

Hypothesis

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Hypothesis is an informed statement that suggests a possible relationship between variables measured in research.

A better explanation of the purpose of a hypothesis is that a hypothesis is a proposed solution to a problem.

Example

If 50 mL of water are added to my plants each day and they grow, then adding 100 mL of water each day will make them grow even more.

Hypothesis and proposition

Hypothesis is an informed statement that suggests a possible relationship between variables measured in research.

A proposition is an argument based on those findings.

Both refer to the formulation of a possible answer to a specific scientific question. The main difference between the two is that a hypothesis must be testable and measurable, while a proposition deals with pure concept for which no laboratory test is currently available.

Proposition relies heavily on prior research, reasonable assumptions and existing correlative evidence. A scientist can use a proposition to spur further research on a question or pose one in hopes that further evidence or experimental methods will be discovered that will make it a testable hypothesis.

Examples of proposition

Organizations collaborate, because they derive mutual benefit.

Treating employees better will make them more loyal.

Man is mortal.

Examples of hypothesis

Drinking sugary drinks daily leads to obesity.

Overweight adults who value longevity and seek happiness are more likely than other adults to lose their excess weight and feel a more regular sense of joy.

Null and Alternate Hypothesis

Null hypothesis, H_0 — the "no effect" statement

Temperature has no effect on the solubility of salt.

The new teaching method makes no difference to exam scores.

Alternate hypothesis, H_1 — what you suspect is true

Solubility of salt increases with temperature. (directional)

The new teaching method changes exam scores. (non-directional)

We never "prove" H_0 — we either reject it, or fail to reject it.

A null hypothesis (H_0):

There is no significant change in my health during the times when I drink green tea only or coffee only.

An alternate hypothesis (H_1, directional):

My health improves during the time when I drink green tea only, as opposed to coffee only.

If I eat more vegetables, then I will lose weight faster.

If I add fertilizer to my garden, then my plants will grow faster.

Type I and Type II errors

The courtroom: H_0 = "the accused is innocent"

Type I error (α): convicting an innocent person — rejecting H_0 when it is TRUE.

A false positive — a false alarm.

Type II error (β): letting a guilty person go free — failing to reject H_0 when it is FALSE.

A false negative — a miss.

Memory aid

Type I — crying wolf when there is no wolf.

Type II — sleeping through a real wolf.

The same two errors, other names

Smoke alarm: false alarm (Type I) vs missed fire (Type II).

Medical test, H_0 = "no disease": false positive (Type I) vs false negative (Type II).

Fingerprint scanner — H_0 = "the claimed user is genuine"

Rejecting a genuine user = Type I = FRR (False Rejection Rate).

Accepting an impostor = Type II = FAR (False Acceptance Rate).

The trade-off

Making one error rarer makes the other more common — the FAR and FRR curves cross at the CER (crossover error rate). Which error is worse depends on the application: a bank vault fears FAR; your phone unlock fears FRR.

α, β and power

α = P(Type I error) — the significance level. YOU choose it in advance (usually 0.05): the maximum false-alarm risk you will tolerate.

β = P(Type II error) — the risk of missing a real effect.

Power = 1 − β — the chance of detecting an effect that is really there.

The tension

Making α stricter (0.05 → 0.01) makes false alarms rarer — but misses (β) more likely.

The only way to reduce both at once: a larger sample size n.

p-value vs α — do not mix them up

α is a threshold you fix BEFORE seeing the data (e.g. 0.05).

p is computed FROM the data: the probability of a result at least this extreme if H_0 were true.

Decision rule: reject H_0 if $p \le \alpha$

Example — is the coin fair?

Flip 100 times, get 61 heads. If the coin were fair, P(a result this lopsided) ≈ 0.035.

$p = 0.035 \le \alpha = 0.05 \rightarrow$ reject H_0: the coin is biased.

Warning

Never compare the test statistic with α. The statistic (z, t) is compared with a CRITICAL VALUE; the p-value is compared with α. ($z = 2.75 > 1.645 \Leftrightarrow p = 0.003 < 0.05$ — same verdict, two languages.)