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# Independent and Dependent Variables: Definitions, Examples and Other Types

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## Abstract

Quantitative research questions and hypotheses depend on a clear statement of which variable is expected to affect which. When the roles are confused, hypotheses point the wrong way and the analysis tests a relationship the study did not intend to test. This article defines the independent variable as the presumed cause and the dependent variable as the measured outcome, and describes control variables, which are held constant in an experiment or adjusted for statistically in observational research. A single hypothetical experiment, in which four pots of the same plant receive different amounts of fertilizer, illustrates each role. The article compares experimental, quasi-experimental and correlational designs by the causal claims each supports, and offers three checks for identifying each variable's role, applied to research questions from completed doctoral studies. It then distinguishes moderating variables, which change the strength or direction of a relationship, from mediating variables, which explain how it arises, and both from confounding variables, which distort it from outside. It closes with latent variables and with common errors in specifying variables. It is intended for students and early-career researchers designing a quantitative study, and for the educators who teach research methods.

**Keywords:** independent and dependent variables; dependent and independent variables with examples; define dependent and independent variables; examples of independent dependent and controlled variables; independent vs dependent variable; moderating and mediating variables; open educational resource

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## 1. Introduction

A quantitative study is built on a statement of which variable is expected to affect which. If that statement is wrong, the error does not stay in one place: the hypotheses point the wrong way, the analysis tests the wrong relationship, and an examiner or reviewer reading the methods section is likely to notice. The mistake is easy to make and costly to correct late in a project.

Confusion about variables often begins in the research question, when the question does not make clear what is expected to affect what. This article sets out each type of variable and follows one simple experiment through all of them, so that the differences can be seen side by side. Section 2 defines a variable, and Sections 3 to 6 cover the core roles and how to identify them in a research question. Sections 7 to 9 describe three kinds of "third variable", each of which bears on the relationship between an independent and a dependent variable: moderating, mediating and confounding variables. Sections 10 and 11 cover latent variables and common errors in specifying variables.

## 2. What a Variable Is

A variable is **any characteristic that varies** from one person, place, time or condition to the next. The dose of a medicine is a variable, because it can be higher or lower. So are age, income, job satisfaction and test scores, because people differ on each of them.

Variables also differ in type. Some are categories (gender, or the teaching method a class receives); others are numbers on a scale (age, a test score). The type guides **which statistical tests are appropriate**. Stevens (1946) distinguished four scales, or levels, of measurement (nominal, ordinal, interval and ratio), each permitting a different set of statistics. Figure 1 summarizes the four levels.

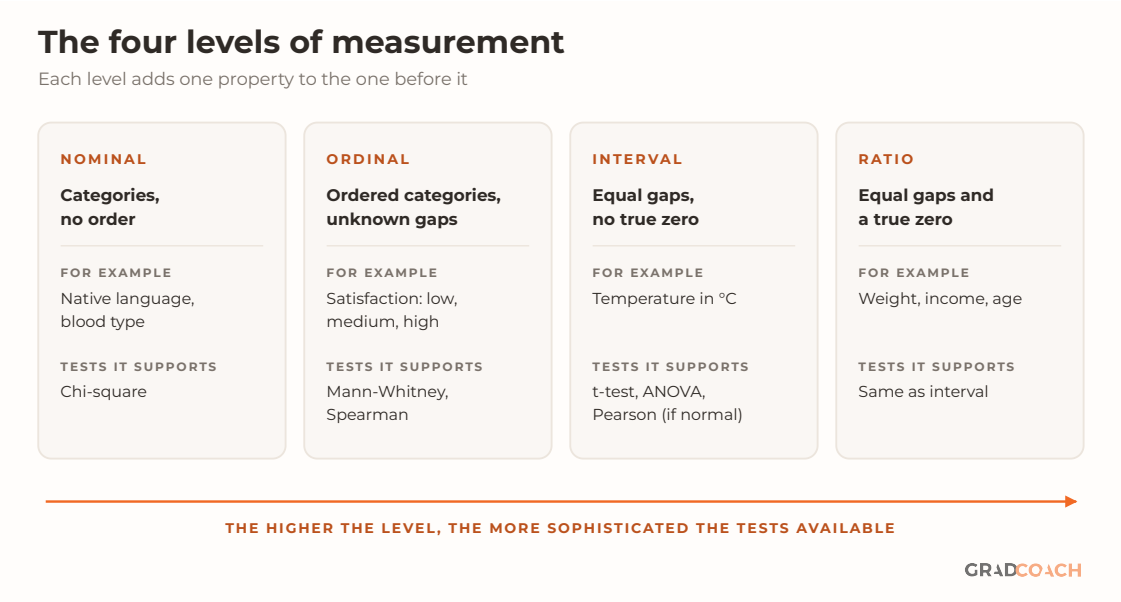



**Figure 1.** The four levels of measurement and the tests each typically supports.

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Most research questions ask how one variable relates to another: for example, how age relates to sleep quality, how different teaching methods affect learning outcomes, or how diet affects weight gain or loss. Each of these questions has a presumed cause and a presumed effect, and the labels described in the rest of this article name those roles. In experimental studies especially, the aim is to understand **cause and effect**: one variable is changed, others are held steady, and the outcome is observed. Three variables do most of that work: the independent, dependent and control variables.

## 3. The Independent Variable

The independent variable is **the presumed cause** in a relationship between two or more variables. When it changes, another variable is expected to change in response. The APA Dictionary of Psychology defines it as the variable in an experiment that is manipulated, or that is observed to occur before the outcome, in order to assess its effect, and notes that it may or may not be causally related to the dependent variable (American Psychological Association [APA], 2018c). Three examples follow:

1. Increasing the **dosage of a medication** (variable A) could lead to better or worse **health outcomes** for a patient (variable B).
2. Changing a **teaching method** (variable A) could change the **test scores** students earn on a standardized test (variable B).
3. Changing a **diet** (variable A) could lead to **weight** loss or gain (variable B).

In each case, variable A is the independent variable. In statistical analyses such as path analysis, regression analysis and structural equation modeling, an independent variable is often called a causal, explanatory or predictor variable (APA, 2018c).

Not every independent variable is like these three. A dose, a teaching method and a diet can all be set by a researcher, so they can be manipulated in an experiment. Others, such as age, gender or years of experience, **cannot be assigned by the researcher**. A study can only compare people who already differ on them, which limits what it can claim (Section 4.1).

A simple hypothetical experiment, used throughout this article, makes the roles concrete: four pots of the same plant, each given a different amount of fertilizer. The amount of fertilizer is the independent variable (Figure 2, left).

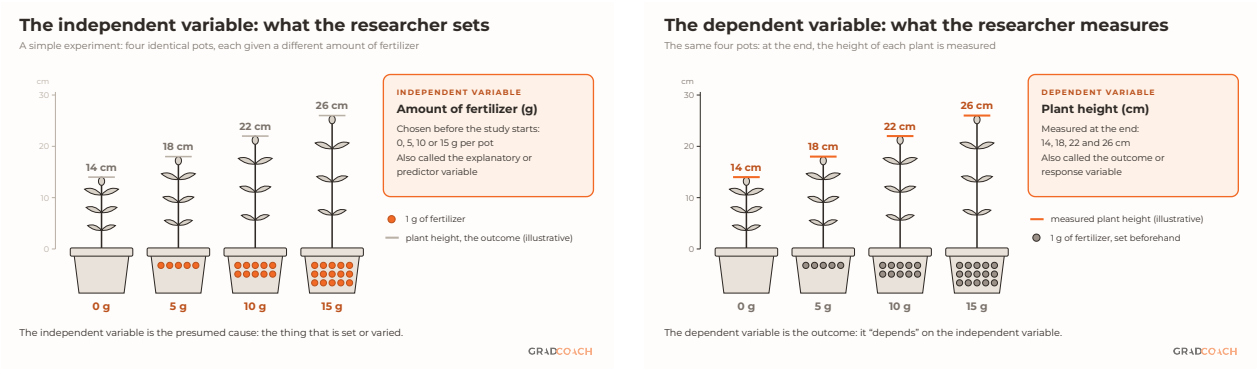



**Figure 2.** The independent variable set for each pot (left) and the dependent variable measured at the end (right).

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## 4. The Dependent Variable

If the independent variable is the cause, the dependent variable is the **effect**, or outcome. It is the variable expected to change as a result of a change in the independent variable, which is why it "depends" on it. It is also called the outcome, response or criterion variable (APA, 2018b). In the fertilizer experiment, the dependent variable is the height each plant reaches (Figure 2, right).

In the three examples in Section 3, variable B (health outcomes, test scores and weight) is the dependent variable.

The dependent variable must be measured with particular care, because any change in it is the study's result. An outcome is not always easy to measure reliably, and even a reliable measure cannot by itself show that **the independent variable caused the change** rather than something else.

### 4.1 Correlation, causation and research design

Correlation does not imply causation: two variables can move together without one causing the other (Rohrer, 2018). The number of people who own a certain brand of car might be correlated with the number of people in a certain type of job. This does not mean that owning the car leads to the job, or the reverse. A third factor, such as income or age group, could drive both. Such a factor is a confounding variable (Section 9).

Confidence that an independent variable causes a change in a dependent variable usually requires an **experimental design**, in which the researcher controls the conditions and randomly assigns cases to them. Random assignment of the independent variable rules out confounding of this kind, because a third factor such as income can no longer be systematically related to which condition a case receives (Rohrer, 2018, p. 38). Even so, results obtained in a laboratory do not always hold in real settings.

The alternatives are correlational research, in which nothing is manipulated, and quasi-experimental research, in which a change is introduced but cases are not randomly assigned to it. In a quasi-experiment, assignment usually rests on self-selection or on an administrator's decision, which introduces threats to internal validity that the researcher must acknowledge when interpreting the findings (APA, 2018e). Both designs can run on a larger scale and in real settings. Figure 3 compares the three designs using the fertilizer experiment.

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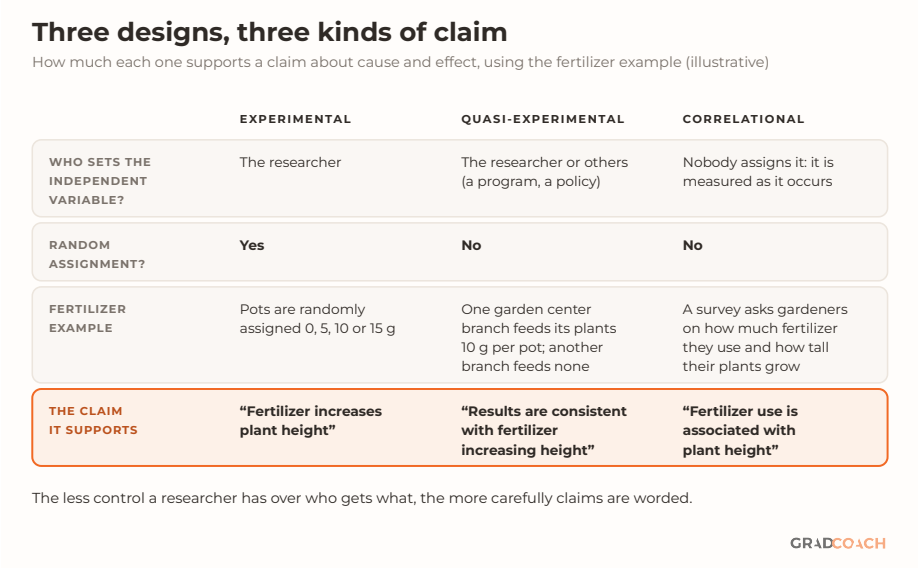



**Figure 3.** Experimental, quasi-experimental and correlational designs and the claims each supports.

A correlational or quasi-experimental study should therefore **not be reported in the language of an experiment**, and its limitations should be acknowledged in the write-up.

## 5. Control Variables

In an experiment, a control variable (or controlled variable) is a variable that is **intentionally held constant** so that it cannot influence the result. It stays the same for every participant and every condition. The APA Dictionary of Psychology describes a control variable as one that is thought to affect the outcome but is not of particular interest to the researcher; its effects are removed either by holding it at a constant level or by statistical means (APA, 2018a).

Control variables exist because of the problem described in Section 4: the effect of an independent variable is hard to isolate when other factors are changing too. Researchers therefore **hold as many of those factors steady** as is reasonable. Depending on the study, variables that may need to be controlled include temperature, time of day, lighting, the instructions given to participants, and noise or distractions.

There is **no generic list**, because the appropriate controls depend on the study. A researcher should consider everything that could vary in the setting and affect the outcome, and decide how each will be handled. Published studies close to the planned one are a useful guide to which variables others have controlled for.

In the fertilizer experiment, the type of plant, the type of fertilizer, the amount of sunlight and the pot size are **the same in every pot**, so they are the controlled variables. Figure 4 combines the three roles. Because only the fertilizer changes between pots, any difference in height points back to it.

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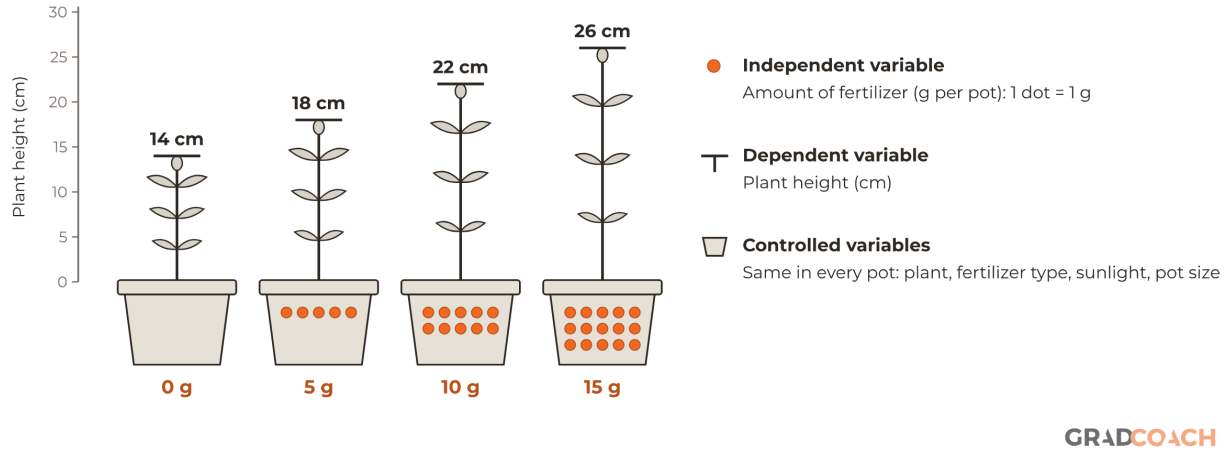



**Figure 4.** Independent, dependent and controlled variables in one experiment. From Jansen (2026b), CC BY 4.0.

Outside the laboratory, it is often impossible to hold things constant. A survey cannot make every respondent the same age. Instead, the variable is **measured and adjusted for** in the analysis, which is called statistical control (APA, 2018a). An education doctorate from Valdosta State University, comparing business and educational leaders, builds statistical control into its research question:

> RQ4: What differences, if any, exist between business leaders and educational leaders on Model the Way, Inspire a Shared Vision, Challenge the Process, Enable Others to Act and Encourage the Heart after controlling for age and length of employment?
>
> Feuerbach (2016, p. 11)

The phrase "after controlling for" names two control variables, age and length of employment, and indicates that the comparison between business and educational leaders is made with both taken into account. A study that uses a survey or existing records should **name its control variables in its research questions or hypotheses** in the same way.

No study can control every possible variable. For those that cannot be controlled, the potential impact should be **acknowledged and taken into account** in the conclusions drawn.

## 6. Identifying the Role of Each Variable

When applied to a particular research question, the labels can be difficult to assign. Three checks help:

1. **Which variable comes first in time?** A cause must come before its effect, so the variable that occurs or is set first is usually the independent variable. Hill (1965/2015) listed this temporal relationship among the considerations for judging whether an association is causal.
2. **Which variable is set, or used to group participants?** A variable that the researcher assigns, or by which participants are sorted, is usually the independent variable.
3. **Which variable is measured as the result?** The variable collected at the end, to see whether it changed, is the dependent variable.

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If all three checks point the same way, the roles are settled. If they do not, **the research question probably does not yet state what is expected to affect what**, and it should be revised before anything else.

The wording of a research question usually reveals the roles, through phrases such as "the impact of X on Y", "a difference in Y between groups of X" and "X as predictors of Y", where X is the independent variable and Y the dependent variable. Table 1 gives five research questions from completed doctoral studies, with the variables each suggests.

**Table 1.** Research questions from five doctoral studies, with their independent and dependent variables.

| Research question | Independent variable | Dependent variable |
|---|---|---|
| "What is the impact of temperature setting on the effectiveness of AutoDoc?" (Kou, 2026, p. 76) | The temperature setting of the language model | How effective AutoDoc's documents are |
| "How do subtitle errors impact the evaluation of the speaker and the content?" (Kadoma, 2026, p. 12) | Subtitle errors | How listeners rate the speaker and the content |
| "...a significant difference in the academic achievement of students who participated in the after-school program compared to the students who did not..." (Green, 2022, p. 7) | Taking part in the after-school program, or not | Scores on the state English language arts test |
| "Is there a statistically significant relationship between attending library instruction and GPA for first-time, full-time freshman?" (Wright, 2019, p. 11) | Attending library instruction | GPA |
| "Are selected athletic training clinical education variables and faculty demographic characteristics significant predictors of the three-year aggregate [Board of Certification] pass rate..." (Walters, 2020, p. 6) | Clinical education variables and faculty demographics | The programs' three-year pass rate |

The library question is the hardest to read, because "a relationship between" does not say which way the influence runs. **The order in time settles it**: students attend library instruction before their grade point average (GPA) is recorded, so instruction is the independent variable.

None of the last three questions suggests that anyone was randomly assigned. In the after-school study, school staff and parents identified students for the program from their earlier test scores, grades and promotion status, and participation was optional (Green, 2022, pp. 9–10); in the library study, a class received instruction only if its professor requested a session (Wright, 2019, p. 10). Studies of this kind can show a relationship but cannot establish a cause (Section 4.1).

"Effectiveness" in the first row also deserves attention. A dependent variable must be measurable, and in its temperature experiment Kou's thesis scores AutoDoc's documents on **correctness, uniqueness, overlap and the number of snippets** (Kou, 2026, pp. 91–92). A dependent variable that names a broad idea, such as effectiveness or satisfaction, should be accompanied by a statement of how it will be measured.

Once the roles are clear, they should be stated plainly in the methodology. The following extract, from a business doctorate at Lincoln International Business School, University of Lincoln, sets out all three roles in a few sentences:

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> The dependent variable, adoption intention (ADT), represents consumers' willingness to use CDPs. The independent variables were derived from two theoretical frameworks. ... Control variables were also incorporated into the model. Consumers with a monthly disposable income above VND 10 million were categorized into a high-income group (coded as 2), while others were classified as low-income (coded as 1).
>
> Luong (2025, p. 79)

The extract names the dependent variable first, then the two theories from which the independent variables came, then **exactly how a control variable was coded**. The full passage names all nine independent variables and gives the coding of each of the four control variables (Luong, 2025, p. 79). A reader never has to guess which role a variable plays. Where a study has more than a handful of variables, a table can do the same job.

A variable's role can also change within one thesis. In Luong's regression model, income is a control variable. A separate multivariate analysis of variance (MANOVA), which compares groups on several outcomes at once, tested hypothesis H11. In that analysis, income becomes the independent variable, and six of the regression's independent variables, such as price value and compatibility, become the dependent variables (Luong, 2025, pp. 91–107). That hypothesis was rejected, but the point holds: **the role belongs to the analysis, not to the variable**, and should be stated for each analysis.

Independent, dependent and control variables are the ones met most often, but they are not the only ones. Moderating, mediating and confounding variables are all "third variables": each, in a different way, changes how the relationship between an independent and a dependent variable should be read. Latent variables raise a problem of measurement rather than of relationships. The following sections take them in that order.

## 7. Moderating Variables

A moderating variable **changes the strength or direction** of the relationship between an independent variable and a dependent variable. In the classic paper on the distinction, Baron and Kenny (1986) define a moderator as a qualitative or quantitative variable "that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable" (p. 1174). A moderator indicates when, or for whom, an effect is larger, smaller or reversed.

In a study of sleep deprivation and academic performance, for example, gender could be tested as a moderator, to see whether men's and women's scores decline by different amounts when they lose sleep. If they do, gender moderates the relationship.

A moderator need not be a category. In the fertilizer experiment, sunlight was held constant. If sunlight is instead allowed to vary, it becomes a candidate moderator. In the illustrative model in Figure 5, each gram of fertilizer adds 0.35 cm of height at 4 hours of sun a day, 0.8 cm at 7 hours and 1.25 cm at 10 hours. Fertilizer still helps in every case, but **how much it helps depends on the sunlight**, so sunlight is a moderator.

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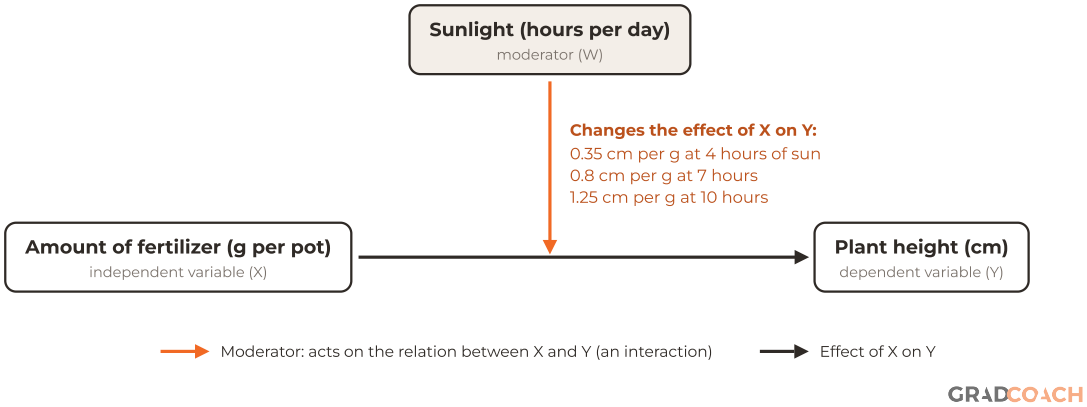



**Figure 5.** Sunlight moderating the effect of fertilizer on plant height. From Jansen (2026d), CC BY 4.0.

In Figure 5, the moderator's arrow lands on the arrow from fertilizer (X) to height (Y), not on height: sunlight changes the effect itself. Sunlight was a control variable in the first experiment and is a moderator here. When controls are planned, it is therefore worth considering, for each one, whether the effect of the independent variable might depend on it.

Moderators are often harder to detect than researchers expect. Anchoring is the pull of a previously considered number on a later estimate. A psychology doctorate from the University of Bamberg reviewed the research on whether eight personality traits, as the thesis classes them (the Big Five, cognitive ability, cognitive reflection and self-control), moderate anchoring. Its summary is direct:

> Meta-analyses for each of the potential moderators revealed that there is currently no evidence of any personality moderator of anchoring. The most plausible reason for the absence of personality moderators is that individuals' susceptibility to anchoring cannot be measured reliably.
>
> Röseler (2021, p. iv)

Two lessons follow. First, **an expected moderator may not appear**, and that is still a finding worth reporting. Second, **a test of moderation is only as good as its measures**: if they are unreliable, a real moderator can remain hidden. In statistics, moderation is tested as an interaction effect between the independent variable and the moderator. Measurement error in the moderator or the independent variable results in low power in tests of multiplicative interaction effects (Busemeyer & Jones, 1983, as cited in Baron & Kenny, 1986, p. 1176). Interaction effects are also often modest in size, and a review of recent articles in influential psychology journals found that the median power to detect interactions of a typical size was .18, so the median study would detect a real interaction of that size less than one time in five (Sommet et al., 2023). A study that plans to test a moderator should therefore **check its sample size** with a power analysis designed for interactions.

## 8. Mediating Variables

A mediating variable sits **between the independent and dependent variables** and explains how one affects the other. The independent variable changes the mediator, and the mediator in turn changes the outcome. Baron and Kenny (1986) draw the line between mediators and moderators in

a single sentence:

> Whereas moderator variables specify when certain effects will hold, mediators speak to how or why such effects occur.
>
> Baron and Kenny (1986, p. 1176)

In the fertilizer experiment, one reason fertilizer makes plants taller is that **it raises the nitrogen in the soil**, and nitrogen helps the plant grow. Soil nitrogen is the mediator.

In the illustrative model in Figure 6, each gram of fertilizer raises soil nitrogen by 4 mg/kg (path *a*), and each mg/kg of nitrogen adds 0.15 cm of height with fertilizer held constant (path *b*). The product of the two is the **indirect effect**: 4 × 0.15 = 0.6 cm per gram. The remaining 0.2 cm per gram is the direct effect (*c*′), which does not run through nitrogen, and the two sum to the total effect of 0.8 cm per gram (*c*). In the single-mediator model estimated by ordinary least squares regression, the product *ab* equals the difference *c* − *c*′, so the indirect effect can be calculated either way (MacKinnon et al., 2007).

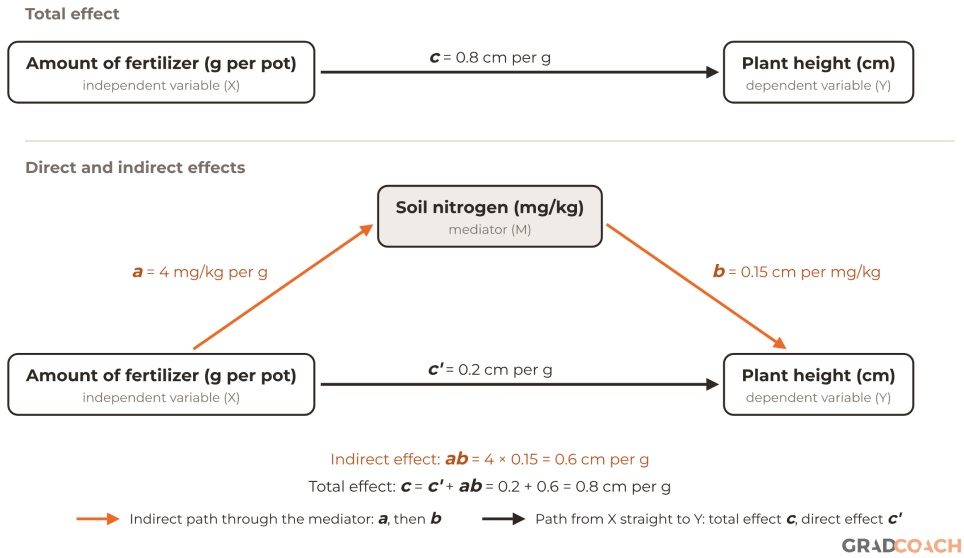



**Figure 6.** Soil nitrogen mediating the effect of fertilizer on plant height. From Jansen (2026c), CC BY 4.0.

The defining feature of a mediator is that **it is caused by the independent variable** and in turn affects the outcome. A third variable that influences both the independent and the dependent variable from outside is not a mediator but a confounder (Rohrer, 2018, p. 34; Section 9).

A mediation question usually names the mediator outright. This one comes from an education doctorate on English language learners:

> RQ 3 – To what extent is the relationship between English Language Proficiency level and academic achievement of English language learners mediated by academic growth?
>
> Loughridge (2022, p. 50)

Here, English language proficiency is the independent variable, academic achievement is the dependent variable, and academic growth is the proposed mediator. The phrase “to what extent” matters. It leaves room for growth to explain part of the relationship rather than all of it, just as

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nitrogen explains 0.6 of the 0.8 cm in the plant example. Baron and Kenny (1986, p. 1176) treat mediation as a matter of degree: a direct path reduced to zero is strong evidence for a single, dominant mediator, while a direct path that remains indicates that other mediating factors are also at work. A researcher proposing a mediator should **state why the independent variable should change it**, and phrase the question so that partial mediation is a possible answer.

## 9. Confounding Variables

A confounding variable is **a factor outside the main relationship** that can distort it. Skelly et al. (2012) describe confounding as a mixing of effects, in which the effect of the exposure under study (the independent variable, in this article's terms) is mixed with the effect of an additional factor, distorting the true relationship. For a variable to confound a relationship, it must meet three conditions (Skelly et al., 2012):

1. It is **associated with the independent variable**.
2. It is **related to the dependent variable** in its own right, not only through the independent variable.
3. It is **not caused by the independent variable** or by the outcome. A variable caused by the independent variable that lies on the path to the outcome is a mediator (Section 8).

The standard example is ice cream and drownings. Sales of ice cream and the number of drownings rise together, but ice cream does not cause drowning. **Hot weather drives both**: more people buy ice cream, and more people go swimming (Figure 7).

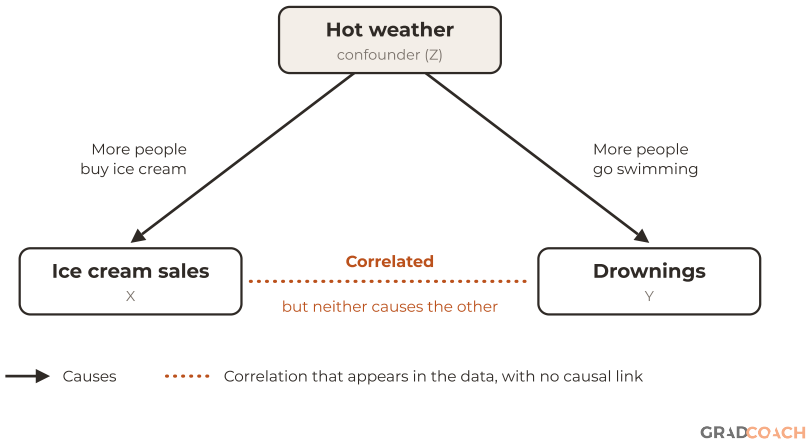



**Figure 7.** A confounder: hot weather causes both ice cream sales and drownings. From Jansen (2026a), CC BY 4.0.

Confounders appear frequently in real research, often in places that look obvious once identified. Advertising is one example. A resource economics doctorate from the University of Massachusetts Amherst sets out the problem:

> Firms increase their advertising spending at times when and in places where sales are also likely to be higher. Indeed, to address the problem of unadjusted confounders in advertising effects, most of the marketing and economics literature to date has adopted an experimental approach.
>
> Cengiz (2022, p. 8)

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The logic is the same as in the ice cream case. Whatever makes sales likely to be high, such as a holiday season, also leads firms to spend more on advertising, so a simple comparison would credit the advertising with sales it did not cause. The remedy the extract describes, experimentation, works because **randomly assigning the independent variable** prevents the confounder from lining up with it (Rohrer, 2018, p. 38).

Where randomization is not possible, the next step is to measure the likely confounders and adjust for them. Skelly et al. (2012) conclude that study design must include the measurement and reporting of potential confounders, and that their association with both the exposure and the outcome must be explored in the analysis. They single out demographic and clinical factors; in their spine-surgery example the candidates are age, weight and smoking status. Potential confounders should be **listed before data are collected**, because a variable that was never measured cannot be adjusted for.

## 10. Latent Variables

A latent variable is one that **cannot be observed or measured directly**. The APA Dictionary of Psychology defines it as a theoretical construct used to explain one or more manifest variables, the variables that can be measured, and notes that it is approximated through several measures, each presumed to assess part of the construct (APA, 2018d). The same entry gives two other names for it: latent construct and latent factor.

In a study of mental health, for example, resilience could be a latent variable. It cannot be measured directly, but it can be inferred from survey items about how quickly people recover from setbacks, how calm they remain under pressure, and whether they persist when things become difficult. Many other concepts that researchers study are latent, among them emotional intelligence, quality of life, business confidence, ease of use and fitness.

In practice, a latent variable is measured through **several observed indicators**, usually survey items, each capturing part of it. The APA dictionary's example is conscientiousness, inferred from items about behaviors such as attending classes consistently and handing in assignments on time; the patterns across such items are then analyzed to infer the latent variable (APA, 2018d), with methods such as factor analysis and structural equation modeling. Figure 8 shows the resilience example.

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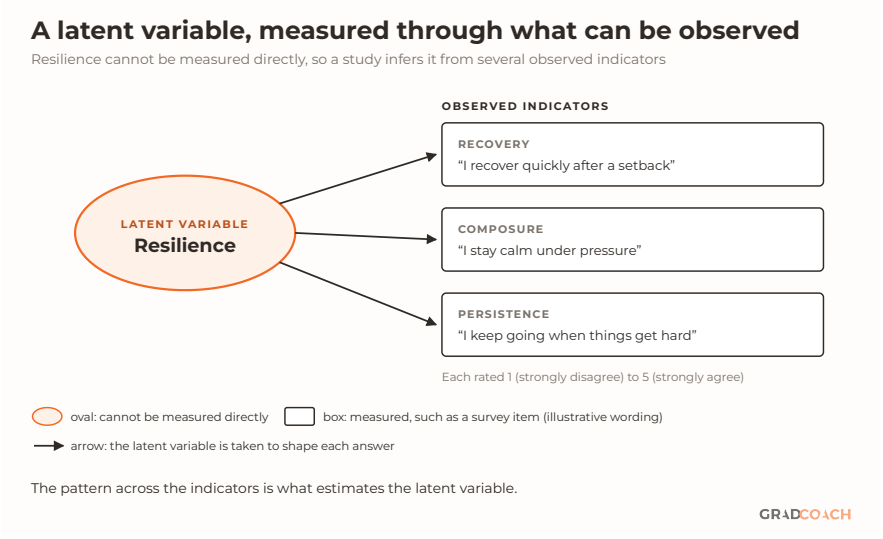



**Figure 8.** A latent variable, resilience, estimated from three observed indicators.

A study that includes a latent variable should report how reliable its indicators are as a set, because the estimate is only as good as the items behind it. Coefficient alpha is the most widely reported reliability statistic in psychological research, despite well-documented deficiencies, and coefficient omega is a practical alternative (Dunn et al., 2014).

## 11. Common Errors in Specifying Variables

Three errors in specifying variables are worth checking for in a draft:

1. **Calling the outcome the independent variable.** A variable measured at the end to see whether it changed is the dependent variable, whatever label earlier studies have given it.
2. **Confusing moderators and mediators.** A moderator changes how strongly X affects Y; a mediator is changed by X and then changes Y (Sections 7 and 8). A third variable that X cannot change is not a mediator.
3. **Treating demographic variables as background.** Age, gender and income can be control variables in one study and moderators in another. The role each plays should be decided and stated.

Most of these errors can be avoided by one practice: before the hypotheses are written, **the model is drawn as boxes and arrows**, with every variable in it. Graphical causal models of this kind make a study's assumptions about the relations between variables explicit (Rohrer, 2018). A variable that cannot be placed on the diagram does not yet have a defined role in the study.

## 12. Conclusion

The independent variable is the presumed cause, the dependent variable is the measured outcome, and control variables are held constant or adjusted for so that they cannot distort the result. The research question should make each role clear, and the three checks in Section 6 identify them. A moderator changes how strongly the independent variable affects the outcome, while a mediator explains how it does so and is itself caused by the independent variable. A confounder is associat-

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ed with both variables from outside the relationship, so it should be controlled by randomization where possible and measured and adjusted for where not. Unless the independent variable was randomly assigned, causal claims should be worded with caution: “associated with” for a correlational study, and “consistent with an effect” for a quasi-experiment.

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