# Developing a research hypothesis


## Dr. Luca Longo

School of Computer Science, Technological University Dublin

ADAPT centre, The global centre of excellence for digital content and media innovation (TCD, DIT, DCU, UCD)

AIRC, The Applied Intelligence Research Center (TU Dublin)

D-Real, SFI center for research training in digitally-enhanced reality

CeADAR, Ireland's centre for applied Artificial Intelligence

ML-Labs, SFI center for research training in machine learning









✉ **luca.longo@tudublin.ie**

**http://www.lucalongo.eu/**

# The research hypothesis

A research hypothesis is the most important element of a **scientific research project**.

It is a **predictive testable statement.**

If _____[*I do this*] _____, then _____[*this*]_____ will happen.

# Hypothesis: a precise statement

A hypothesis is a precise statement

- **directional hypothesis**: it indicates the nature and direction of the relationship/difference between variables
- **non-directional hypothesis**: it only states that relationship/difference will occur

# Hints for forming hypotheses

- single sentence
- simply stated
- at least one variable
- variable/s clearly stated
- relationship/difference precisely stated
- testable

Hypothesis is always tentative and it is the focus of the research

# What you think will happen

What you ’think’ will happen, of course, must be based on your understanding of the science (through a literature review) and scientific principles involved in the experiment you are proposing.

**Note**: you don’t simply ‘guess’.

It is not a random guess rather an ‘educated guess’ based on what you already know and learn about a phenomena.

# Hypothesis and variables

In order to write a robust hypothesis, you must understand what the **variables** are for your project.

**Reminder:** a hypothesis is a testable statement and **the variables in it must be testable**.

# An obvious statement

**Hypothesis**: If machine learning is used, then the performance can be better predicted

It seems like an obvious statement, isn't it?

*The above hypothesis is too simplistic for a post-graduate project!*

# Rationale

**You should find some problem for which the answer is not obvious or already known.**

The hypothesis must be:

- based on your ‘educated guess’ not on known data or facts
- written before starting with experimental procedures and not after.

# Tips for writing the hypothesis

The research hypothesis/es:

- come/s **after the research question**
- is **NOT a question** but a predictive testable statement
- must be **clear**, written in simple language and **precise**
- is followed by one **experiment** and not many
- must be **TESTABLE**

# Testable hypothesis

- **measurable variables:** to accept/reject a research hypothesis, an experiment needs to be planned/executed & measurements or observations made to check how planned variables are related;
- **replicability:** the experiment must be replicable multiple times and by other reseachers;
- **reproducibility:** the scientific findings obtained in the experiment must be reproducible by other researchers.

# Null hypothesis

The null hypothesis[1] (H0) is the **commonly accepted fact**.

Researchers and scientists work to **reject, disprove or nullify the null hypothesis**.

[1] The word 'null' means that it is a commonly accepted fact that researchers work to 'nullify'. This does not mean the statement is null itself (null $\sim$ nullifiable).

# Alternate hypothesis

An **alternate hypothesis** is a complementary (inverse) statement to the research (null) hypothesis.

Researchers come up with an alternate hypothesis, (one thought to explain a phenomenon), and then work to reject the null hypothesis.

## Why Do we need to Test the null hypothesis and not just prove the alternate one?

- part of the scientific process requires it
- various methods are used in science to prove/disprove theories, guaranteeing **new hypotheses have no flaws**
- Clearly stating both null & alternate hypotheses is safer and it ensures the research is **not flawed**[2]
- If aim is to prove the alternate hypothesis without considering the null hypothesis, we are set for failure & the experiment **won't be taken seriously**.

[2] Not including the null hypothesis in the research is considered extremely bad practice by the scientific community

# Example 1 - part 1

**Argument**: Not so long ago (even nowadays), people believe/ed that the world is/was flat.

**Null hypothesis** H0: The world is flat.
**Alternate hypothesis** H1: The world is round.

# Example 1 - part 2

Several scientists (ex. Copernicus) set out to disprove the null hypothesis.

**Result**: rejection of the null & acceptance of alternate.

Most people accepted it. Those who did/do not formed the Flat Earth Society[3].

[3] https://en.wikipedia.org/wiki/Modern_flat_Earth_societies

# Example 1 - part 3

What would have happened if Copernicus had not disproved the null hypothesis and merely proved the alternate?

**No one would have listened to him!**

In order to change the way people think, **we first must prove that their thinking is wrong**.

# Example 2 - hypothesis formation

The hypothesis is usually hidden in a word problem, and it is a statement of what you expect to happen in the experiment.

**Educated guess:** a researcher thinks that if Support Vector Machine (SVM) is applied to classify emails into ham/spam then an accuracy of 85% or more can be achieved [4].

[4] 85% because literature suggested this was the highest accuracy obtained so far

# Example 2 - convert hypothesis into math

**Alternate hypothesis H1**: accuracy $> 85\%$

**Null hypothesis H0**: accuracy $<= 85\%$

# Doubts

What if a researcher does not know what will happen?

# Example 3 - part 1

State what will happen if the experiment will not make any difference.

**Null hypothesis H0**: accuracy = 85%

**Alternate hypothesis H1**: accuracy $\neq$ 85%

# Suggested readings


- Creswell, J. 1994 **Research Design: Qualitative and Quantitative Approaches**. (Sage)
- Leary, 2014 **Introduction to behavioural research methods** (Pearson)
- Marder, M.P. 2011 **Research methods for science**. (Cambridge university press)