Potential outcome framework
Graphical framework

Causal Inference

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References:

Prof. Thomas Richardson, course materials of CS&SS 556

D. James Greiner and Donald B. Rubin, "CAUSAL EFFECTS OF PERCEIVED IMMUTABLE CHARACTERISTICS", 2011

Potential Outcome

For binary treatment X, we define two potential outcome variables:

- $Y(x = 0)$: the value of Y that *would* be observed for a given unit *if* assigned $X = 0$;

- $Y(x = 1)$: the value of Y that *would* be observed for a given unit *if* assigned $X = 1$;

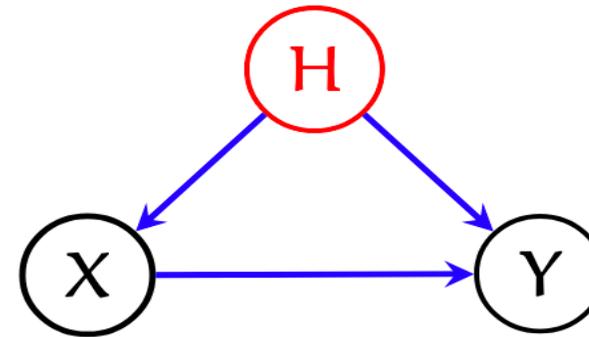| Unit	Potential Outcomes		Observed	
	$Y(x = 0)$	$Y(x = 1)$	X	Y
1	0	1	1	1
2	0	1	0	0
3	0	0	1	0
4	1	1	1	1
5	1	0	0	1

Definition of No Confounding

We define *no confounding* to be present (marginally) iff

$$Y(t) \perp\!\!\!\perp X \text{ and } Y(c) \perp\!\!\!\perp X$$

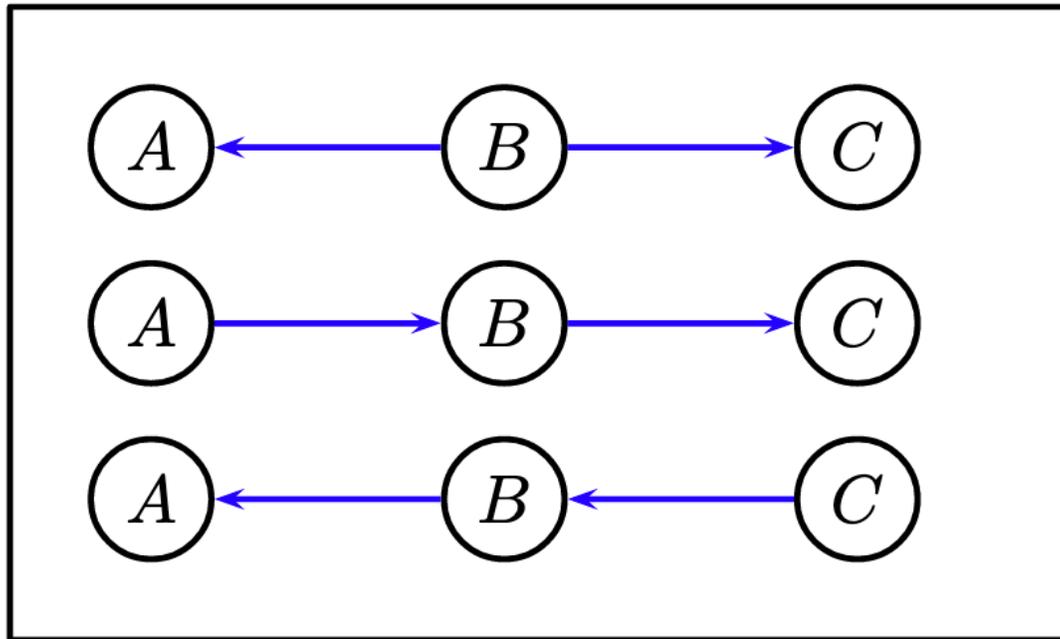Note that in the next section of the talk we will consider X binary takin

No Confounding
$$Y(x) \perp\!\!\!\perp X, \text{ for } x \in \{t, c\}$$

Confounding
$$Y(x) \not\perp\!\!\!\perp X, \text{ for } x \in \{t, c\}$$

Markov Equivalence

Different graphs can represent the same set of distributions:

$$\Rightarrow \qquad A \perp\!\!\!\perp C \mid B$$

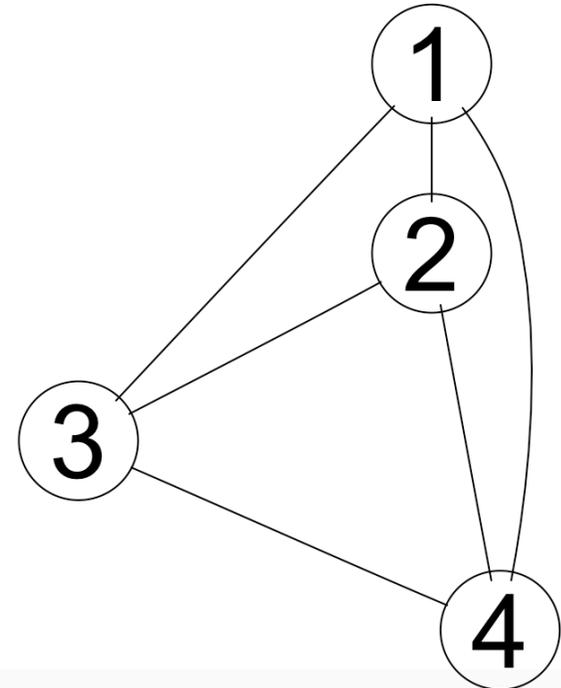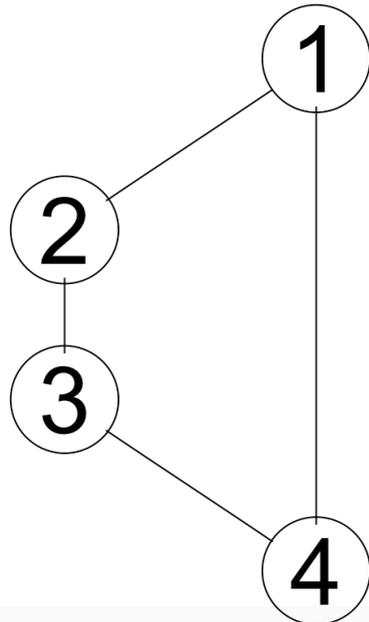# Dependency vs. Correlation Matrix of Mvtnorm

```
       [,1] [,2] [,3] [,4]
[1,]     1    0    0    0
[2,]     0    1    0    0
[3,]     0    0    1    0
[4,]     0    0    0    1
```
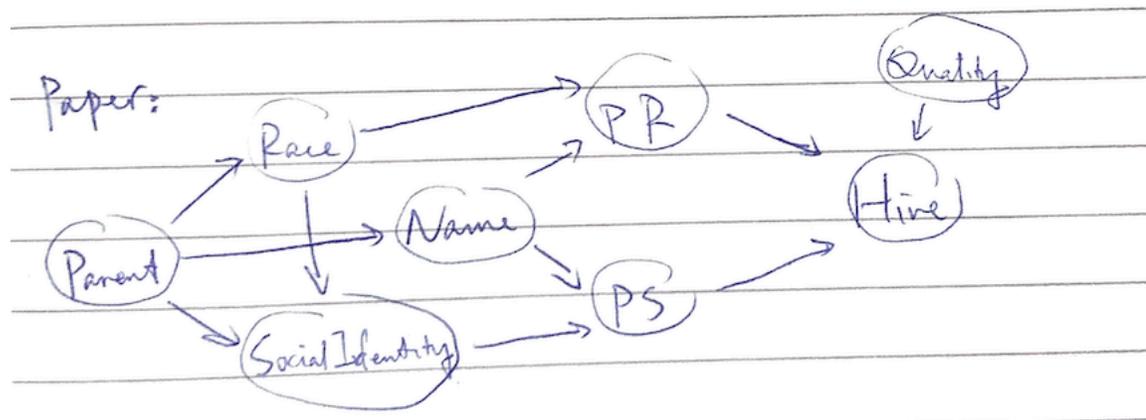
1 2 3 4

```
       [,1] [,2] [,3] [,4]
[1,]   0.8  0.1  0.2  0.1
[2,]   0.3  0.9  0.3  0.1
[3,]   0.1  0.1  0.7  0.2
[4,]   0.1  0.5  0.5  0.7
```

```
       [,1] [,2] [,3] [,4]
[1,]   1.0  0.3  0.1  0.1
[2,]   0.3  1.0  0.3  0.1
[3,]   0.1  0.3  1.0  0.3
[4,]   0.1  0.1  0.3  1.0
```

Race impact Hiring Results?

- Race is immutable.
- If there is an edge from Perceived Race to Hire Result, then they are dependent and so there exists racism ☹.
- If there's no edge, difference races are treated fairly ☺.
- Some of the possible edges are as following:

A possible experiment:

- In stead of interviewing in person, send out resumes with black sounding name vs. white sound names (-> Perceived Race).

- Other qualities are controlled.