Title: Everything that can be learned about a causal structure with latent variables by observational and interventional probing schemes

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Series: Quantum Foundations, Quantum Information

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Everything that can be learned about a causal structure with latent variables by observations and interventions

arXiv: 2407.01686

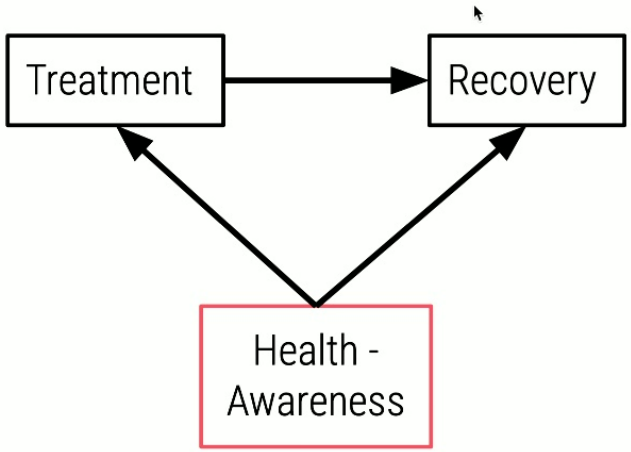
Marina Maciel Ansanelli

Joint work with Elie Wolfe and Robert Spekkens

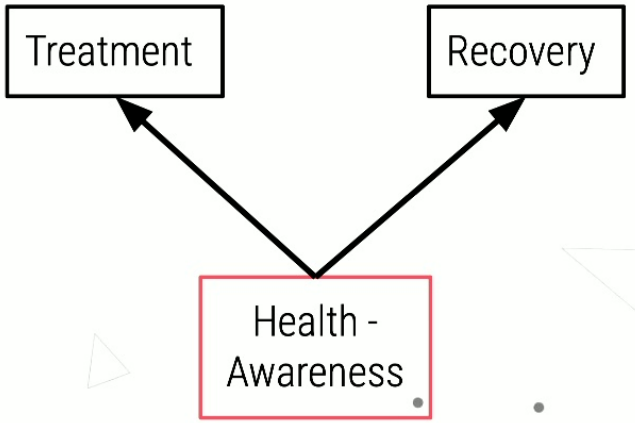
PERIMETER INSTITUTE

UNIVERSITY OF WATERLOO

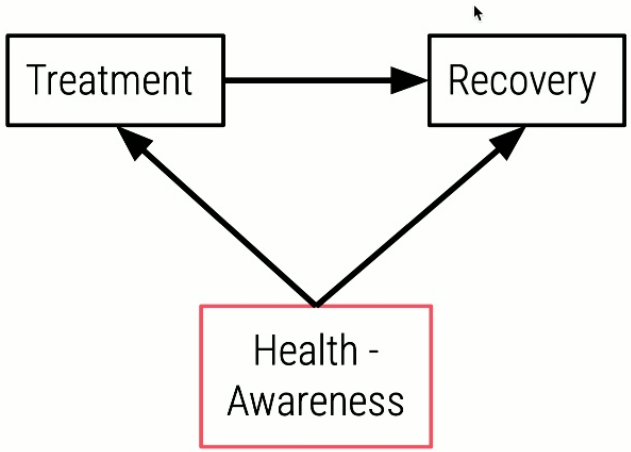
Does the treatment cause the recovery?


Treatment
Recovery
Health -
Awareness

OR


Treatment
Recovery
Health -
Awareness

Observationally equivalent



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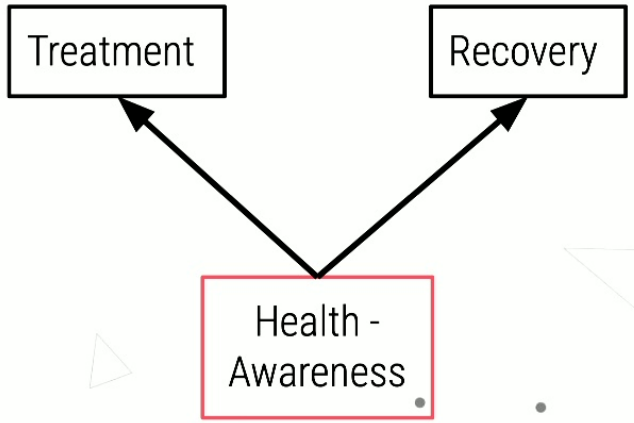
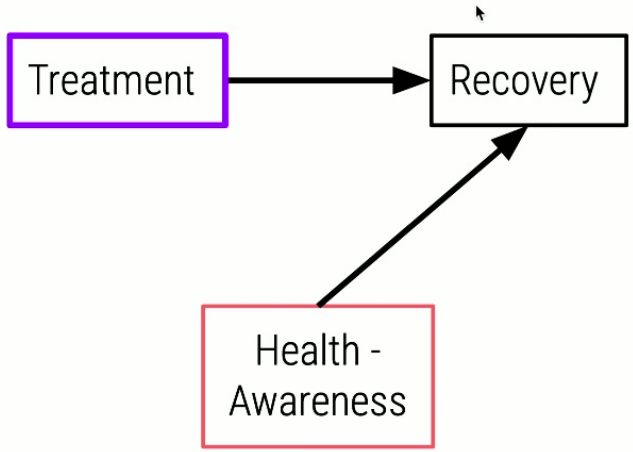
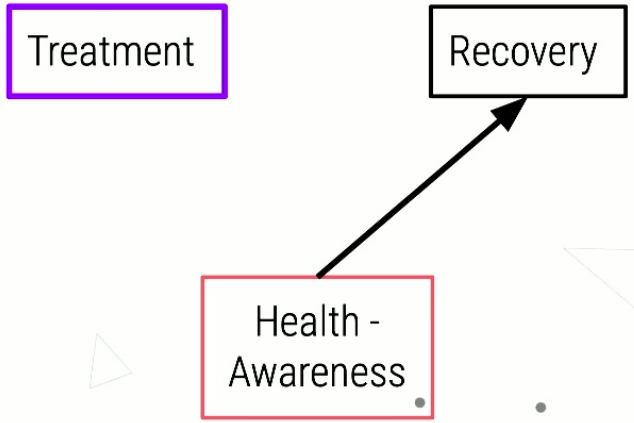


Passive observation only: Indistinguishable



OR

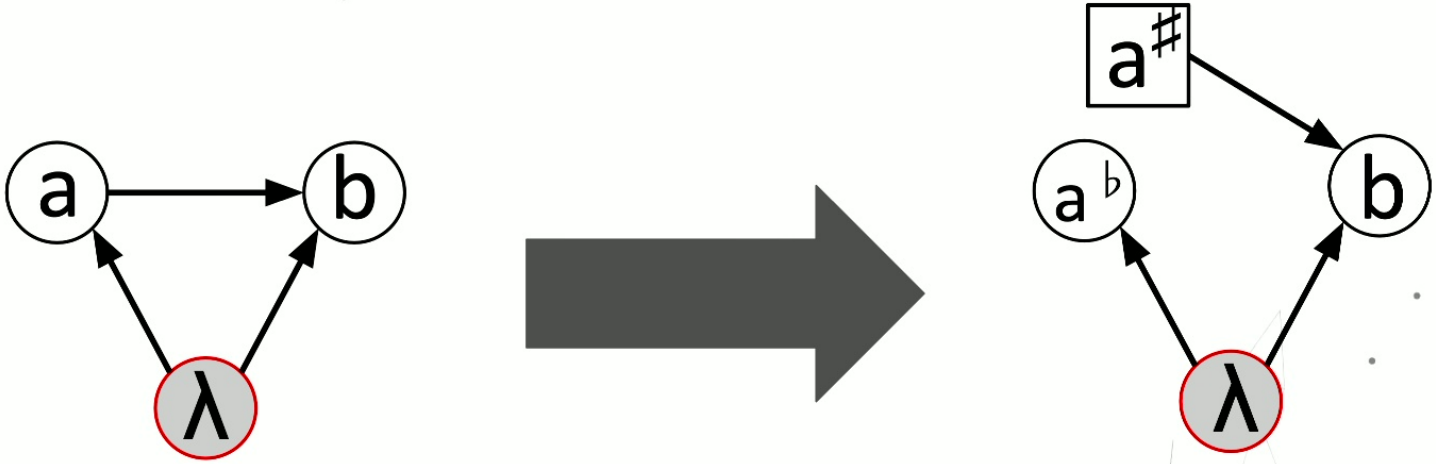


Passive observation only: Indistinguishable
Intervene on Treatment: Distinguishable

When is it impossible to distinguish two causal structures *even when there is access to interventions*?

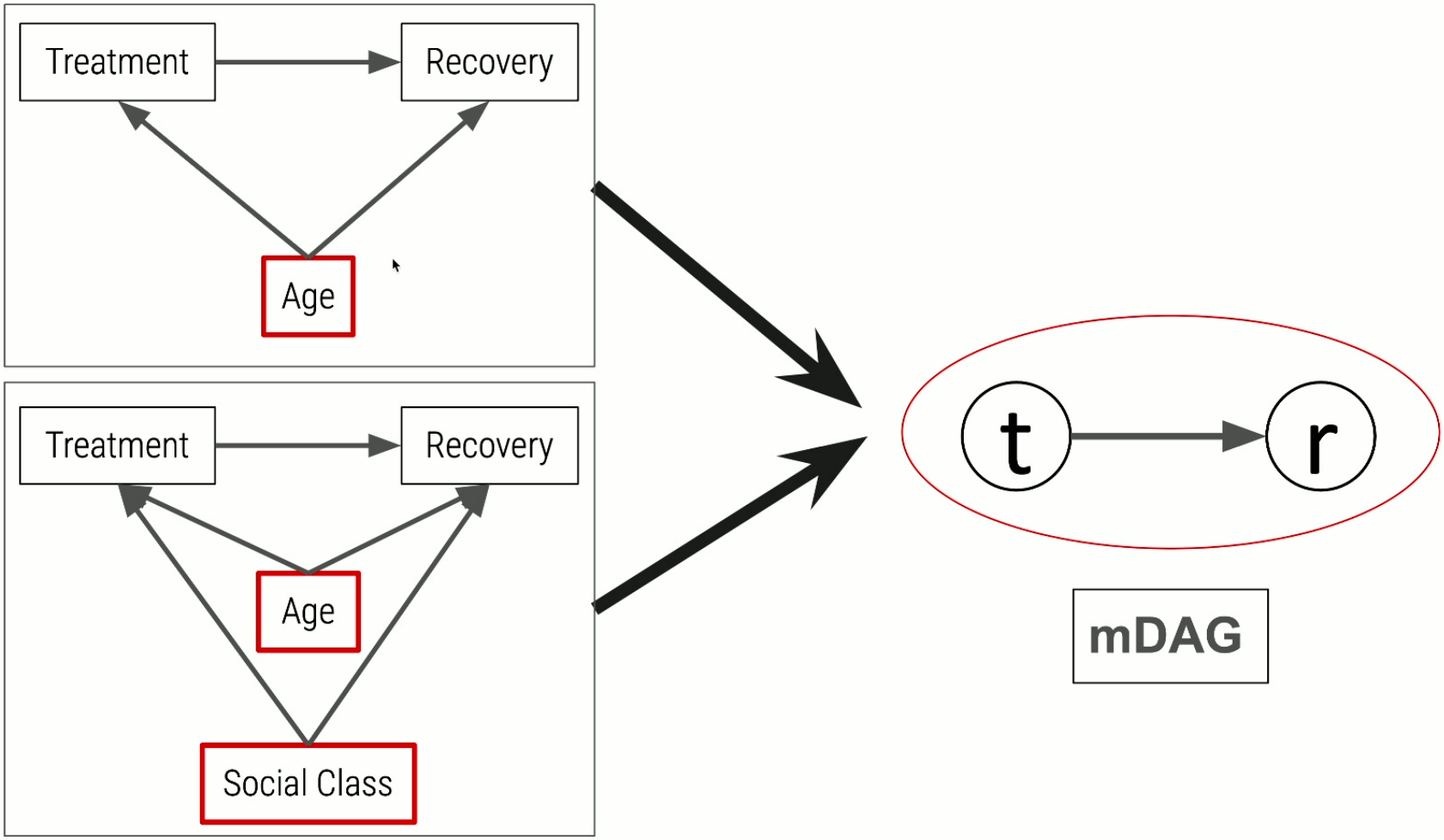
Observe&Do Probing Scheme

First observe the natural value of the variable ($a^{\flat}$), and then perform an intervention that forces it to take another value ($a^{\sharp}$).



$$P(a^{\flat} b | a^{\sharp})$$

Do this for <u>every</u> visible variable = **Observe&Do Probing Scheme**



Robin J. Evans. Graphs for Margins of Bayesian Networks. Scand. J. Stat., 43(3):625–648, 2016.

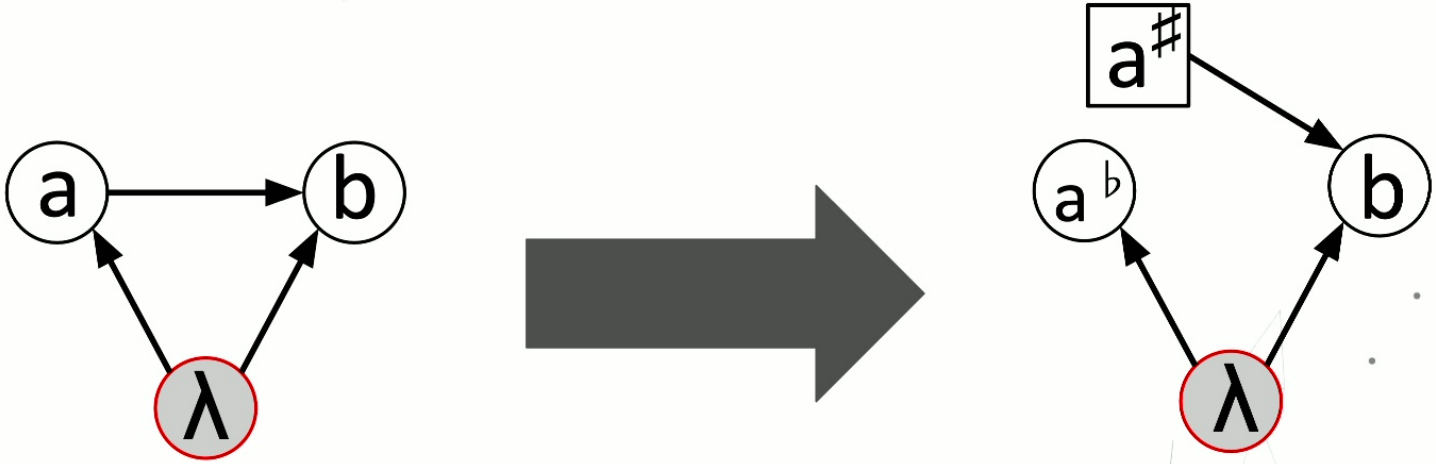
Indistinguishable under access to the Observe&Do Probing Scheme

Correspond to the same mDAG

Can we *weaken* our interventional probing scheme, but still be able to distinguish between causal structures that correspond to different mDAGs?

Observe&Do Probing Scheme

First observe the natural value of the variable ($a^{\flat}$), and then perform an intervention that forces it to take another value ($a^{\sharp}$).

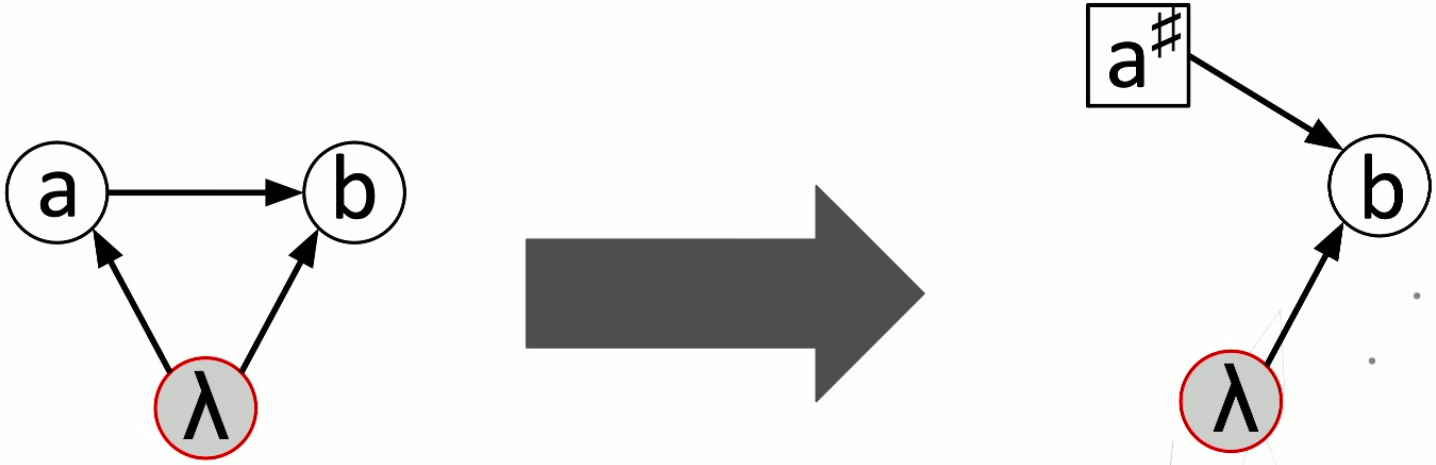


$$P(a^{\flat} b | a^{\sharp})$$

Do this for <u>every</u> visible variable = **Observe&Do Probing Scheme**

All-patterns Observe-or-Do Probing Scheme

Observe the natural value of a variable *or* perform a do-intervention on it, but not both.

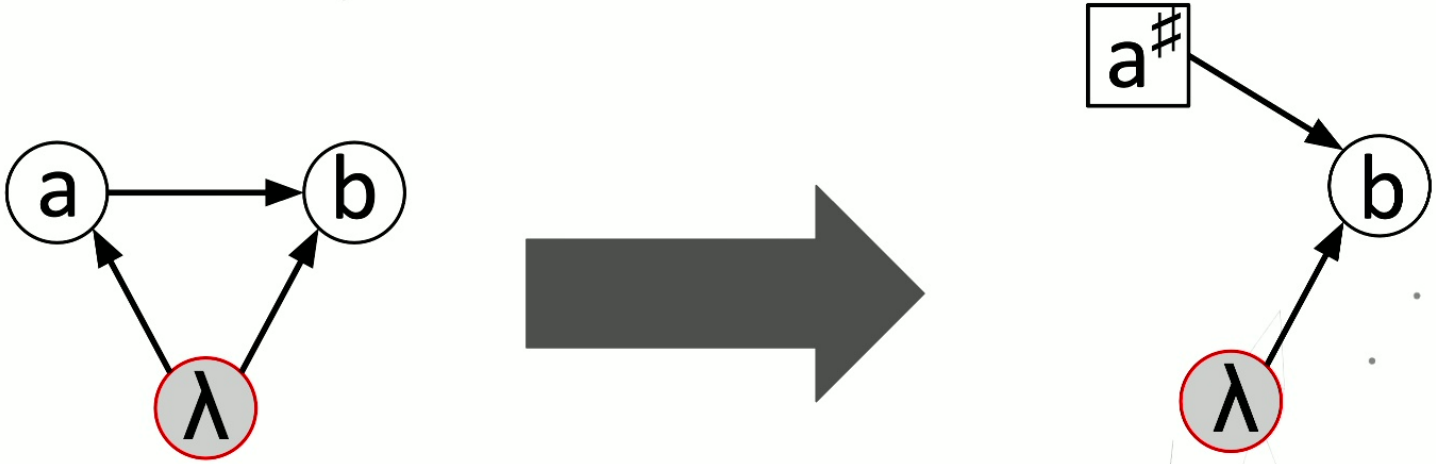


$$P(b|a^{\sharp})$$

Intervene on every subset of visible variables = **All-patterns Observe-or-Do Probing Scheme**

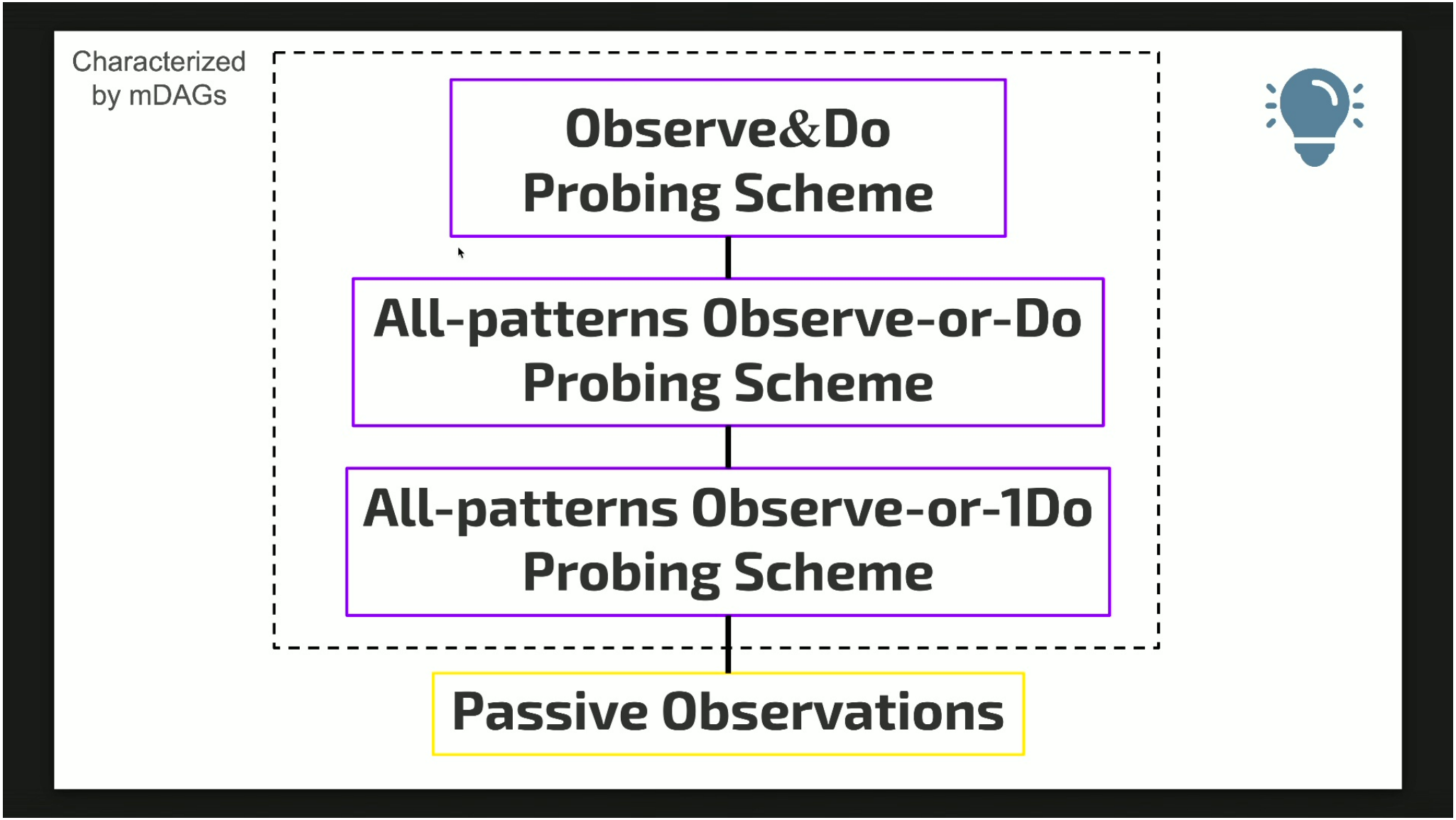
All-patterns Observe-or-1Do Probing Scheme

Restricted to do-interventions that set the variable to *one* of its possible values.



$$P(b|a^{\sharp} = 0)$$

Intervene to one value on every subset of visible variables = **All-patterns Observe-or-1Do Probing Scheme**


Characterized by mDAGs
Observe&Do Probing Scheme
All-patterns Observe-or-Do Probing Scheme
All-patterns Observe-or-1Do Probing Scheme
Passive Observations

arXiv: 2407.01686

THANKS

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