

Critical Thinking

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‘Cause’ and Necessary and Sufficient Conditions

Cause

Why is understanding causal relationships important?

Does a high level of cholesterol cause heart attacks?

Does taking vitamin C prevent colds?

Does smoking cause lung cancer?

Does mercury in fish cause birth defects?

When are we dealing with mere correlation?

Among small children there is a positive correlation between exhibiting red spots associated with measles and having a fever. But do the spots cause the fever? Does the fever cause the spots?

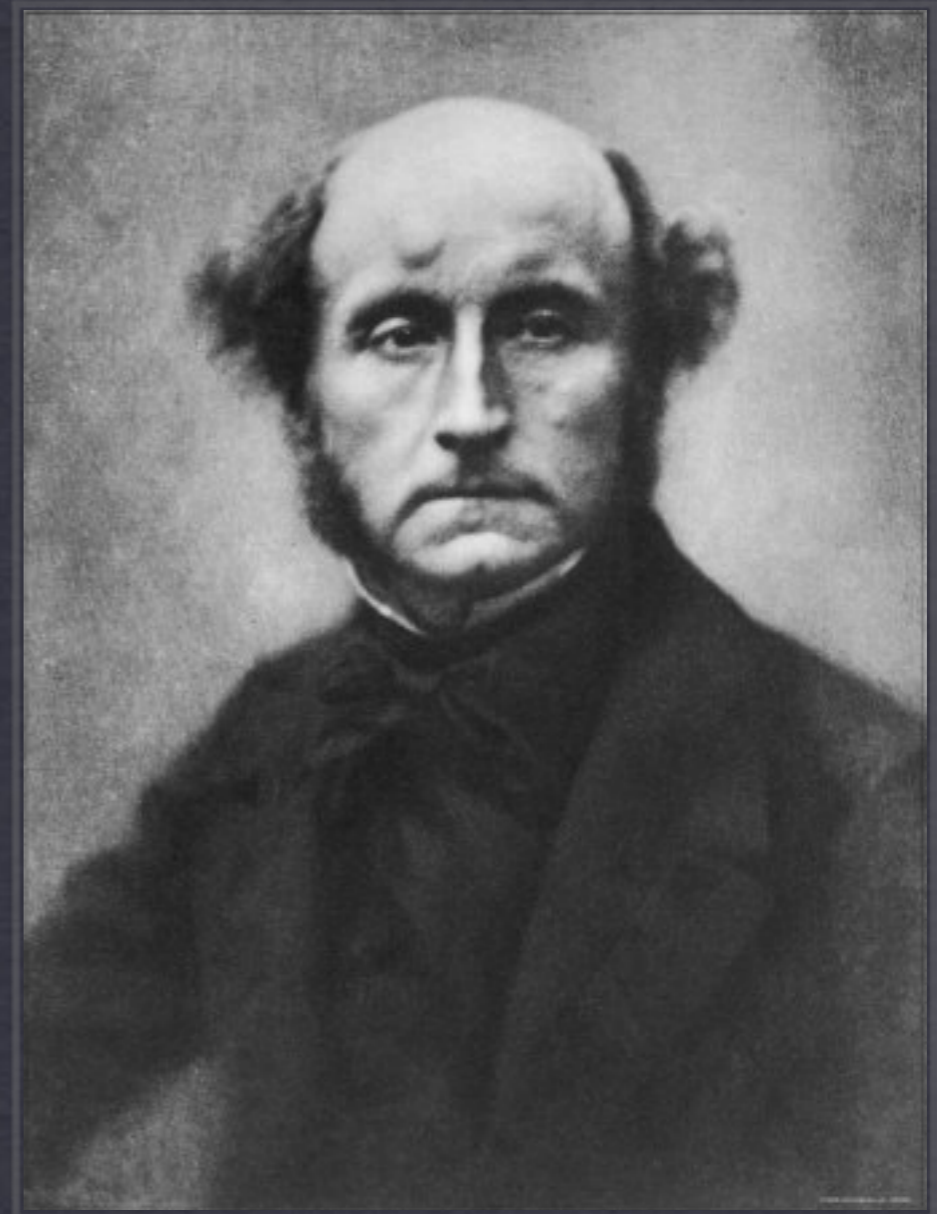
Cause

**Why is understanding causal relationships important?
When are we dealing with mere correlation?**

It is well established that the death rate from heart attacks among widows is greater than the rate among married women in general. This fact has been cited as evidence for the hypothesis that being married prevents heart attacks.

Mill's Five Methods

1. METHOD OF AGREEMENT
2. METHOD OF DIFFERENCE
3. JOINT METHOD OF AGREEMENT AND DIFFERENCE
4. METHOD OF RESIDUES
5. METHOD OF CONCOMITANT VARIATION



The Method of Agreement

The method of agreement identifies a cause in the sense of a necessary condition.

Five people eat dinner in a restaurant. Jack has salad, french fries, a hamburger, ice cream, and mixed vegetables. Bob has salad, french fries, soup, ice cream, fish, and mixed vegetables. Mary has a hamburger, soup, and ice cream. Tim has fish, mixed vegetables, ice cream, salad, and soup. Gail has mixed vegetables, fish, ice cream, french fries, and salad. Afterwards, all of them became sick from something they ate.

What food caused the sickness?

MILL'S METHOD OF AGREEMENT

Possible necessary conditions

Occurrence	A	B	C	D	E	F	G	Phenom.
1	*	--	*	*	--	*	*	*
2	*	*	*	--	*	*	*	*
3	--	*	--	*	--	*	--	*
4	*	*	--	--	*	*	*	*
5	*	--	*	--	*	*	*	*

The Method of Difference

The method of difference identifies a single factor that is present in an occurrence in which the phenomenon in question is present, and absent from an occurrence in which the phenomenon is absent.

A pair of twins, Jane and Jan, have dinner in a restaurant. The twins have identical susceptibilities to food poisoning. Jane orders soup, salad, chicken, carrots, rice, and ice cream. Jan orders soup, salad, chicken, carrots, rice, and no ice cream. Later, Jane gets sick from something she ate, but Jan does not. What food caused Jane's sickness?

The Joint Method of Agreement and Difference

The joint method of agreement and difference consists of a systematic effort to identify a single condition that is present in two or more occurrences in which the phenomenon in question is present and that is absent from two or more occurrences in which the phenomenon is absent, but never present when the phenomenon is absent nor absent when the phenomenon is present.

Six people eat dinner in a restaurant. Liz has soup, a hamburger, ice cream, french fries, and mixed vegetables. Tom has salad, soup, fish, mixed vegetables, and ice cream. Andy has salad, a hamburger, french fries, and ice cream. Sue has french fries, a hamburger, and salad. Meg has fish and mixed vegetables. Bill has french fries, a hamburger and soup. Later Liz, Tom, and Andy get sick from something they ate, but Sue, Meg, and Bill do not. What food made the first three diners sick?

MILL'S JOINT METHOD OF AGREEMENT AND DIFFERENCE

Possible necessary or sufficient conditions

Occurrence	A	B	C	D	E	F	G	Phenom.
1	--	*	*	--	*	*	*	*
2	*	*	--	*	*	--	*	*
3	*	--	*	--	*	*	--	*
4	*	--	*	--	--	*	--	--
5	--	--	--	*	--	--	*	--
6	--	*	*	--	--	*	--	--

The Method of Residues

The method of residues consists of separating from a group of causally connected conditions and phenomena those strands of causal connection that are already known, leaving the required causal connection as the “residue.”

After occupying his new house Mr. Smith found it drafty. He traced the source of the draft to three conditions: a broken window in the garage, a crack under the front door, and a broken damper in the fireplace. When the window was replaced he noticed an improvement, and a further improvement when the weather stripping was installed on the door. He concluded that the draft that remained was caused by the broken damper in the fireplace.

MILL'S METHOD OF RESIDUES

A B C

causes

a b c

A causes a.

B causes b.

Therefore, C causes c.

The Method of Concomitant Variation

The method of concomitant variation identifies a causal connection between two conditions by matching variations in one condition with variations in another. According to one formulation, increases are matched with increases and decreases are matched with decreases. Alternatively, increases could be matched with decreases, or vice versa.

Variation 1: In attempting to diagnose Mrs. Thompson's high blood pressure, a cardiologist noticed a correlation between fluctuations in blood pressure and certain brain waves. As the blood pressure increased, so did the intensity of the brain waves, and as the blood pressure decreased, the intensity of the brain waves decreased. The cardiologist concluded that the two conditions were causally related.

MILL'S METHOD OF CONCOMITANT VARIATION

A B C

is coincident with

X Y Z

A **B + C**

is coincident with

X Y + Z

A B - C

is coincident with

X Y - Z

Therefore, B is causally connected to Y.

The Method of Concomitant Variation

The method of concomitant variation identifies a causal connection between two conditions by matching variations in one condition with variations in another. According to one formulation, increases are matched with increases and decreases are matched with decreases. Alternatively, increases could be matched with decreases, or vice versa.

Variation 2: A sociologist studying divorce noticed a correlation between changes in the national divorce rate and fluctuations in the gross domestic product. As the GDP increases, the divorce rate decreases, and when the GDP decreases, the divorce rate goes up. The sociologist concluded that the two phenomena are causally connected.

MILL'S METHOD OF CONCOMITANT VARIATION

A B C

is coincident with

X Y Z

A B + C

is coincident with

X Y - Z

A B - C

is coincident with

X Y + Z

Therefore, B is causally connected to Y.

Causes and Necessary and Sufficient Conditions

Because there are many ways to think about causes, it is helpful to think about the difference between necessary and sufficient conditions.

When we say “Electrocution is a cause of death” we are saying that electrocution is sufficient to cause death.

When we say “The presence of clouds is a cause of rain” we are saying that the presence of clouds is necessary for there to be rain.

More on Necessary and Sufficient Conditions:

Cookie Recipes:

Water, flour, baking soda, salt, eggs, oats, raisins, sugar, and vanilla are together sufficient ingredients to make cookies. They are all you need!

Is any one of those ingredients necessary? No, every one of them can be substituted out for another ingredient and you would still have cookies.

On the other hand, if you were trying to make oatmeal raisin cookies what ingredients would be necessary?

Oatmeal and raisins!

But would that be sufficient to make cookies? No, oatmeal and raisins are necessary but not sufficient conditions for oatmeal raisin cookies.

More on Necessary and Sufficient Conditions:

When we say “An increase in voltage causes an increase in electrical current” we are saying that the increase in voltage is both necessary and sufficient to increase the electrical current.

Whenever an event occurs, at least *one* sufficient condition is present and *all* the necessary conditions are present.

Necessary? Sufficient?

Oscar Wilde would never have been charged with sodomy had he not filed a lawsuit against his lover's father, who had written Wilde a letter he considered libelous.

SUFFICIENT CONDITION FOR SODOMY CHARGE (ALTHOUGH IT'S CLAIMED THAT IT WAS NECESSARY)

Without freedom, art is impossible.

FREEDOM IS CLAIMED TO BE NECESSARY, BUT NOT SUFFICIENT, FOR ART.

On June 28, 1914, a member of a Serbian secret society called the Black Hand shot and killed Archduke Ferdinand, heir to the Hapsburg throne, during a parade in Sarajevo. The assassination was the event that led to World War I.

SUFFICIENT, BUT NOT NECESSARY, CAUSE OF WORLD WAR I.

Necessary? Sufficient?

Adolph Hitler's deliberate weakening of the German officer corps by replacing professional soldiers with loyal handpicked amateurs was partly responsible for the atrocities committed by the German army during the Second World War.

NEITHER NECESSARY NOR SUFFICIENT.

Earthquakes are caused by the shifting of tectonic plates. When the margins of two plates moving in opposite directions come together, get stuck, then suddenly break loose and slide past one another, the result is an earthquake.

DESCRIPTION OF BOTH NECESSARY AND SUFFICIENT CONDITIONS FOR EARTHQUAKES.

Necessary? Sufficient?

AIDS is caused by infection with HIV, the human immunodeficiency virus.

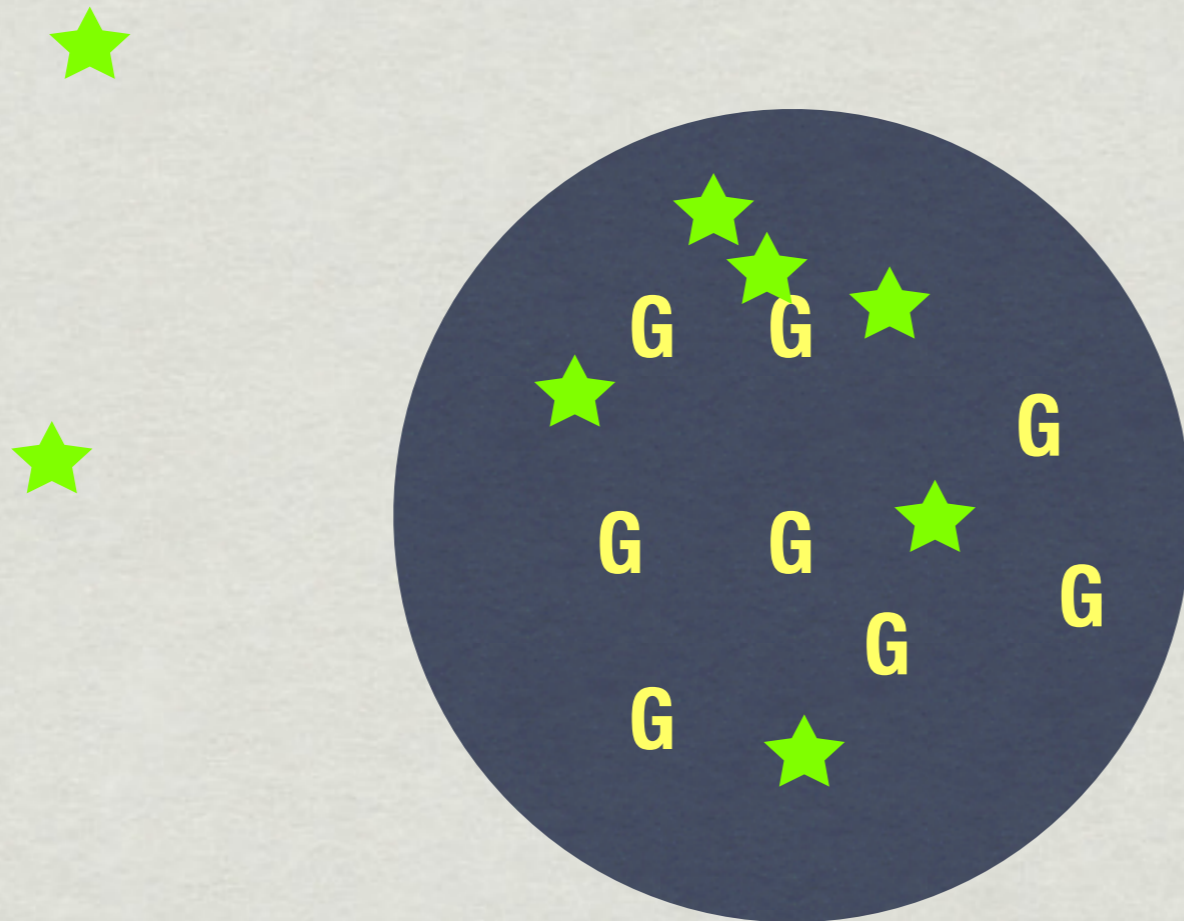
NECESSARY, BUT NOT SUFFICIENT, CAUSE.

Regular exercise, a low-fat diet, and one alcoholic drink a day help prevent heart disease.

NOT NECESSARY, AND NOT SUFFICIENT CAUSALLY.

Necessary? Sufficient?

If no animals enter a reproducing population and none leaves, then if there is an increase in the frequency of a particular gene in the population, the increase is the result of either mutation or of selection.



**ONLY TWO POSSIBLE
CAUSES=
(1) MUTATION
(2) SELECTION**