Why there's no cause to randomize

- John Worrall
- Department of Philosophy, Logic and Scientific Method
- London School of Economics

Randomization: the 'Gold Standard'

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Is it really the gold standard?

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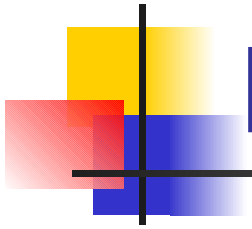
- 4. Whatever the epistemic rights and wrongs, it is just *a matter of fact* that non-randomized studies routinely give an exaggeratedly positive result.

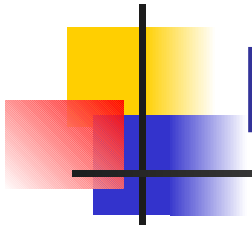
Is it really the gold standard?

- 5. Randomization is necessary if there is to be evidence of genuine *causation* as opposed to 'mere association'.



Randomization and causation

- Will concentrate on 5



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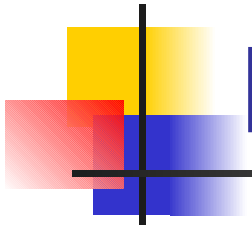

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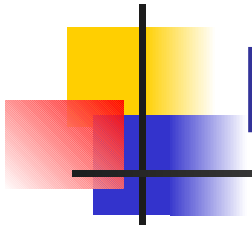

Randomization and causation

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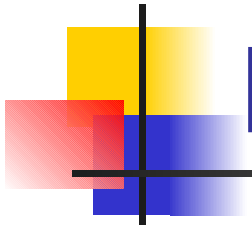
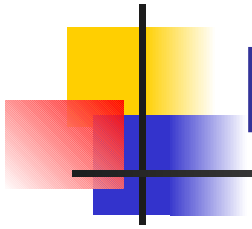
- And will contend that Pearl's argument is not convincing
- Then at the end just make a few brief more positive comments about the way in which I think that progress can best be made



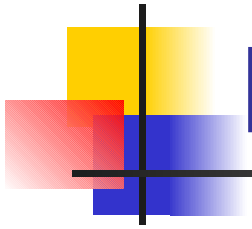
Randomization and causation

- What drives this whole literature is the attempt to ensure that we avoid the *post hoc ergo propter hoc* fallacy.



Pearl on causality

- The central Pearlian project:



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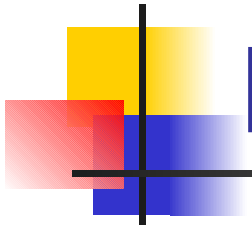

Pearl on causality

- The central Pearlian project:
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- But the networks produced by such an algorithm need not be causal.

Pearl on causality

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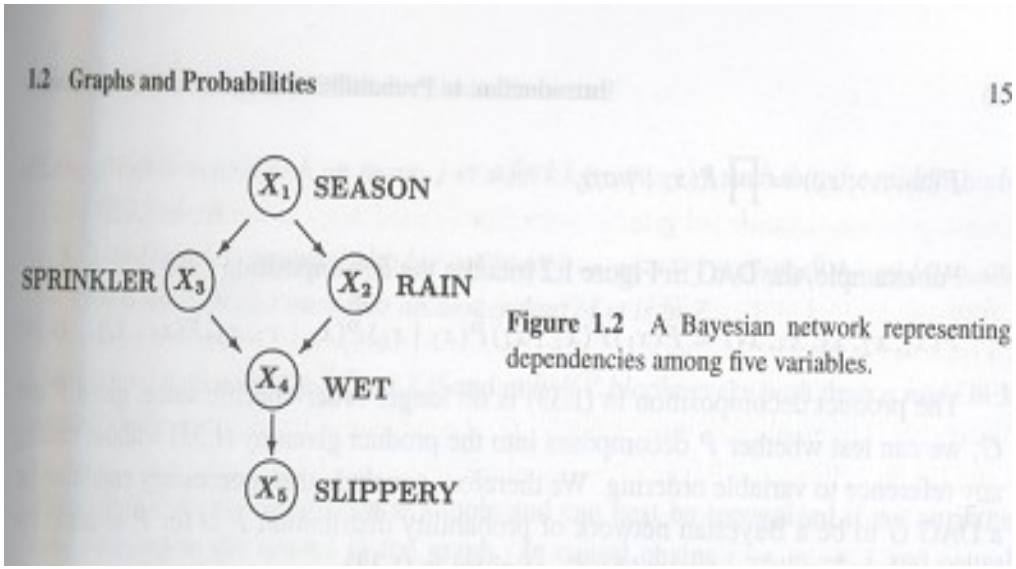
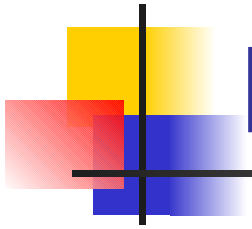
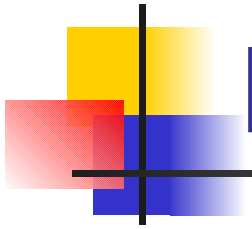




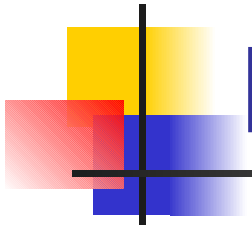
Pearl on causality

- Pearl's own initial example:
- this network will be underwritten not just by 'causal intuition' but also by certain relationships between the *conditional probabilities* that each of the variables possess a particular value (spring, yes, etc), given values of other variables.



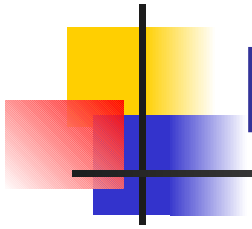
Pearl on causality

- For example, the absence in the graph of a direct connection between $X_1$and X_5, is reflected in the fact that if we already know that the pavement is wet (or dry) we already know the probability that the slipperiness variable takes on the value it does, independently of any of the values of the other variables.



Pearl on causality

- That is, $P(x_5/x_4) = P(x_5/x_1, x_2, x_3, x_4)$



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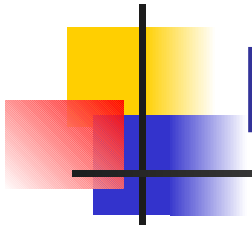

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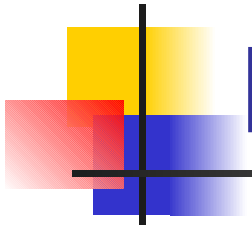
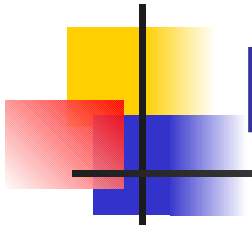
- The extra factor is centrally to do with ‘intervention’



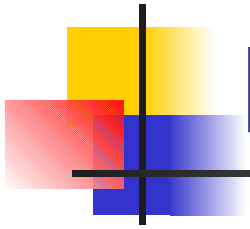
Pearl on causality

- Mutilated network/surgery on network



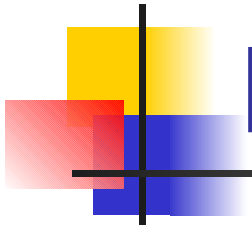
Pearl on causality

- Mutilated network/surgery on network
- Intuitively: you know you have a causal network if you can still predict what will happen after ‘surgery’



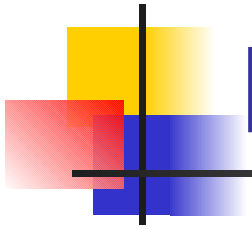
Pearl on causality

- Clearest in deterministic cases:



Pearl on causality

- Clearest in deterministic cases:
- Say that a machine takes some rod of any length X as input, doubles that length in its first sub-component and then there's an independent second sub-component that stretches any rod that comes into it by 1m



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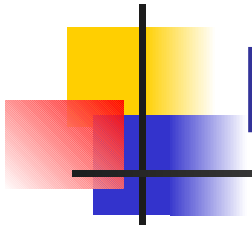
- If we ‘delete’ the normal connection between X and Y (by by-passing the first component) and simply fix the value of Y at y



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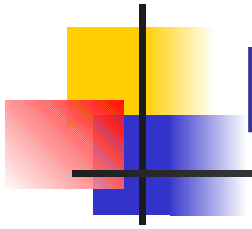
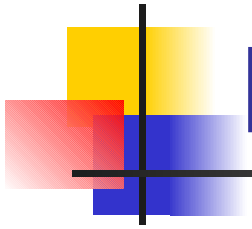
- If we ‘delete’ the normal connection between X and Y (by by-passing the first component) and simply fix the value of Y at y
- Then of course we can still predict what the length of the outgoing rod will be, viz y + 1



Pearl on causality

- Similar but somewhat more complex in the stochastic case:



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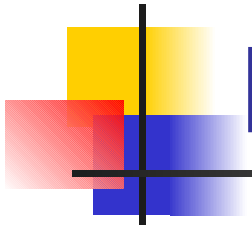
- Suppose we ‘mutilate’ the sprinkler network by simply deciding to set the sprinkler to ‘on’



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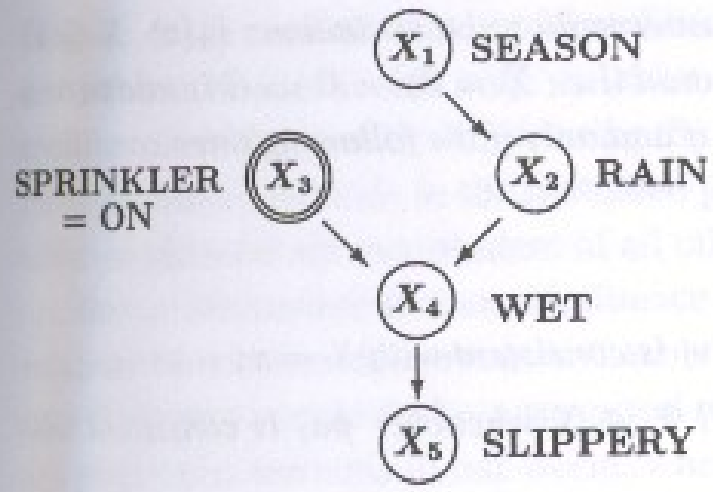
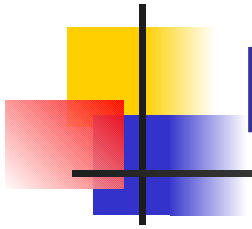


Figure 1.4 Network representation of the action "turning the sprinkler On."



Pearl on causality

- Here what we can predict as a result of ‘surgery’ is the change in the probability distribution

Pearl on causality

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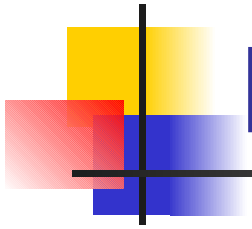
- $P(x_1,x_2,x_3,x_4,x_5) = P(x_1)P(x_2/x_1)P(x_3/x_1)P(x_4/x_2,x_3)P(x_5/x_4)$



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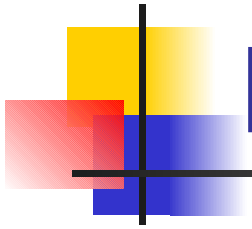
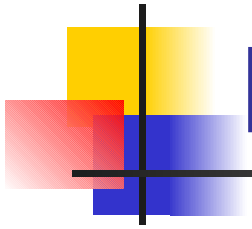


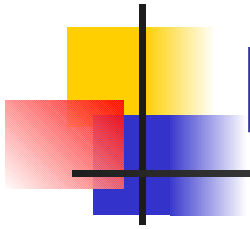
Pearl on causality

"The deletion of the factor $P(x_3/x_1)$ represents the understanding that, whatever relationship existed between seasons and sprinklers prior to the action, that relationship is no longer in effect while we perform the action. Once we physically turn the sprinkler on and keep it on, a new mechanism (in which the season has no say) determines the state of the sprinkler."



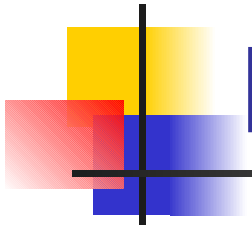
Pearl on causation

- ".. intervention amounts to a surgery on equations (guided by a diagram) and causation means predicting the consequences of such a surgery."



Pearl on causation

- Finally,



Pearl on causation

- Finally,
- X causes Y if there is a directed line from X to Y in a network that has (a) been inferred from probabilistic 'data' in accord with Pearl's algorithm and (b) is genuinely causal in the sense just explained.

Pearl's argument for RCTs

- "Why do we prefer controlled experiment over uncontrolled studies? Assume we wish to study the effect of some drug treatment on recovery of patients suffering from a given disorder. The mechanism governing the behavior of each patient is similar in structure to the circuit diagram [that Pearl considers earlier – think about the two-component deterministic machine I discussed above].

Pearl's argument for RCTs

- Recovery is a function of both the treatment and other factors, such as socio-economic conditions, life style, diet, age, et cetera. …[In the *diagram* below he collapses all these extra factors into one, just called socioeconomic conditions.] Under uncontrolled conditions, the choice of treatment is up to the patients and may depend on the patients' socioeconomic backgrounds.

Pearl's argument for RCTs

- This creates a problem, because we can't tell if changes in recovery rates are due to treatment or to those background factors. What we wish to do is compare patients of like backgrounds, and that is precisely what Fisher's *randomized experiment* accomplishes. How? It actually consists of two parts, randomization and intervention.

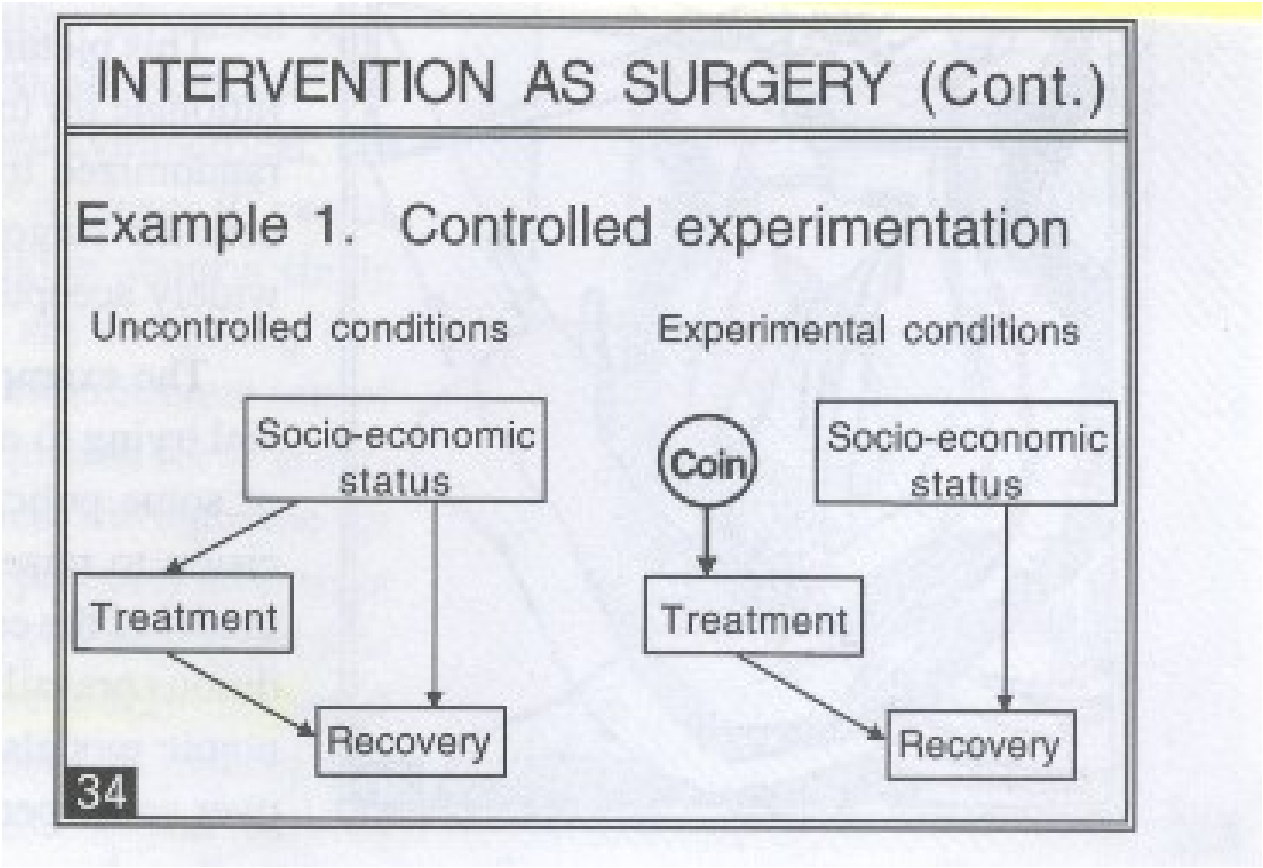
Pearl's argument for RCTs

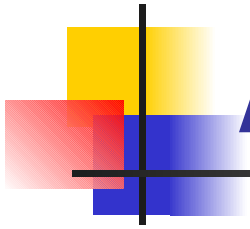
- Intervention means that we change the natural behavior of the individual: we separate subjects into two groups, called treatment and control, and we convince the subjects to obey the experimental policy. We assign treatment to some patients who, under normal circumstances, will not seek treatment, and we give placebo to patients who otherwise would receive treatment.

Pearl's argument for RCTs

- That, in our new vocabulary, means *surgery* – we are severing one functional link and replacing it with another. Fisher's great insight was that connecting the new link to a random coin flip *guarantees* that the link we wish to break is actually broken. The reason is that a random coin is assumed to be unaffected by anything we can measure on a macroscopic level – including of course, a patient's socioeconomic background."

Analysis of Pearl on RCTs





Analysis of Pearl on RCTs

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Analysis of Pearl on RCTs

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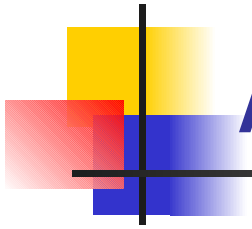
- The issue is Pearl's – too ready? – identification of 'controlled' and 'randomized controlled'



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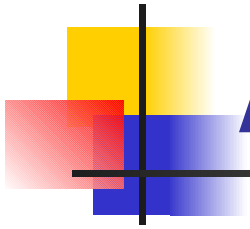

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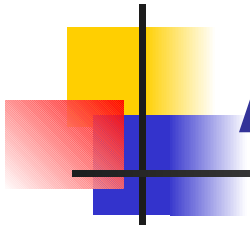
- Does it fare any better within Pearl's framework?
- Stick to practice and don't switch, implicitly, to the indefinite long run



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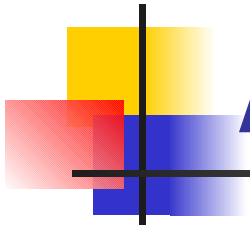
- But surely no one could expect a literal guarantee – Pearl should be interpreted as promising only a " probabilistic guarantee"



Analysis of Pearl on RCTs

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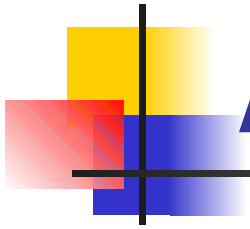

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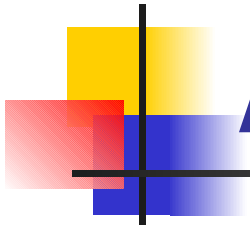

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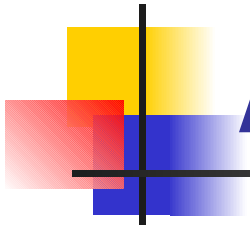

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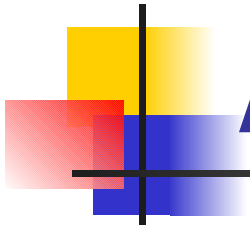

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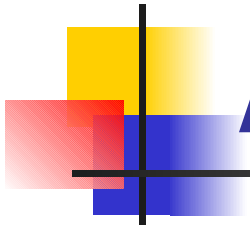

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Analysis of Pearl on RCTs

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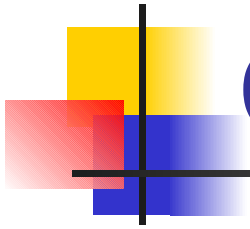
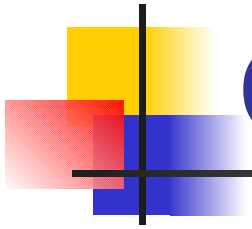


Causality reconsidered



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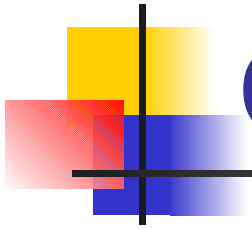

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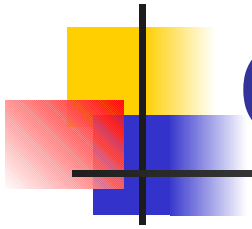

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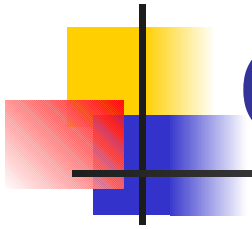
- Randomization is sometimes a help, but never a sine qua non for discovering these



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- "What I do *not* believe [is] that we can usefully lay down some hard-and-fast rules of evidence that must be obeyed before we can accept cause and effect. None of my nine viewpoints can bring indisputable evidence for or against the cause-and-effect hypothesis and none can be required as a *sine qua non*. What they can do, with greater or less strength, is to help us make up our minds on the fundamental question – is there some other way of explaining the set of facts before us, is there any other answer equally, or more, likely than cause and effect."

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- Austin Bradford Hill 'The Environment and Disease:Association or Causation?' *Proceedings of the Royal Society of Medicine*, **58**, 1965, pp 295-300