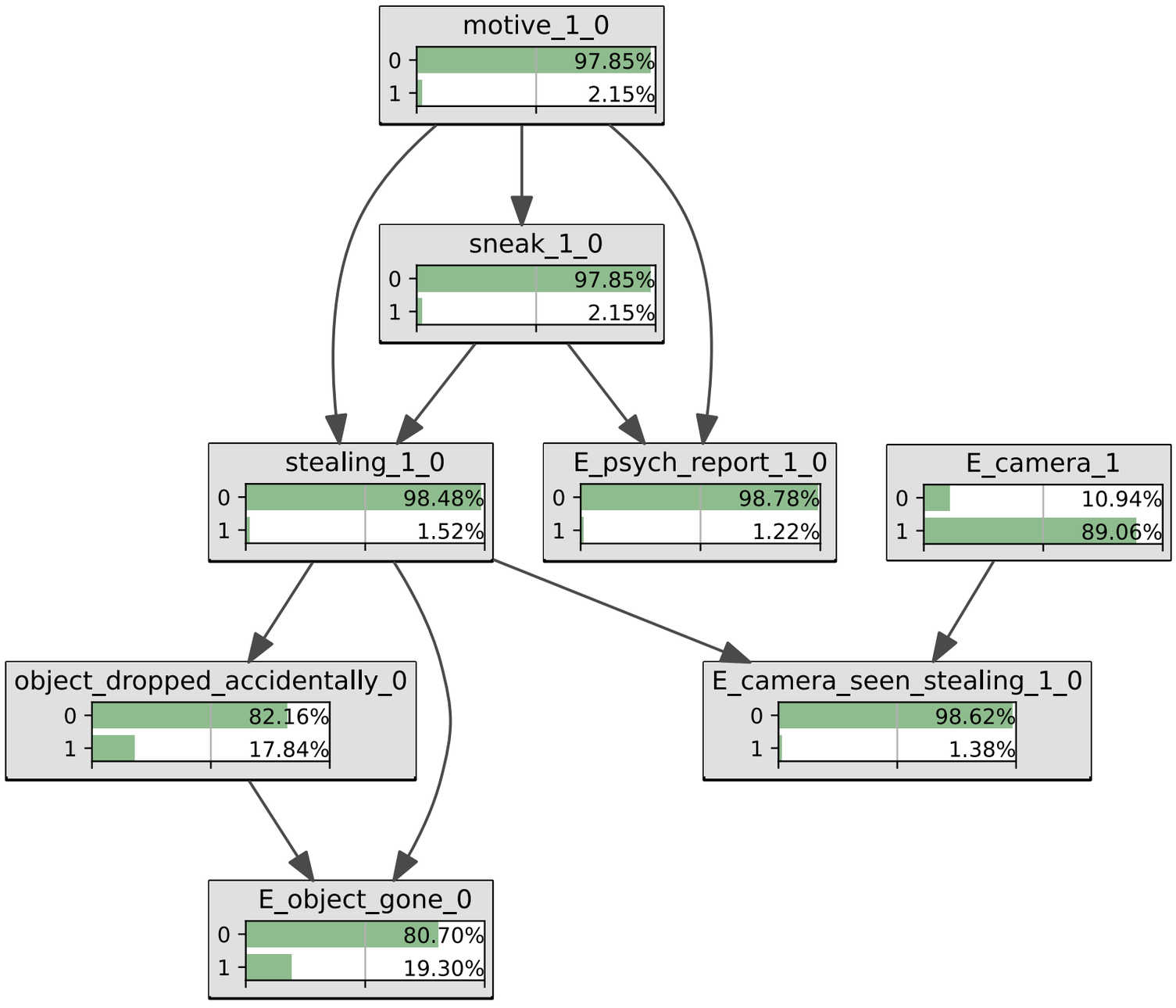


global state : [1, 0, 0, 0, 1, 1, 0, 0]


[0, 0, 0, 0,
0, 1, 0, 0]
[0, 0, 0, 1,
0, 0, 0, 1]
[1, 0, 0, 0,
1, 1, 0, 0]
[1, 0, 0, 0,
1, 1, 0, 0]
[1, 1, 1, 0,
1, 1, 1, 0]

Automatically create a Bayesian network using the K2 algorithm



Inference in 0.75ms

Does the BN reflect the probabilities of the simulation?

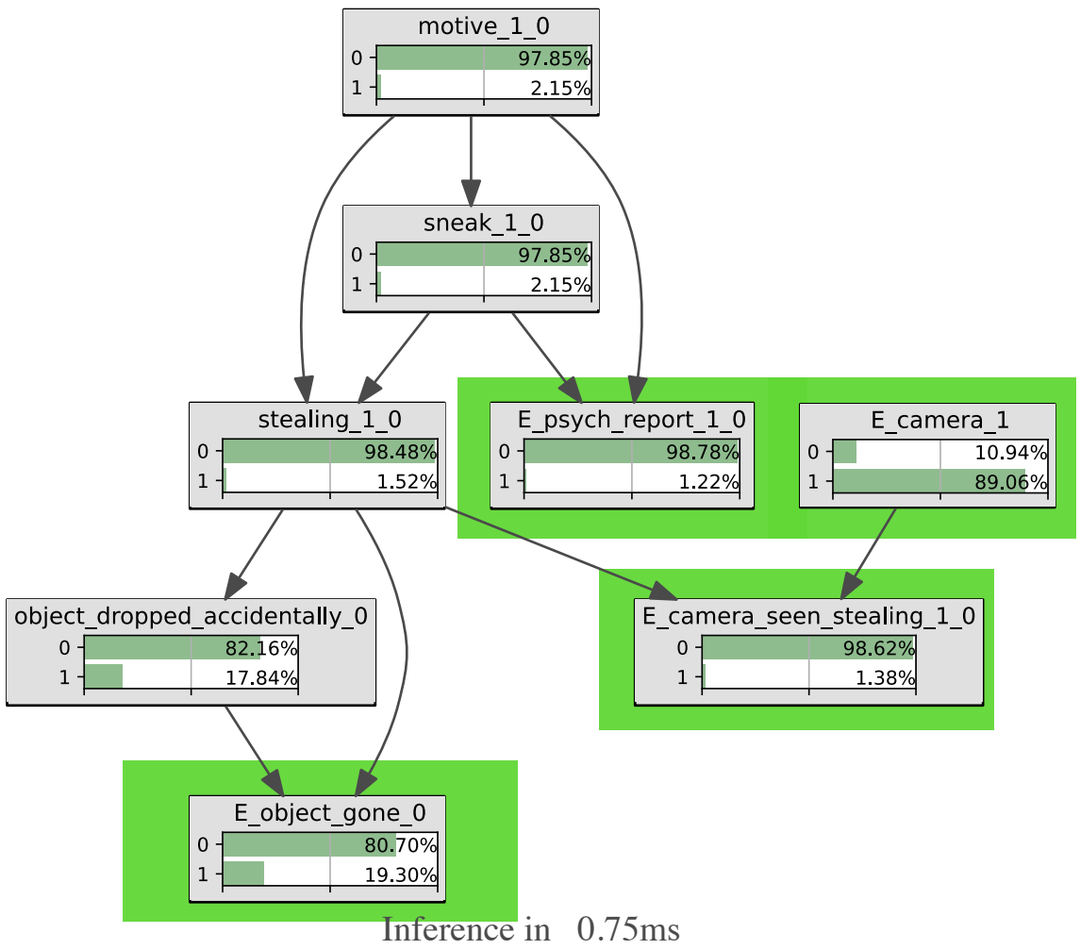
Node name (short)	**Simulation**	**BN**
motive	0.021	0.022
sneak	0.021	0.022
stealing	0.015	0.015
accident	0.178	0.178
psych report	0.012	0.012
camera	0.891	0.891
seen stealing	0.013	0.014
object gone	0.193	0.193

Yes, ±0.001

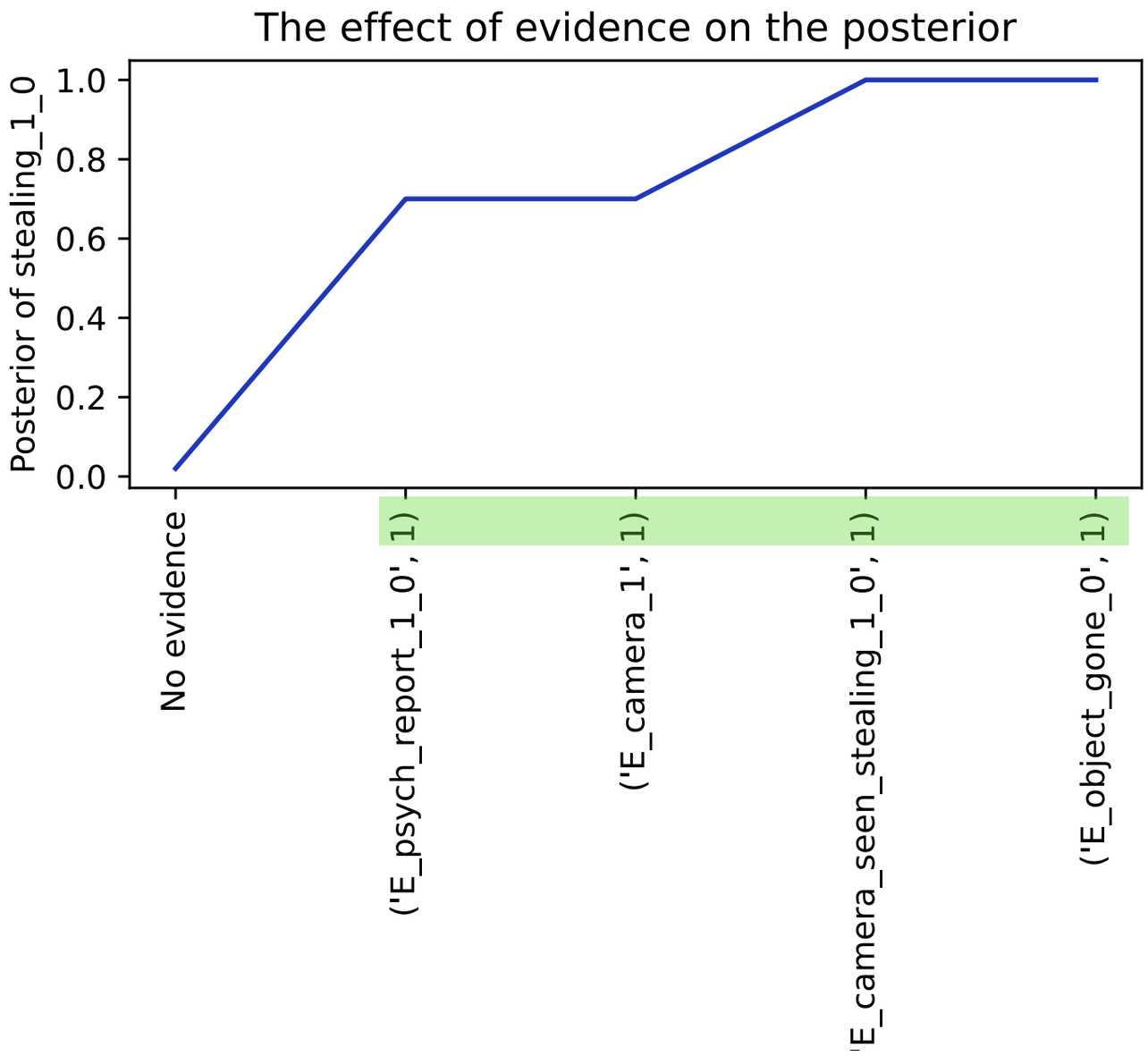
Pragmatically, if we define a guilt threshold as > 0.99,
this is not a precision to worry about

Does this BN respond ‘rationally’ to all possible combinations of evidence?

All evidence supports scenario 1:

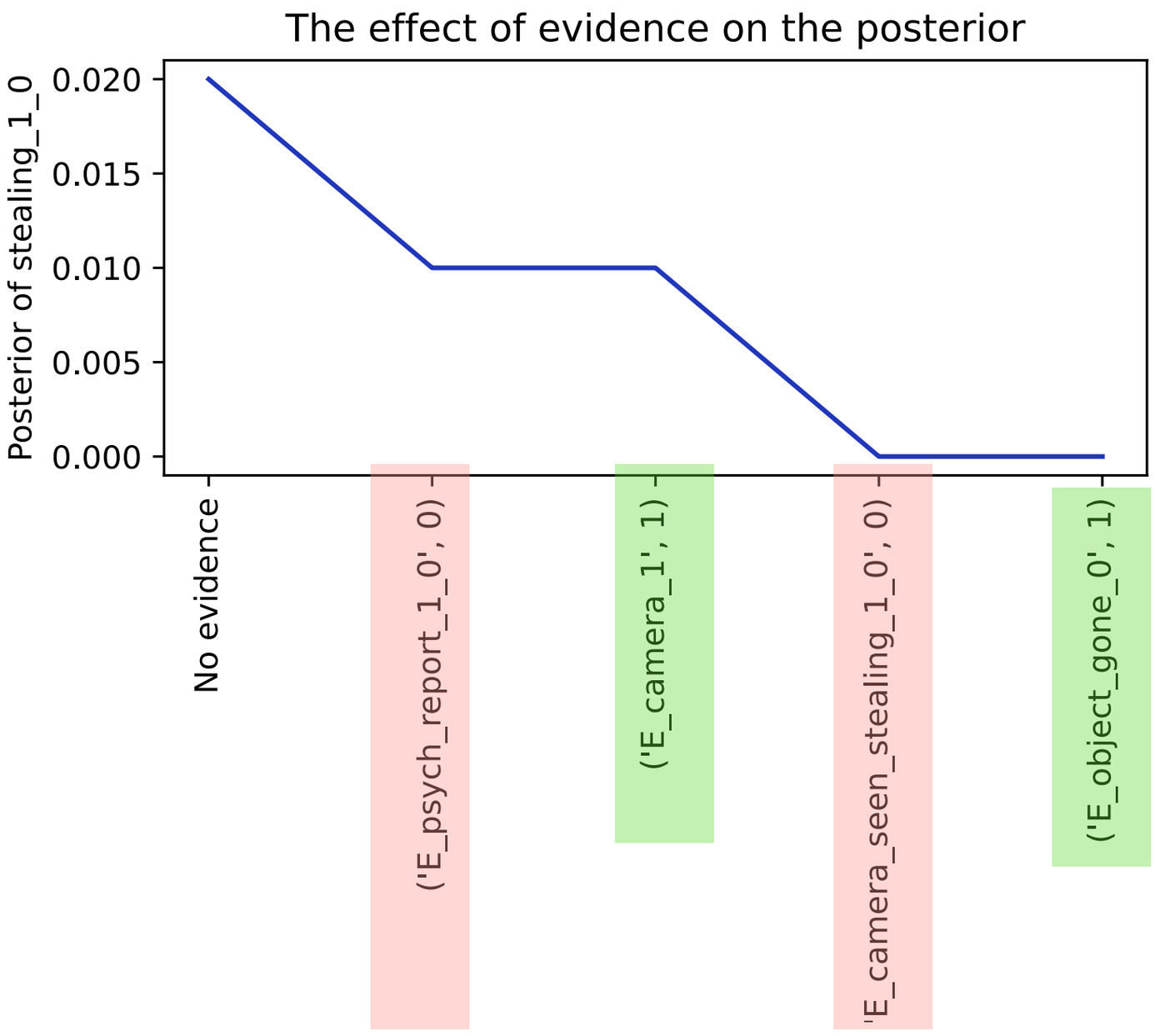


Inference in 0.75ms



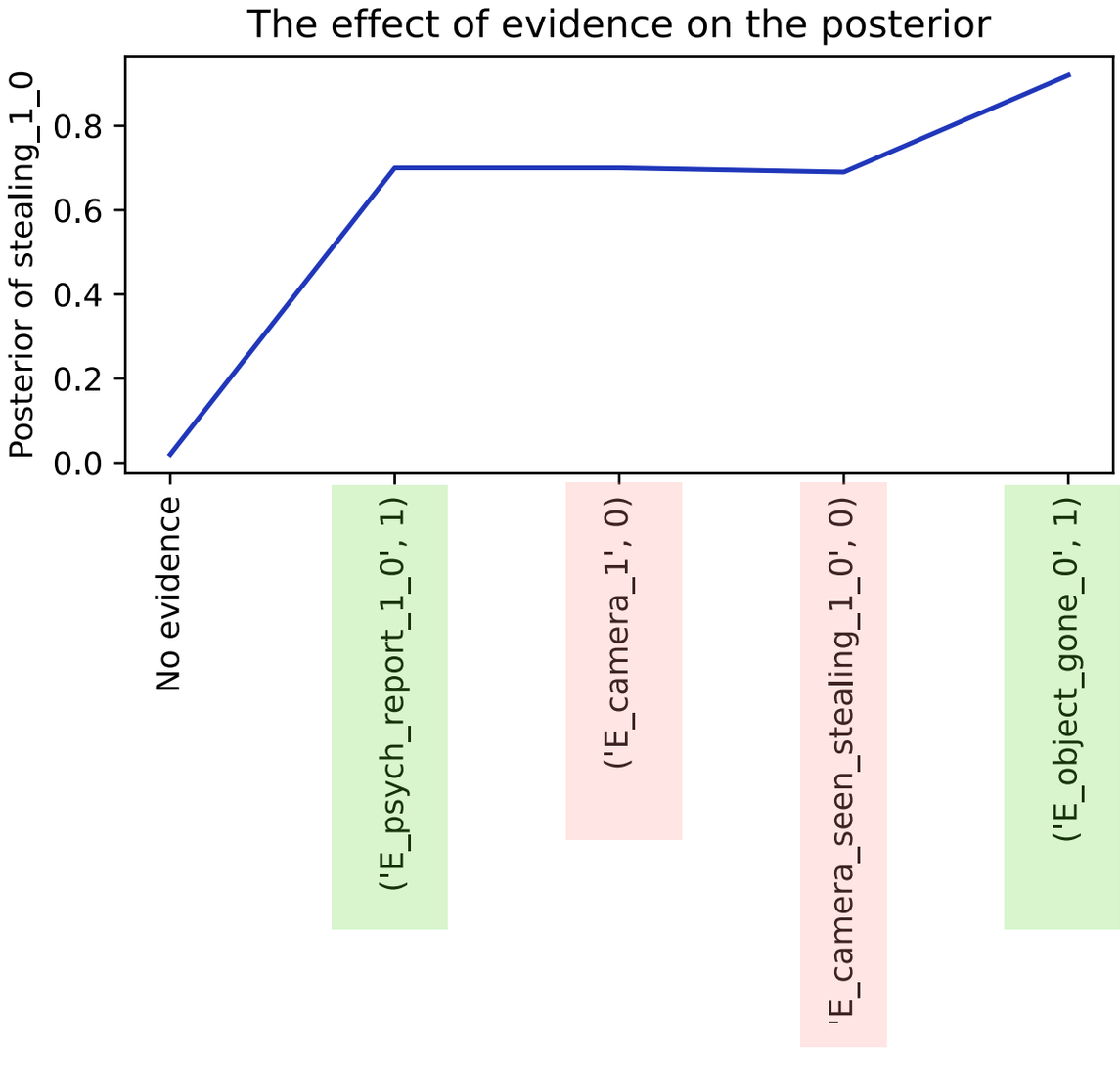
Does this BN respond ‘rationally’ to all possible combinations of evidence?

Only the object is gone! We shouldn’t convict!



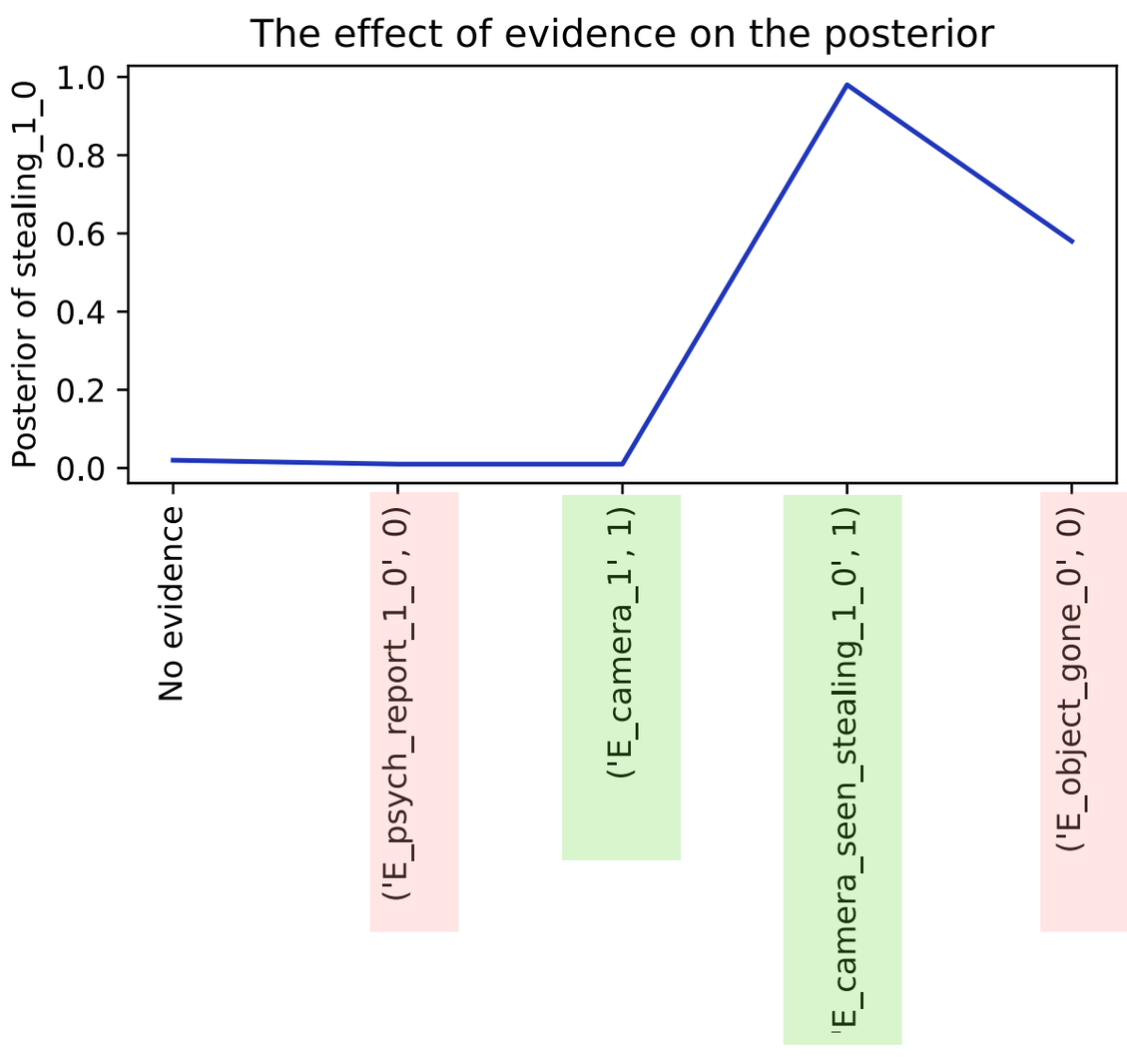
Does this BN respond ‘rationally’ to all possible combinations of evidence?

suspect fits profile and object is gone… but no video evidence



implausible in court

Conflicting evidence: Stealing without object gone



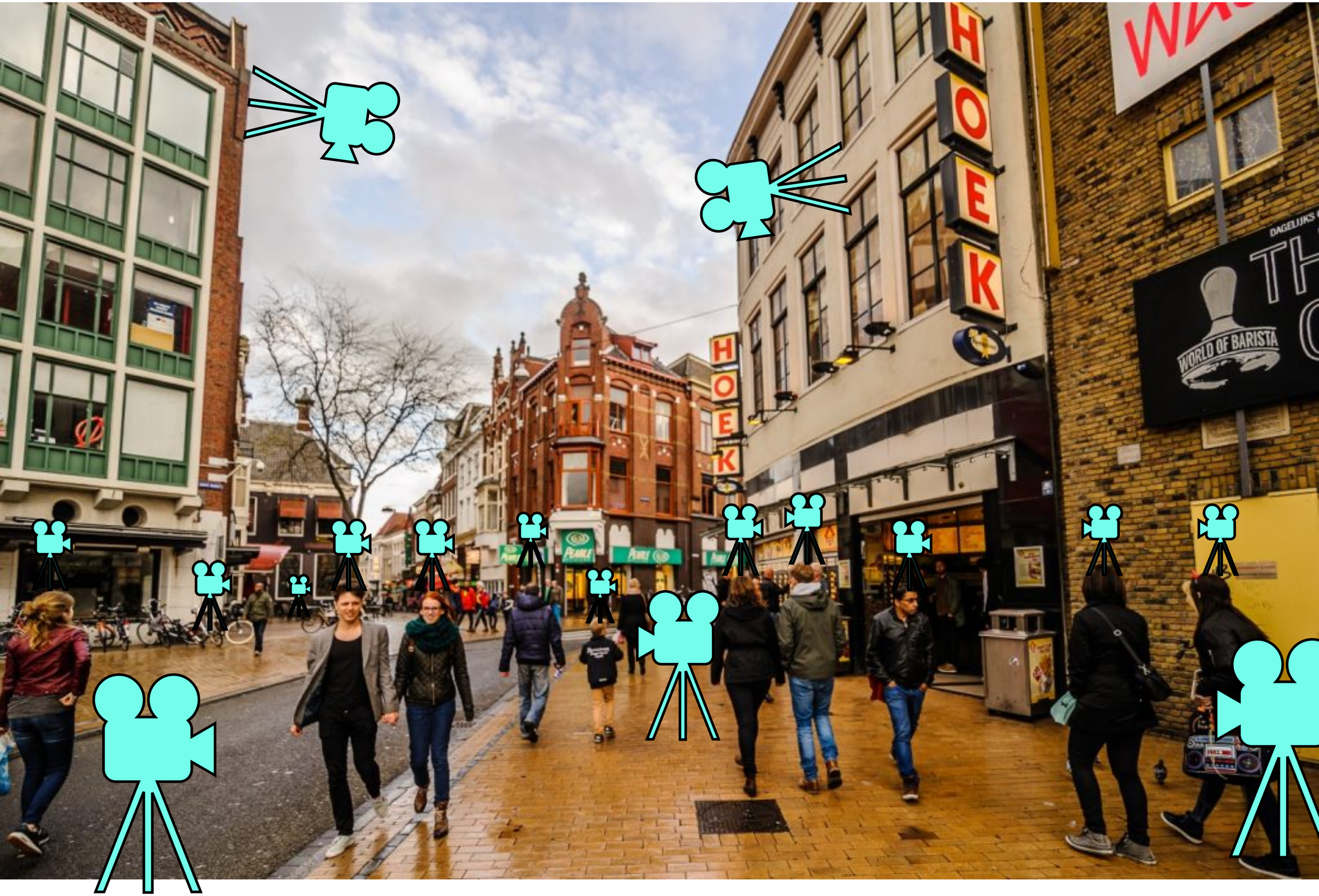
Should give error…?

Is it plausible that this method generalises to real life?

Is it plausible that this method generalises to real life?

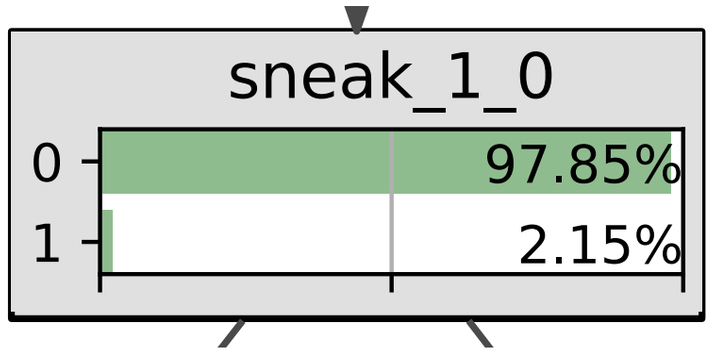
no


HOEK
HOEK
WORLD OF BARISTA


HOEK
HOEK
WORLD OF BARISTA
PEARLE

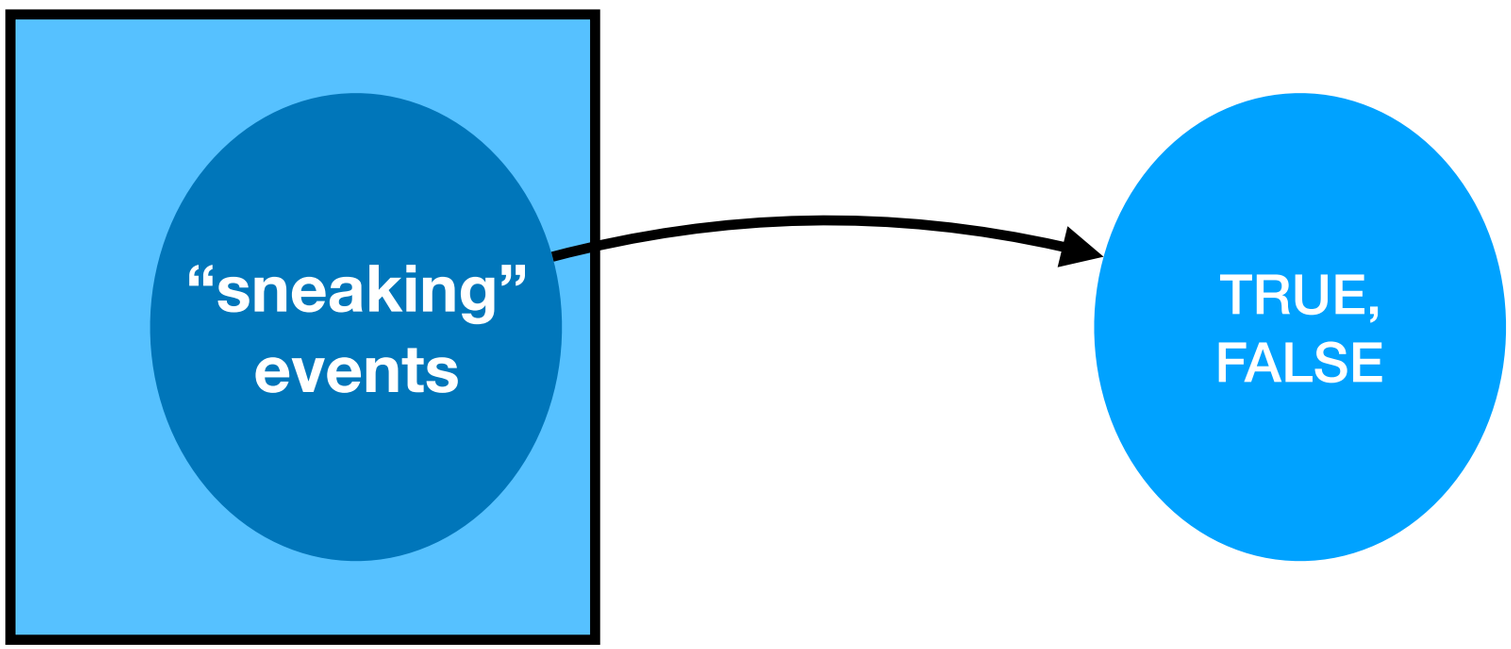
Is it plausible that this method generalises to real life?

Operationalisation



is a random variable

informally speaking



Do Bayesian Networks work as a tool for rationally dealing with evidence?

Criteria discussed here…

- Can we create a BN that reflects the probabilities of the simulation? (yes)
- Does this BN respond ‘rationally’ to all possible combinations of evidence? (mostly)
- Is it plausible that this method generalises to real life? (no)

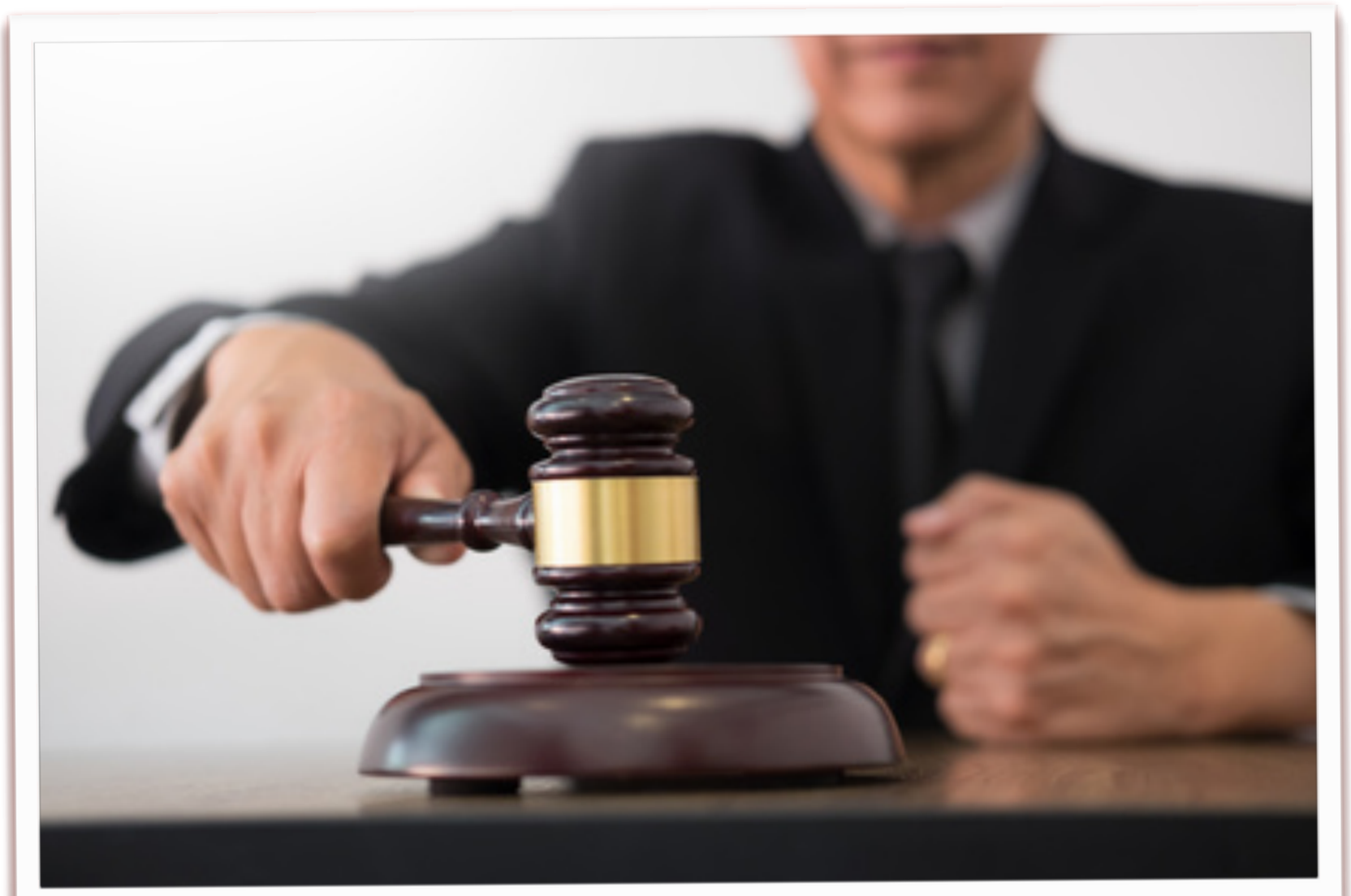
Future research

Add people

“we can never ask how accurate is a person's assessment of the probative weight of evidence given at trial. Such evidence involves unique events, and each fact finder evaluates the evidence according to personal strategies based upon a unique matrix of prior experience.”

Schum, 1982

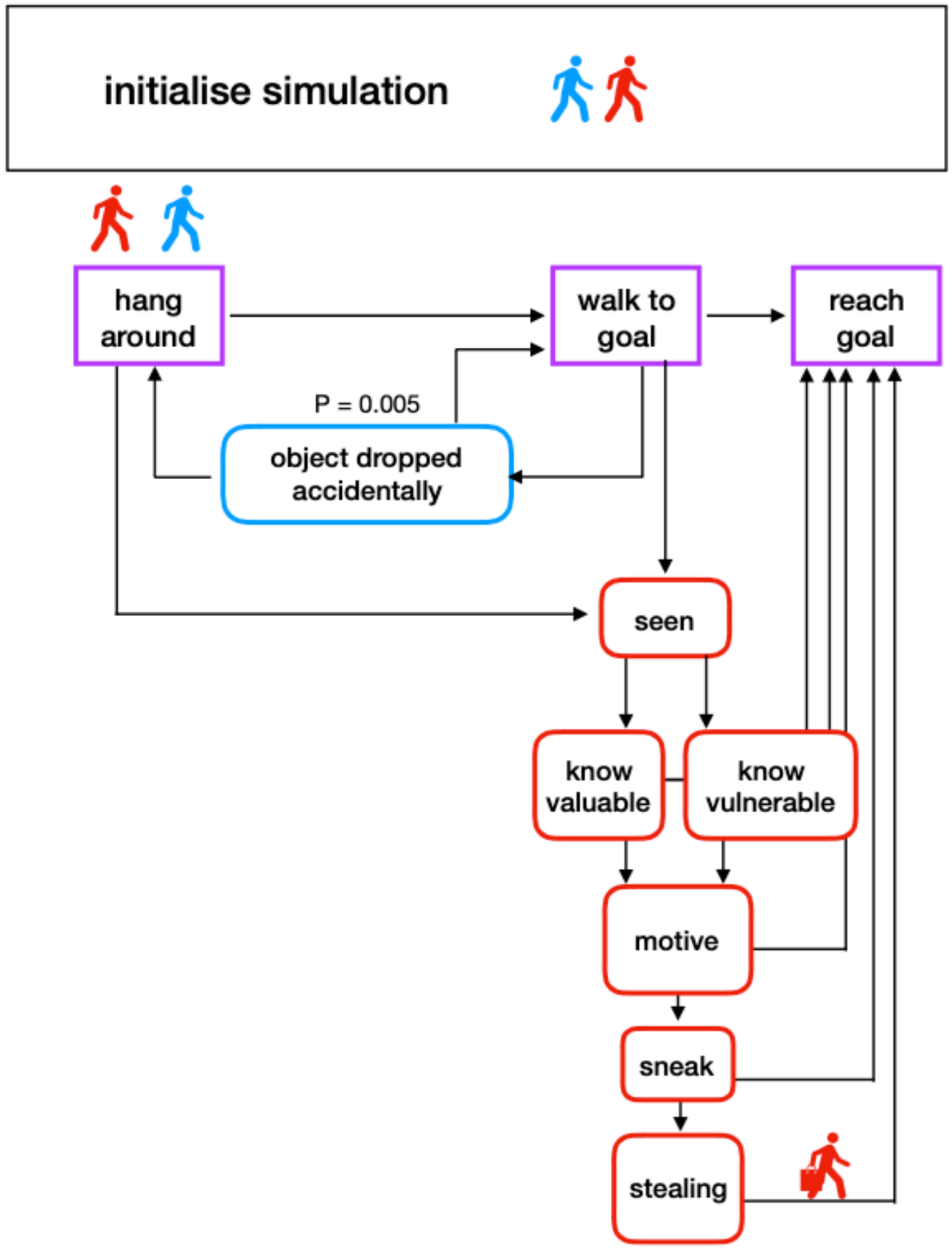
- find ways to test the effect of different operationalisations of random variables (node operalisations) on the network
- more evaluation

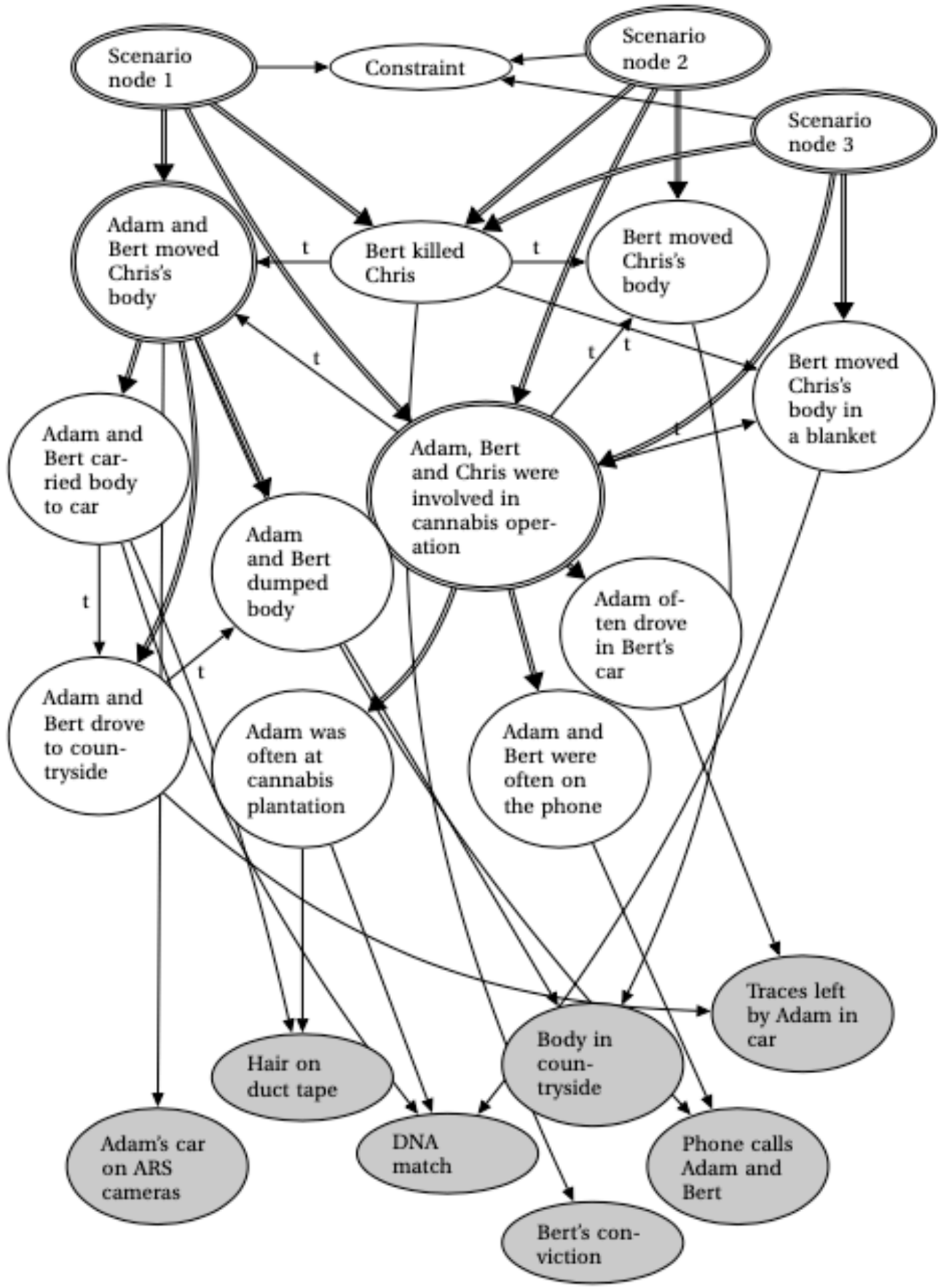


I'm nervous for a presentation

I don't sleep enough the night before

I watch too much Youtube beforehand


initialise simulation
hang around
walk to goal
reach goal
P = 0.005
object dropped accidentally
seen
know valuable
know vulnerable
motive
sneak
stealing


Scenario node 1
Constraint
Scenario node 2
Scenario node 3
Adam and Bert moved Chris's body
Bert killed Chris
Bert moved Chris's body
Bert moved Chris's body in a blanket
Adam and Bert carried body to car
Adam, Bert and Chris were involved in cannabis operation
Adam and Bert dumped body
Adam often drove in Bert's car
Adam and Bert drove to countryside
Adam was often at cannabis plantation
Adam and Bert were often on the phone
Traces left by Adam in car
Body in countryside
Hair on duct tape
Adam's car on ARS cameras
DNA match
Phone calls Adam and Bert
Bert's conviction
t

Vlek, 2016

“we can never ask how accurate is a person's assessment of the probative weight of evidence given at trial. Such evidence involves unique events, and each fact finder evaluates the evidence according to personal strategies based upon a unique matrix of prior experience.”

Schum, 1982

Have we represented everything that we need to reason correctly explicitly in the BN?

thought experiment: we do not change anything about how we determine any of the nodes in the code, we do not change agent behaviour at all. Should the values in the nodes change if we change the environment?

a wall

selwerd

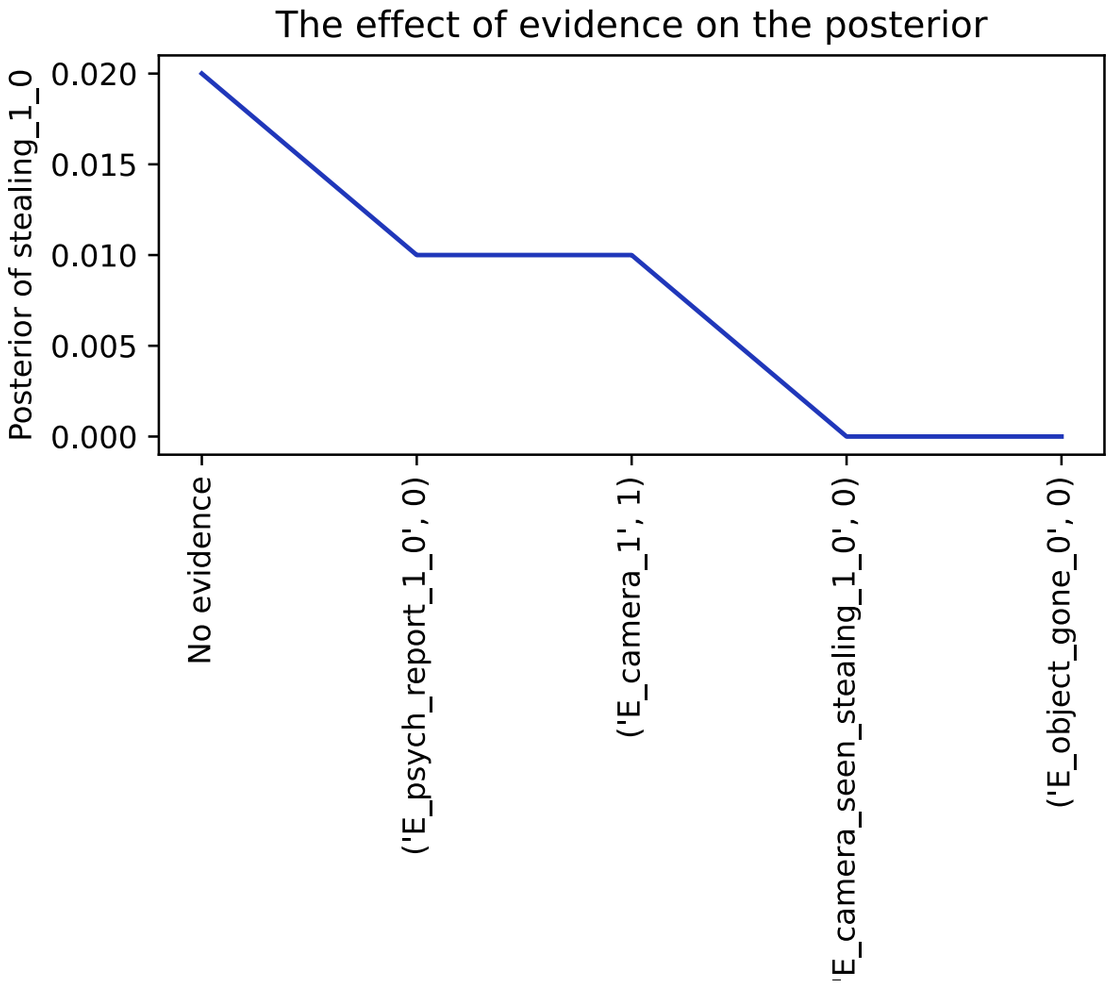
Have we represented everything that we need to reason correctly explicitly in the BN?

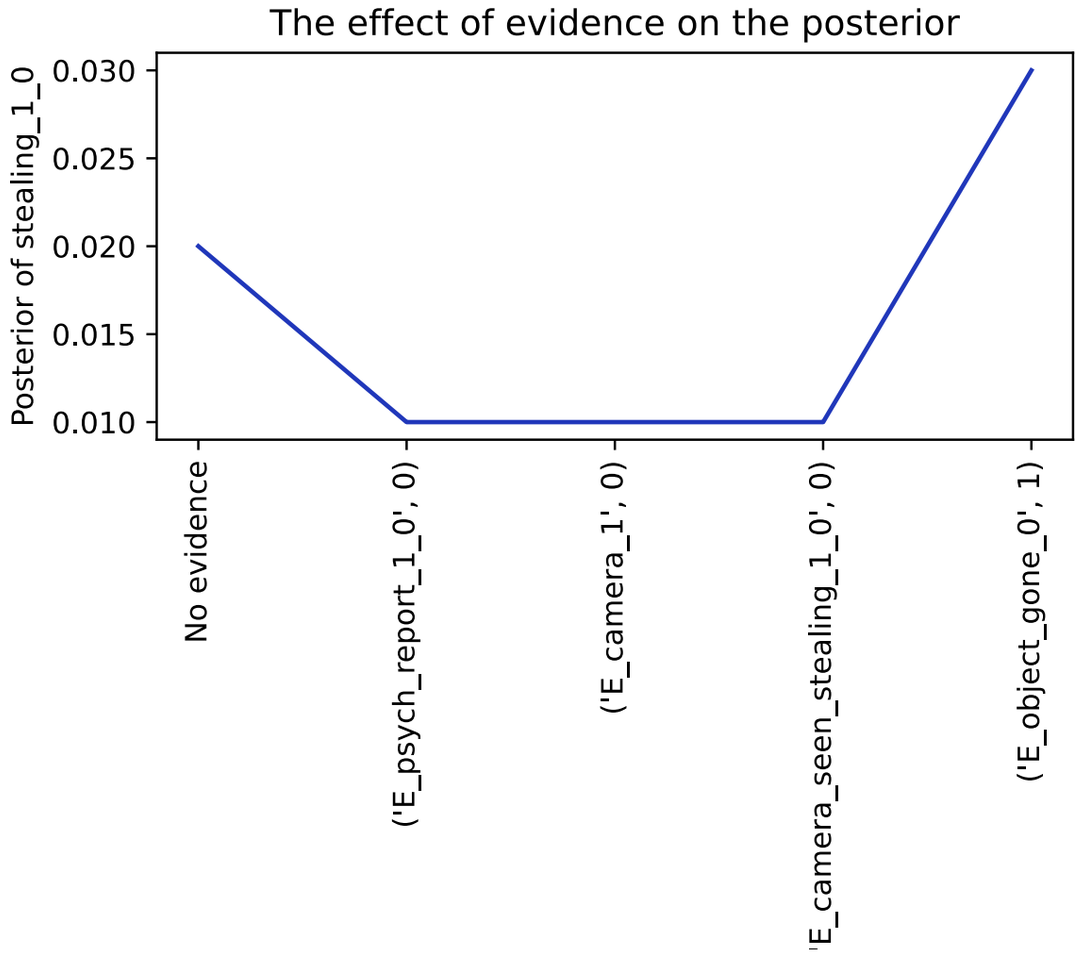
thought experiment: we do not change anything about how we determine any of the nodes in the code, we do not change agent behaviour at all. Should the values in the nodes change if we change the environment?

Node name (short)	**wall**	**selwerd**	**grote markt**
motive	0.04	0.03	0.03
camera	0.88	0.85	0.9

Does this BN respond ‘rationally’ to all possible combinations of evidence?

Other rationals





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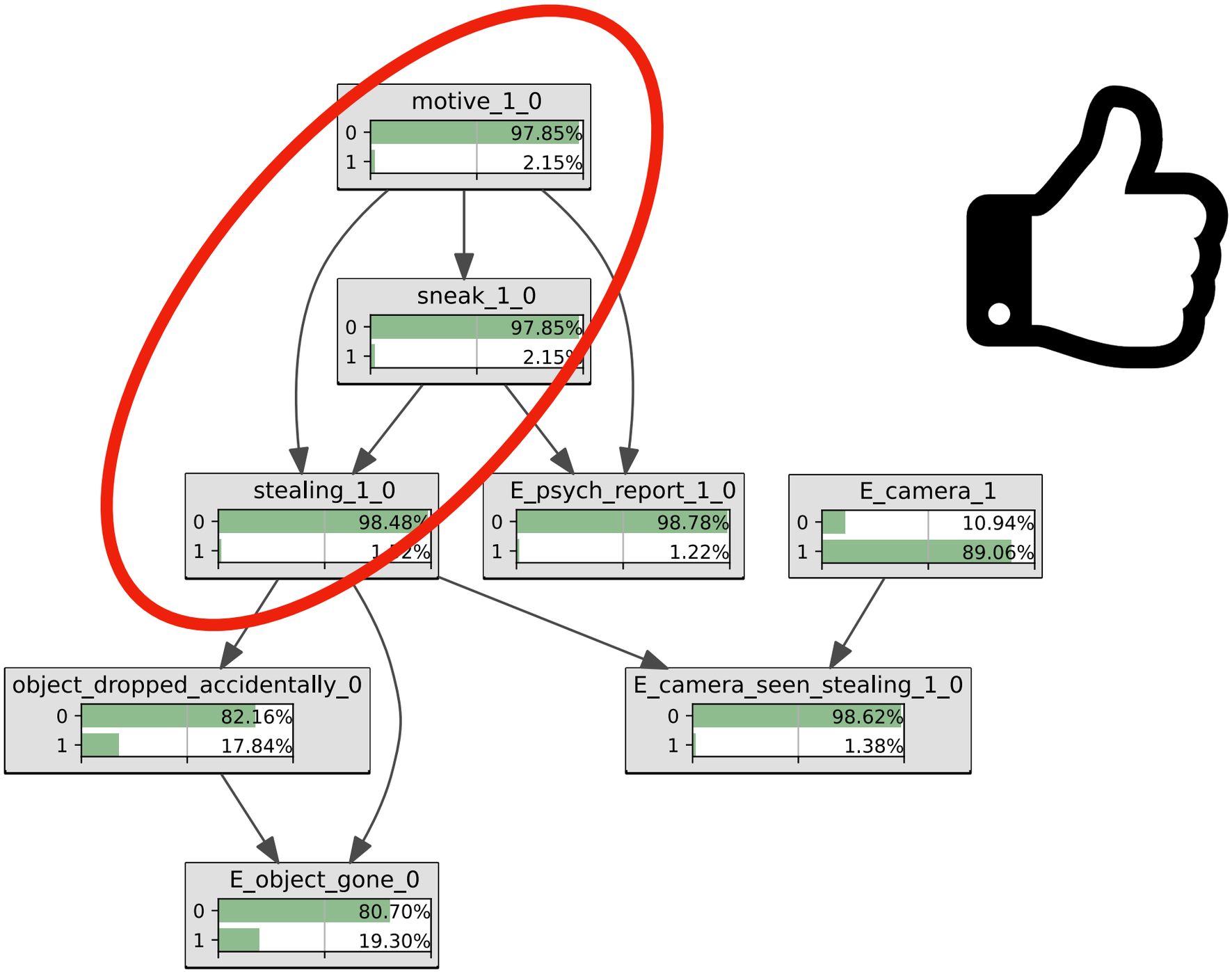

Inference in 0.75ms

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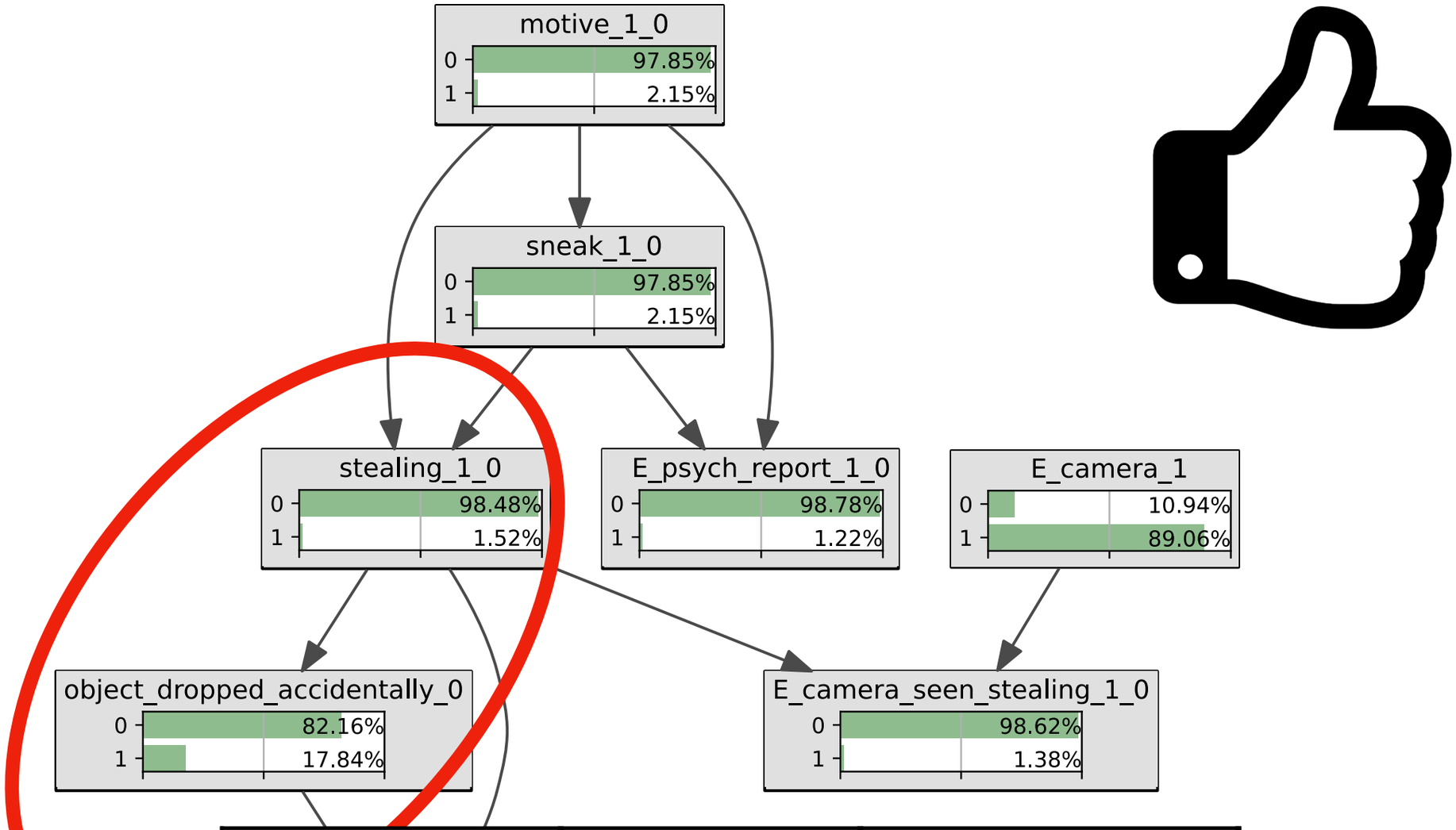

stealing	accident	not (accident)
TRUE	0.02	0.98
FALSE	0.2	0.8