

Philosophy 12: Introduction to Causal Reasoning

Causation to Conditional Association answer key

1. Answer: (a) and (b) Causal connections produce associations. Causal connections are either causal paths, or common causes. The reason (c) is not correct is that the sequence $X \rightarrow Z_2 \rightarrow Z_1 \leftarrow Y$ is not a causal connection between X and Y ; Z_1 is a common effect of Z_2 and Y . Choice (d) is not correct because the sequence $X \rightarrow Z_1 \leftarrow Y$ is not a causal connection between X and Y ; Z_1 is a common effect of X and Y . The reason (e) is not correct is that the sequence $X \rightarrow Z_1 \leftarrow Z \rightarrow Y$ is not a causal connection between X and Y ; Z_1 is a common effect of X and Y .
2. Answer: (a), (b), (c), (d), (e), and (f) $X \rightarrow Z \leftarrow Y$ is an undirected path connecting X and Y . $X \rightarrow Z \leftarrow W$ is an undirected path connecting X and W . $X \rightarrow Z$ is an undirected path connecting X and Z . $W \rightarrow Z \leftarrow Y$ is an undirected path connecting W and Y . $Z \leftarrow Y$ is an undirected path connecting Z and Y . $Z \leftarrow W$ is an undirected path connecting Z and W .
3. Answer: (c), (e), and (f) $X \rightarrow Z \leftarrow Y$ is an undirected path connecting X and Y . $X \rightarrow Z \leftarrow W$ is an undirected path connecting X and W . $X \rightarrow Z$ is a directed path connecting X and Z . $W \rightarrow Z \leftarrow Y$ is an undirected path connecting W and Y . $Z \leftarrow Y$ is a directed path connecting Z and Y . $Z \leftarrow W$ is a directed path connecting Z and W .
4. Answer: (d) A causal connection between X and Y is either a causal path from X to Y , a causal path from Y to X , or a pair of causal paths from a common cause to X and to Y . All the variables on a causal path are mediators. The reason (a) is not correct is that a causal path has no common causes, yet it is a causal connection. The reason (b) is not correct is that a common cause between X and Y produces a causal connection, and the common cause is not a mediator. The reason (c) is not correct is that no variable on a causal connection can be a common effect.
5. Answer: (b) Try drawing a causal connection that has two common causes on it.
6. Answer: (e) Consider the path $X_1 \rightarrow X_2 \rightarrow \dots \rightarrow X_{1,000}$.
7. Answer: (b) The reason (a) is not correct is that a variable is a collider on an undirected path if both arrows point into it. In this case only the arrow from X to Y points into Y . The reason (c) is not correct is that on any undirected path, all variables are either colliders or non-colliders.
8. Answer: (a) (b) is not correct because Y is a collider since both arrows point into it on this path. (c) is not correct because on any undirected path, all variables are either colliders or non-colliders.
9. Answer: (b) All variables on a causal connection are either common causes or mediators. Thus, no variables are colliders on a causal connection.
10. Answer: (a) and (c) The reason (b) is incorrect is that Z_2 is a common cause on the only path between X and Y in this graph, and common causes are non-colliders.
11. Answer: (a) Two variables are predicted to be associated if they are causally connected in the graph. Two variables are causally connected in the graph if there is a causal path from one to the other, or a common cause of both.
12. Answer: (c) and (d) Conditional independence is just like independence, only the conditioning variable must occur in the conditioning set on both sides of the equation.
13. Answer: (b) and (f) Two properties $X = \text{Yes}$ and $Y = \text{Yes}$ are conditionally independent given a third property $Z = \text{Yes}$ if $\text{Fr}(X = \text{Yes} \mid Z = \text{Yes})$ is the same as $\text{Fr}(X = \text{Yes} \mid Z = \text{Yes} \ \& \ Y = \text{Yes})$. The reason (a) is not correct is that this histogram conditions on $\text{EXPOSURE}=\text{No}$, but the question asks whether $\text{EXPOSURE}=\text{Yes}$ is conditionally independent of $\text{SYMPTOMS}=\text{Yes}$. The reason (c) is incorrect is that this histogram could be compared to $\text{Fr}(\text{EXPOSURE} \mid \text{INFECTION} = \text{Yes} \ \& \ \text{SYMPTOMS} = \text{Yes})$, but that isn't an option. The reason (d) is not correct is that the independence relation being examined is conditional on $\text{INFECTION} = \text{Yes}$, so that property must be in the conditioning set of every histogram examined. The

reason (e) is not correct is that the independence reason being examined is conditional on INFECTION = Yes, but in this histogram the property is INFECTION = No.

14. Answer: (a), (b), and (c) X and Y are causally connected because X is a direct cause of Y in graph A. X and Z are causally connected because X is an indirect cause of Z in graph A. Y and Z are causally connected because Y is a direct cause of Z in graph A.
15. Answer: (a), (b), and (c) X and Y are causally connected because X is a direct cause of Y in graph (b). X and Z are causally connected because X is a direct and indirect cause of Z in graph (b). Y and Z are causally connected because Y is a direct cause of Z in graph (b).
16. Answer: (b) No, the extra edge from X to Z in graph (b) changes the predictions about one conditional independence relation.
17. Answer: (d) You must block all the causal connections between EXERCISE and BODY WEIGHT to make them independent. Choice (a) is incorrect because EXERCISE and BODY WEIGHT are not predicted to be independent because they are causally connected. Choice (b) is not correct because EXERCISE and BODY WEIGHT are not predicted to be independent conditional on Appetite since, even though conditioning on APPETITE blocks the causal connection EXERCISE \rightarrow METABOLISM \rightarrow BODY WEIGHT from producing an association, the causal connection EXERCISE \rightarrow APPETITE \rightarrow BODY WEIGHT is not blocked from producing an association. The reason (c) is that EXERCISE and BODY WEIGHT are not predicted to be independent conditional on METABOLISM since, even though conditioning on METABOLISM blocks the causal connection EXERCISE \rightarrow METABOLISM \rightarrow BODY WEIGHT from producing an association, the causal connection EXERCISE \rightarrow APPETITE \rightarrow BODY WEIGHT is not blocked from producing an association.
18. Answer: (a) Two variables are predicted to be associated if they are causally connected in the graph. Two variables are causally connected in the graph if there is a causal path from one to the other, or a common cause of both. The reason (b) is not correct is that being bald and having a bald brother are predicted to be associated because they are causally connected in this graph in virtue of having a common cause.
19. Answer: (b), (c), and (d) Conditioning on *any* mediator blocks a causal path from producing an association. The reason (a) is not correct is that X and Y are causally connected, so they are not predicted to be unconditionally independent by this graph.
20. Answer: (b), (d), (e), and (f) If we condition on any variable that is on the causal connection between a pair of variables, then we prevent the causal connection from producing any association between the pair. The reason (a) is not correct is that BALD SON and BALD COUSIN are causally connected in virtue of GRANDFATHER, which is a common cause. Thus they are predicted to be associated. The reason (c) is not correct is that BALD SON and BALD COUSIN are causally connected in virtue of GRANDFATHER, which is a common cause. Since BALD BROTHER is not a non-collider on this causal connection, conditioning on it does not make the two independent.
21. Answer: (f) and (h) The conditioning set must include enough variables to prevent each causal connection from producing association between X and Y . The causal connections between X and Y are:

(a) $X \rightarrow Z_3 \rightarrow Y$

(b) $X \leftarrow Z_2 \leftarrow Z_1 \rightarrow Y$

(c) $X \leftarrow Z_2 \rightarrow Y$

each must be blocked.