

# A Brief Overview of **\*\*\*P-Values\*\*\***

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“Open Science in Social Sciences”  
BA Blockseminar  
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The data and code to generate the figures in this lecture are available at

[https://github.com/nbreznau/p\\_values](https://github.com/nbreznau/p_values)

# What is a p-value?

- A statistical test result used to evaluate the **null hypothesis**

# What is a null hypothesis?

- The claim that something measured in the world is equal to zero
  - For example:
    - That a vaccine has zero impact on infection rates (a controlled experiment)
    - That the average height difference of boys and girls at age 5 is zero (population observation)
    - That there is zero difference in intelligence between immigrants and natives (population observation)
    - That income has zero effect on happiness after adjusting for religious beliefs (population observation, w/ adjustment)

# What is a p-value?

- A statistical test result used to evaluate the **null hypothesis**
- It is based entirely on **probability**

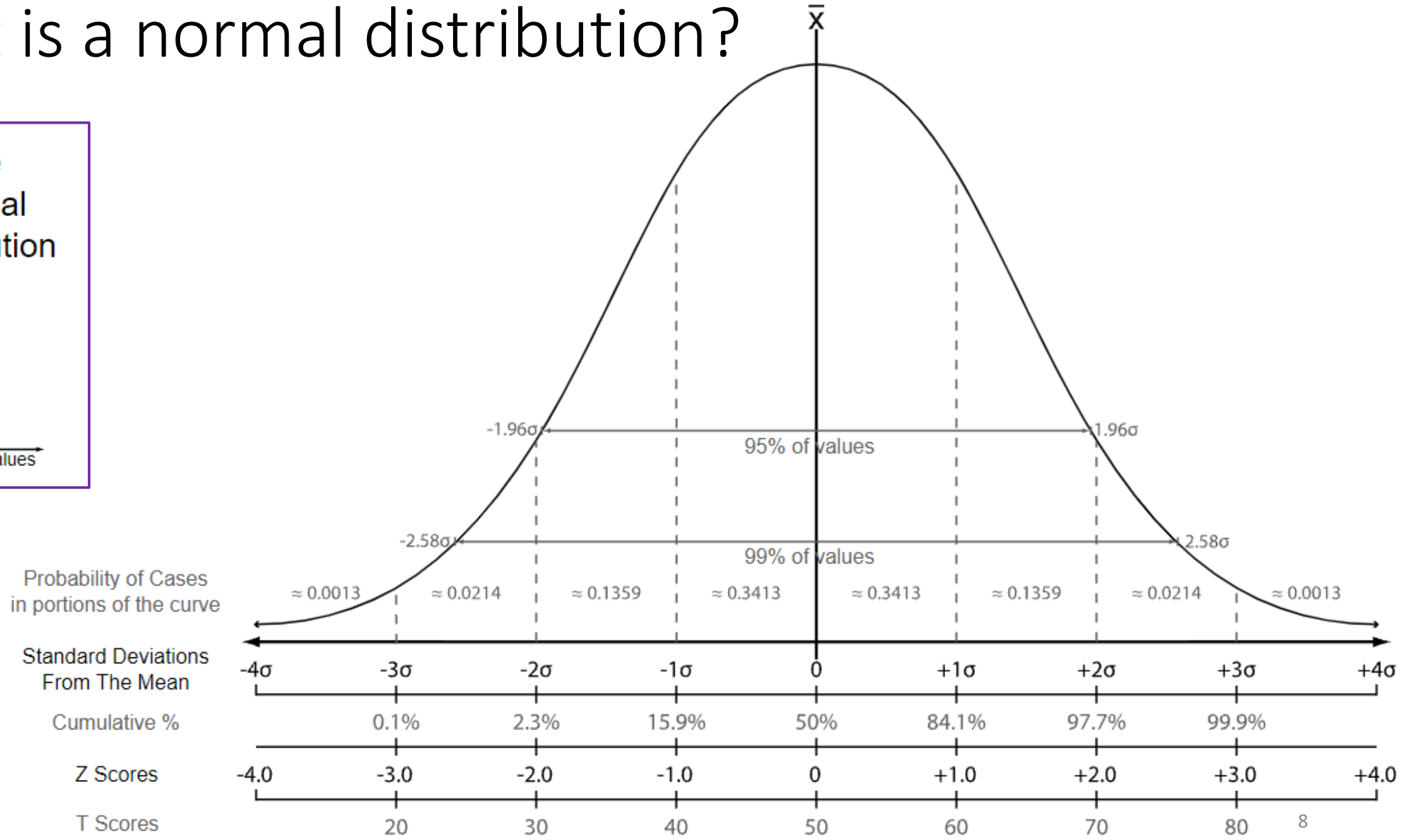
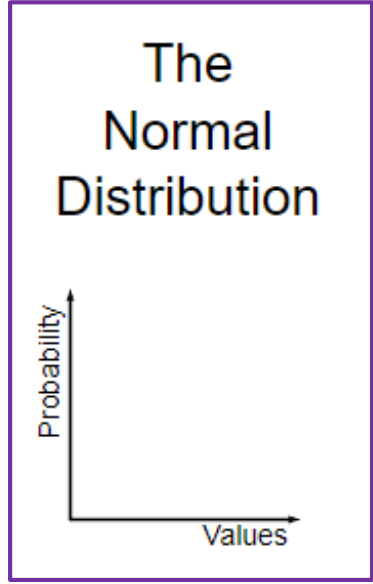
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  - Assumes that the data were randomly sampled from a population
  - Assumes that the test is properly modeled (e.g., improper: testing if getting sick or not makes one more likely to get a vaccine)
  - Assumes a **normal distribution** of observing the null hypothesis if it were true


# What is a normal distribution?





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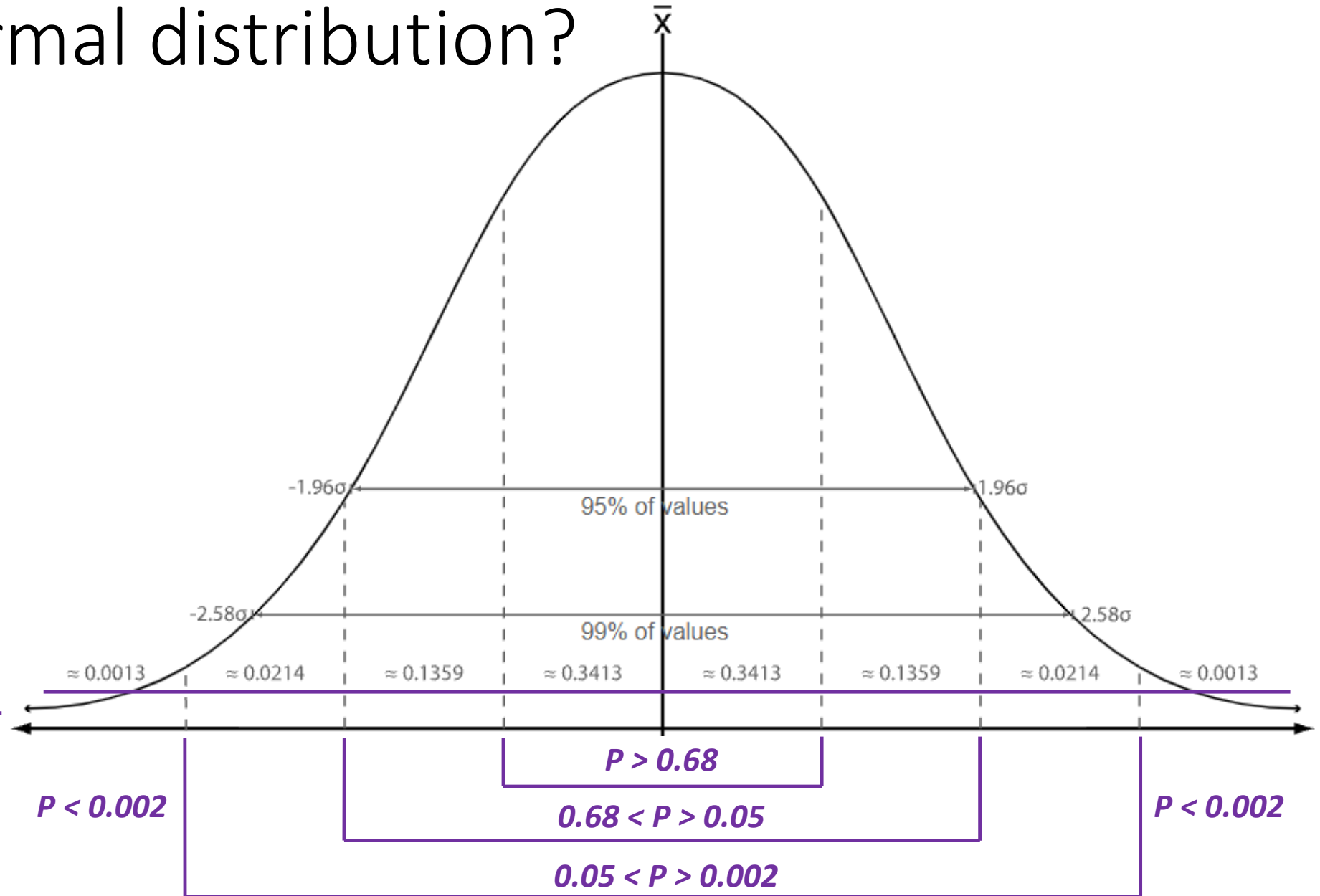


Also known as “**NHST**”  
(Null Hypothesis  
Significance Testing)

# What is a normal distribution?

P-Values  
(if all assumptions are true)

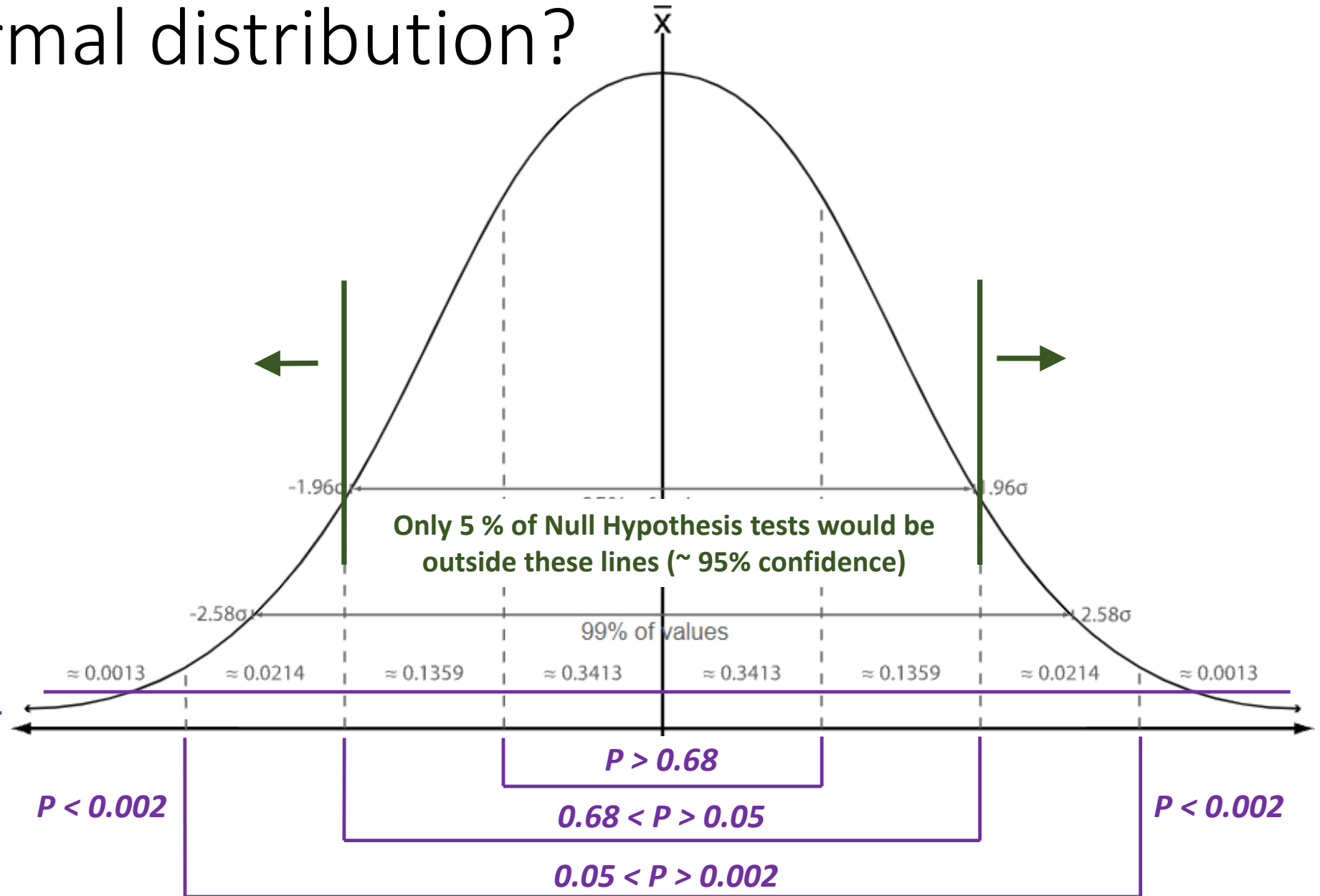
Probability of Cases  
in portions of the curve



# What is a normal distribution?

P-Values  
(if all assumptions are true)

Probability of Cases  
in portions of the curve



# Example 1. NHST – Comparing Means

## Comparing means

- Experiment (randomized controlled trial)
  - Zero difference in infection rates between vaccine and placebo groups
  - Zero difference in employer call-back rates for job candidates with ethnic versus native surnames
- Experiment (intervention)
  - Zero difference between adolescent test scores between schools with the introduction of different teaching techniques

# Example 1. NHST – Comparing Means

## Comparing means

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  - Zero difference in infection rates between vaccine and placebo groups
  - Zero difference in employer call-back rates for job candidates with ethnic versus native surnames
- Experiment (intervention)
  - Zero difference between adolescent test scores between schools with the introduction of different teaching techniques
- Demographic/population properties (non-experimental)
  - Zero difference between height of girls and boys at age five
  - **Zero difference between happiness between those with high incomes and those with low incomes**

# *Can Money Buy Happiness?*

## Example 1. NHST – Comparing Means

How would you test this?

# *Can Money Buy Happiness?*

## Example 1. NHST – Comparing Means

One idea:

- Sample from the populations of different countries
- Ask questions about happiness and income
- Compare the average happiness of those with high to those with low incomes

# *Can Money Buy Happiness?*

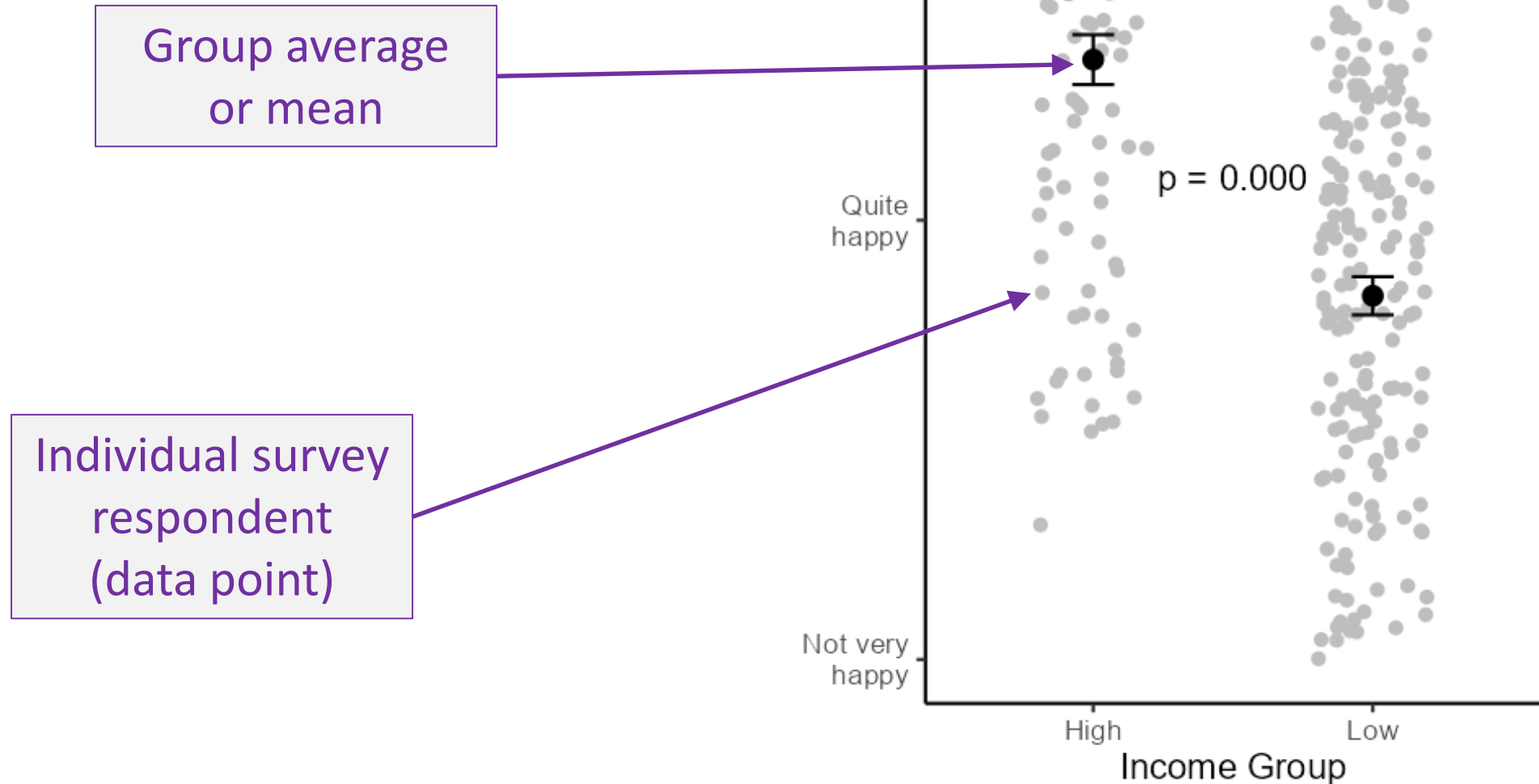
## Example 1. NHST – Comparing Means

### World Values Survey

- Up to 80 countries
- 1985-2021 (7 waves)
- Basis for studies of societal values and change
- Roughly 1,000 or more respondents per country

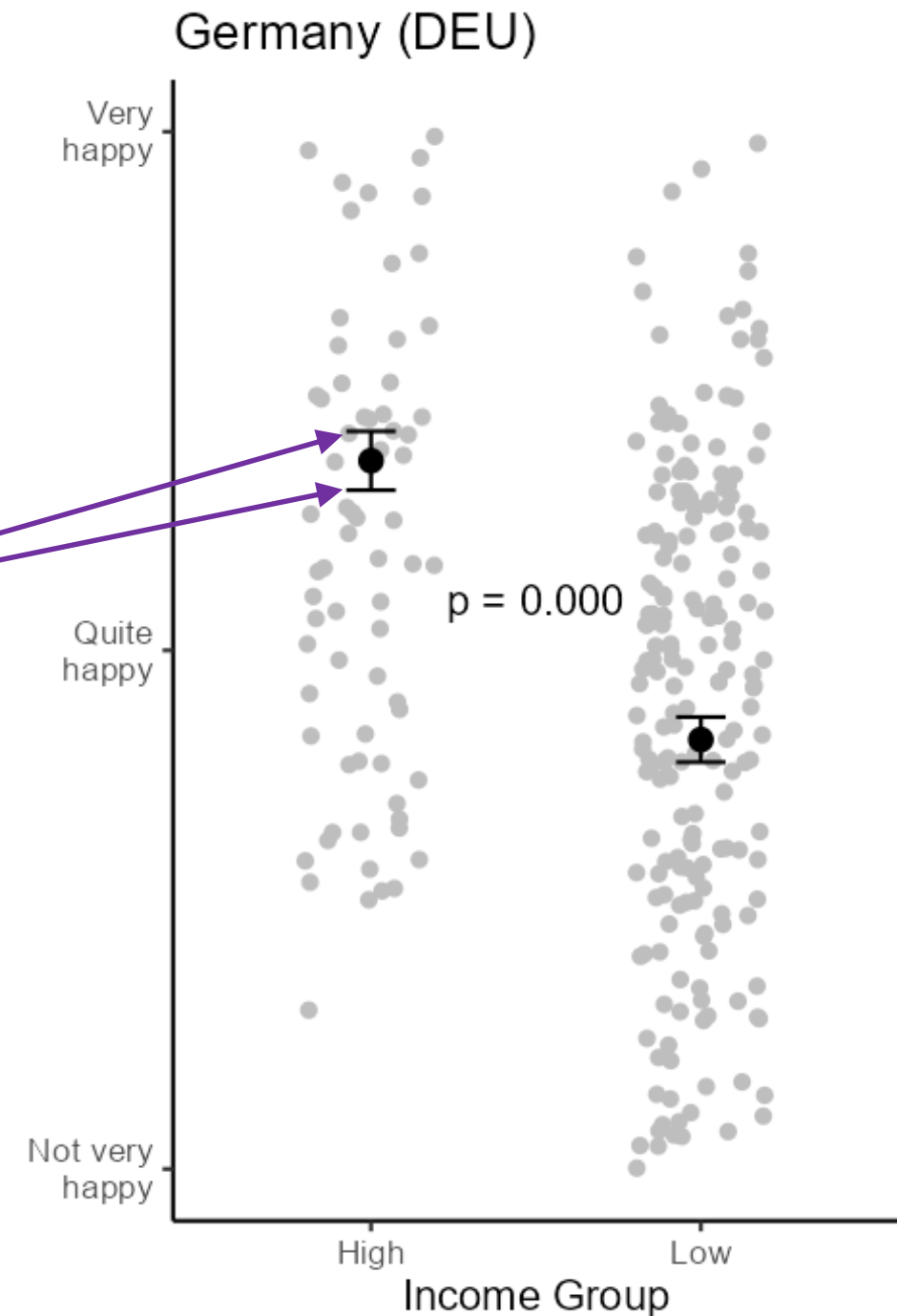


# *Can Money Buy Happiness?*



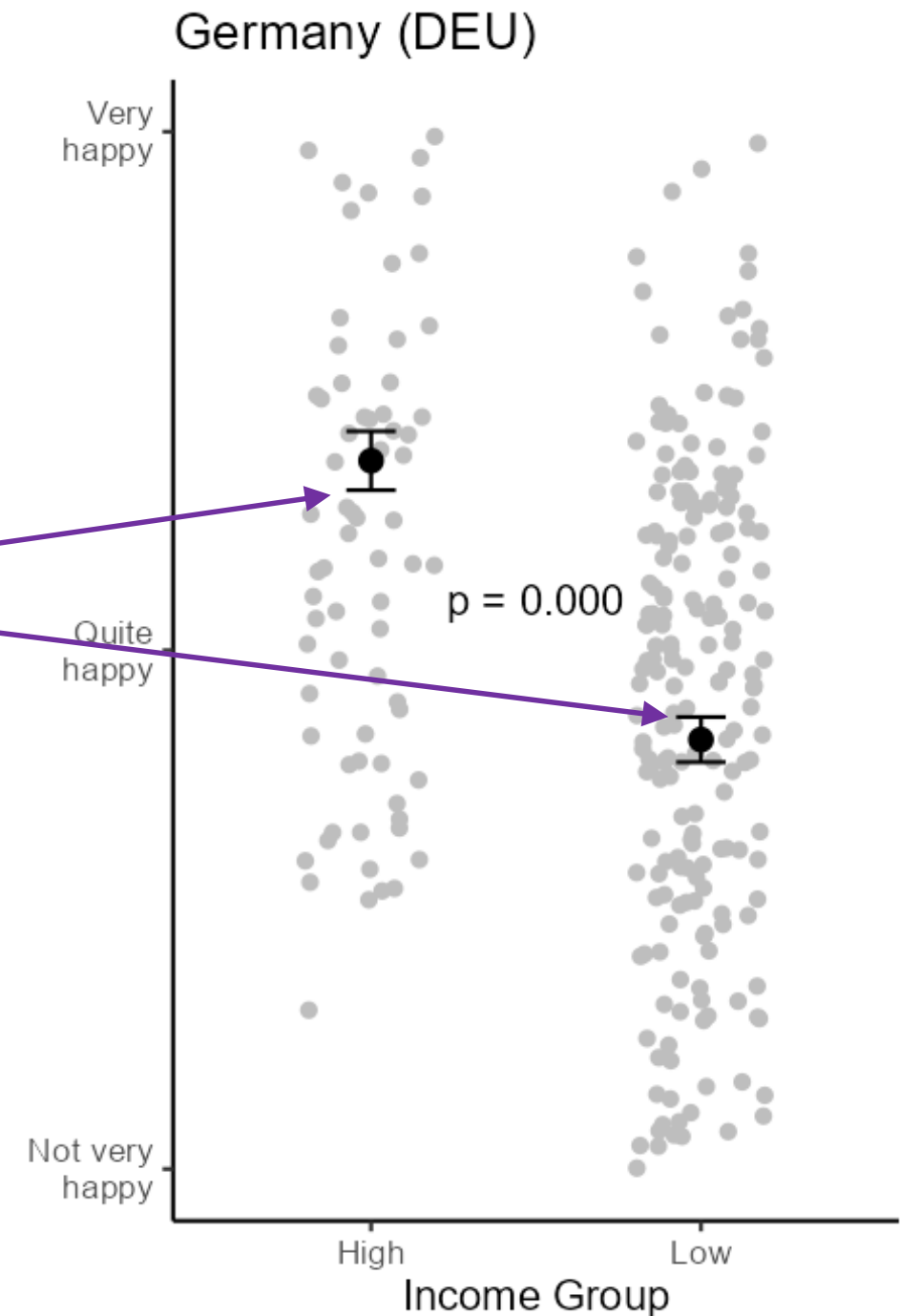
# *Can Money Buy Happiness?*

Standard error  
=  
Standard  
deviation /  
square root of  
sample size



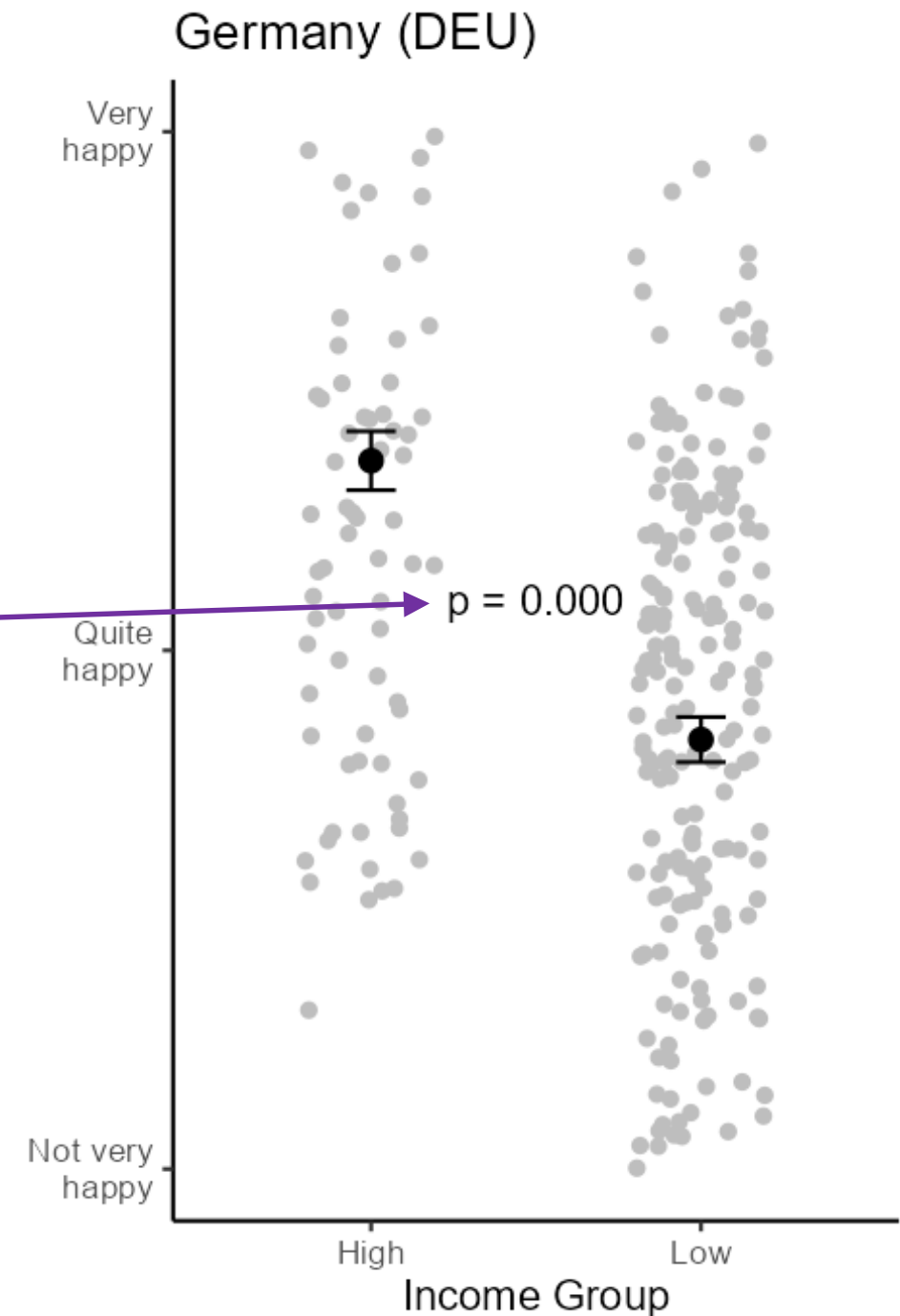
# *Can Money Buy Happiness?*

We can see this  
based on the  
standard error  
bars, they do not  
overlap



# *Can Money Buy Happiness?*

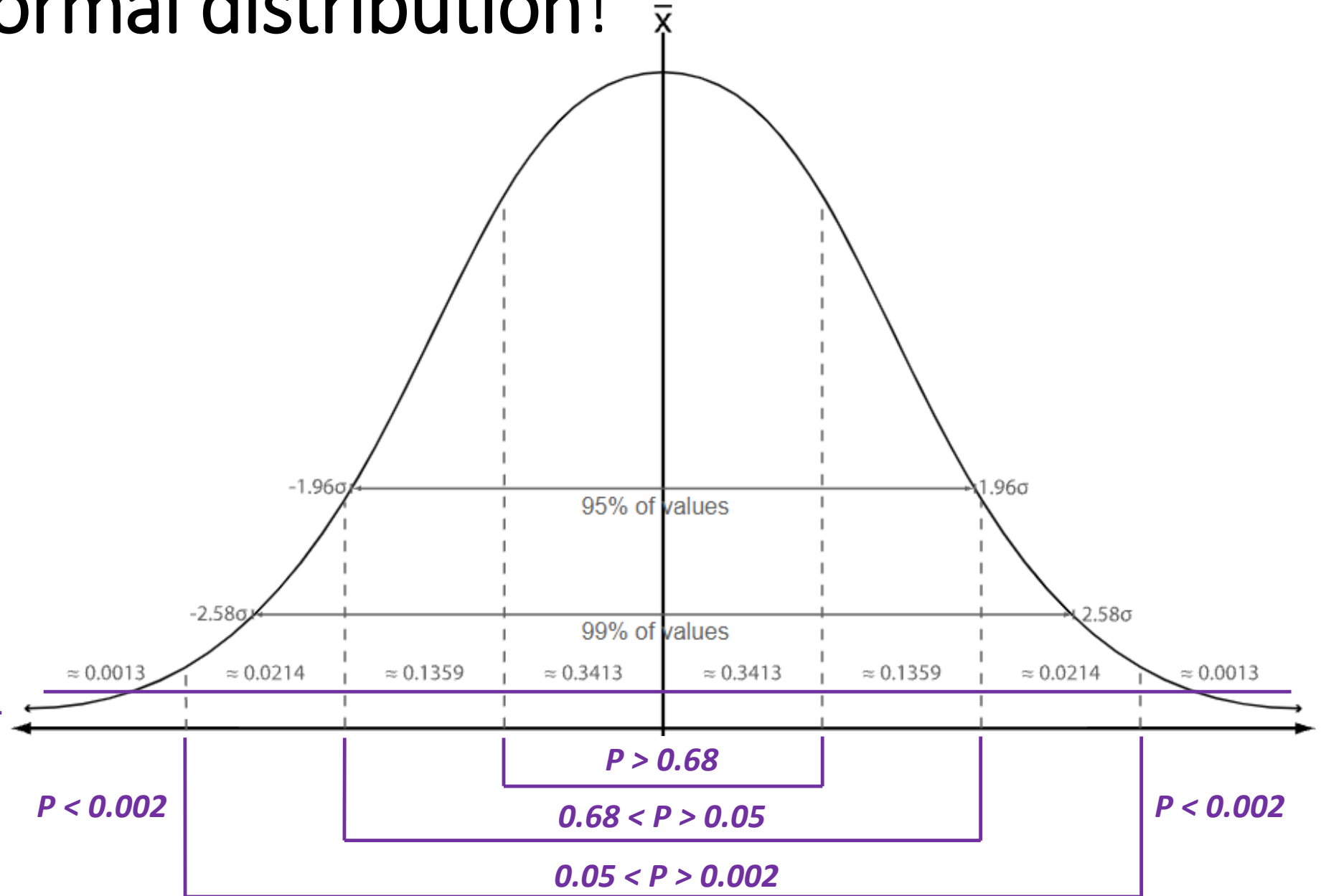
NHST that the  
difference in  
happiness  
between high  
and low income  
groups is zero



# Remember, normal distribution!

P-Values  
(if all assumptions are true)

Probability of Cases  
in portions of the curve



# *Can Money Buy Happiness?*

## Example 1. NHST – Comparing Means

### **Group Task**

- 1) Look at different country comparisons in the folder “...results/means\_p” at [https://github.com/nbreznau/p\\_values](https://github.com/nbreznau/p_values)
- 2) Select two countries to compare, save the two figures on a slide or document
- 3) Be prepared to meaning of the p-values for each country

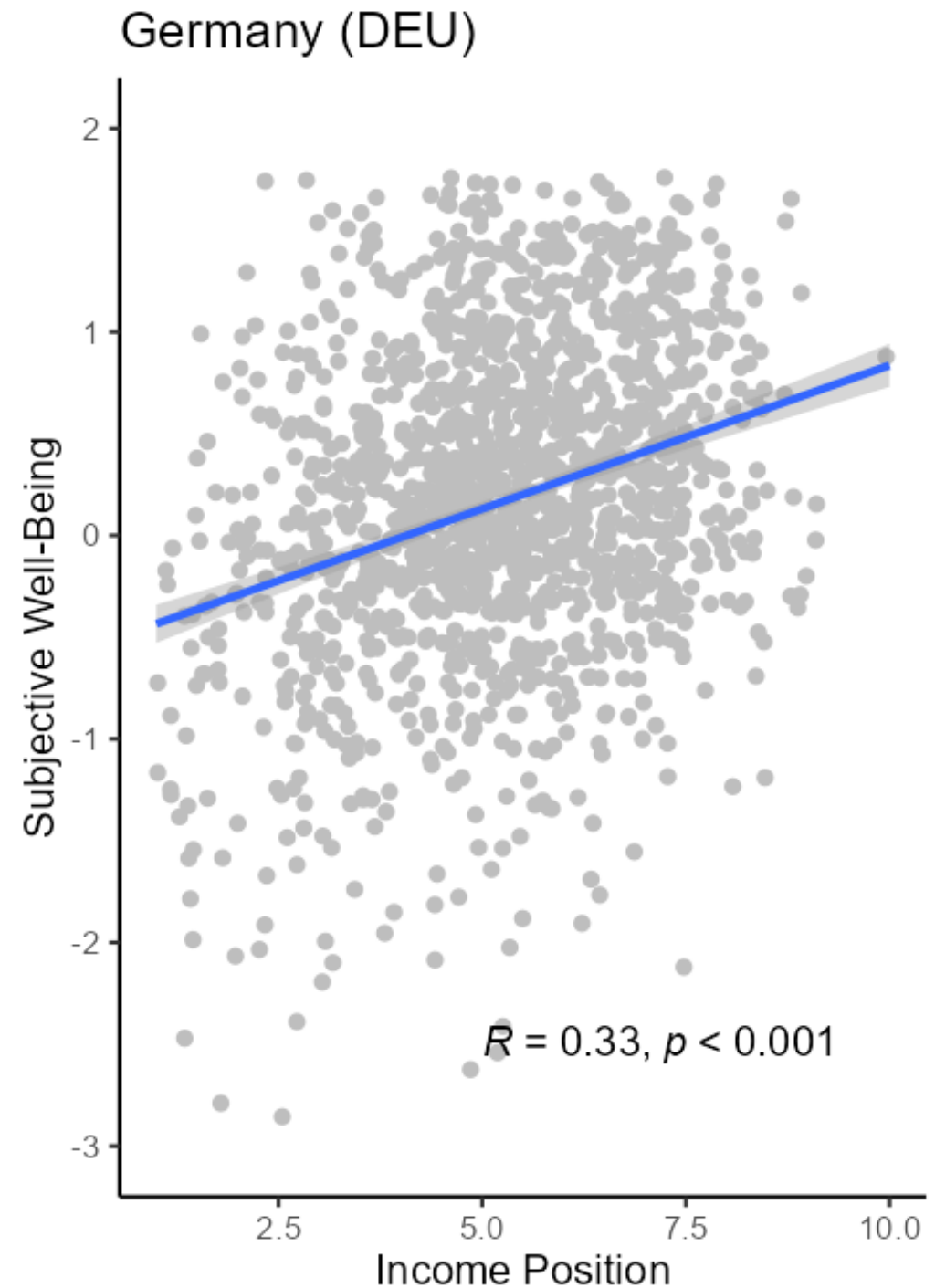
# *Can Money Buy Happiness?*

## Example 2. NHST – Linear Association

- Compare income and happiness as **continuous** measures.
- WVS has an 8-category income scale (quasi-continuous)
- WVS asks ‘how happy are you’ and ‘how satisfied are you with your life’. Using these two questions we can construct a **scale**.

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## Example 2. NHST – Linear Association

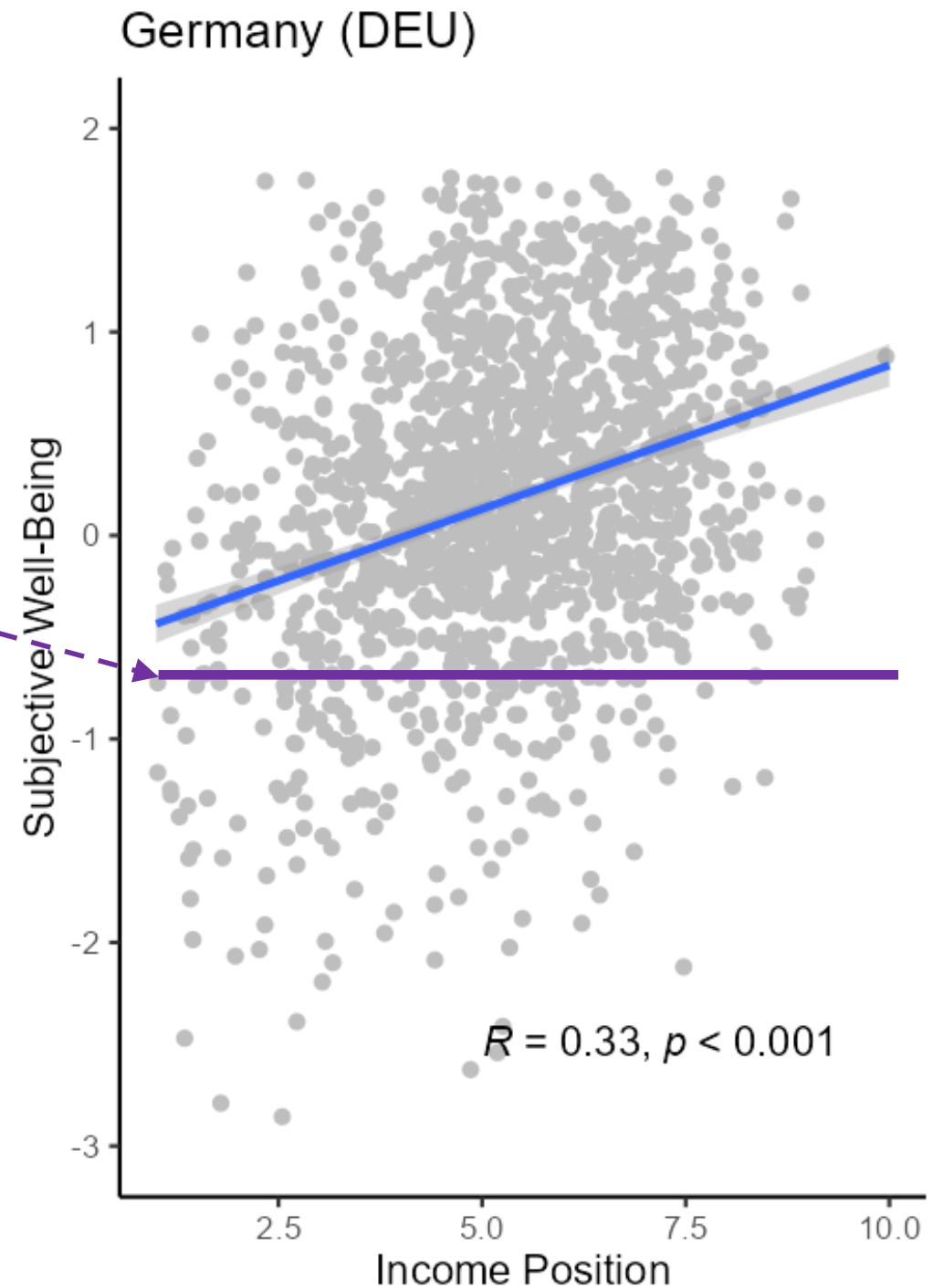




# Can Money Buy Happiness?

## Example 2. NHST – Linear Association

NHST is that the line of best fit has a slope of **zero**

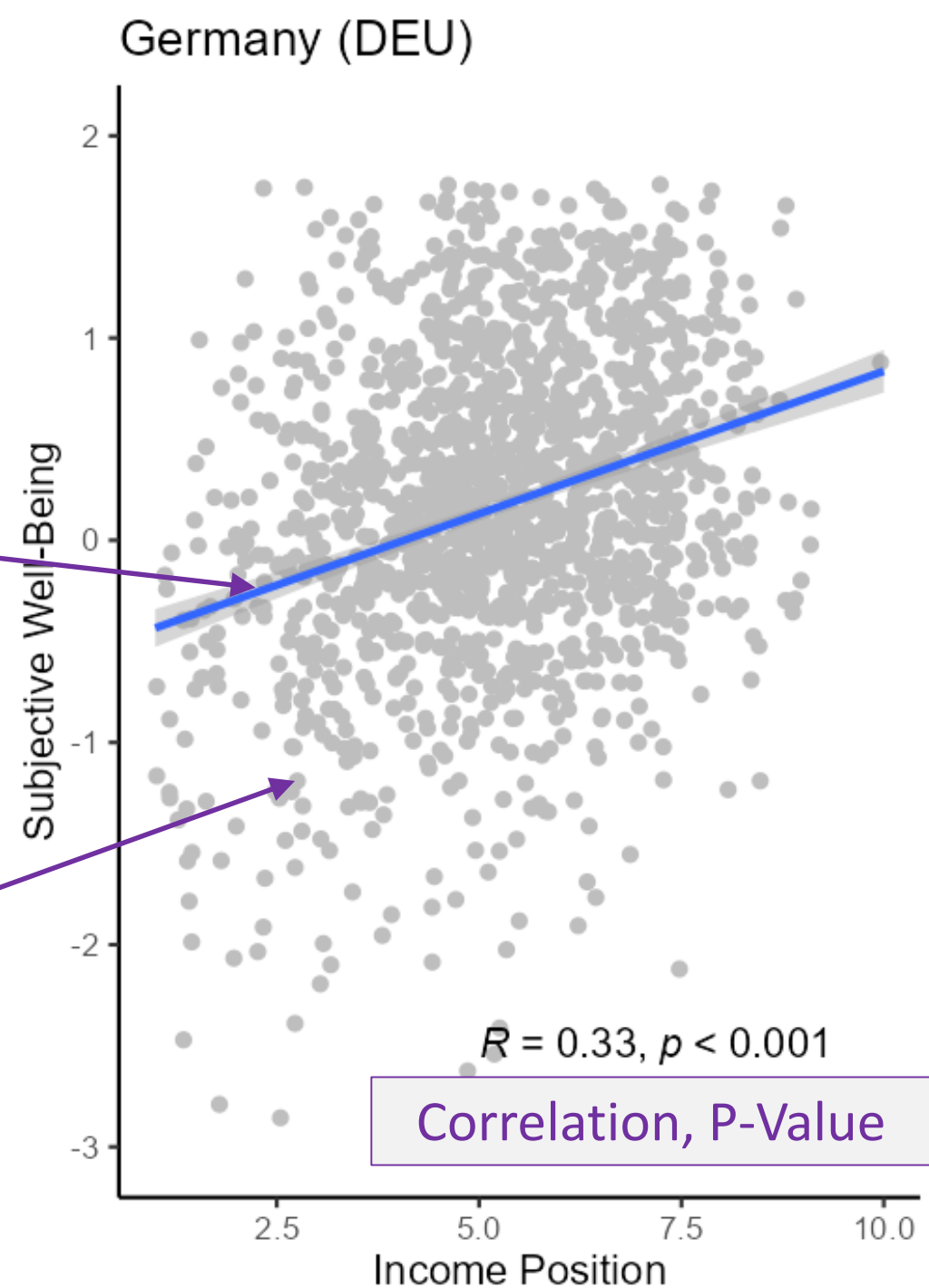


# Can Money Buy Happiness?

## Example 2. NHST – Linear Association

Line of best fit  
(minimizes sum of squared error)

Individual survey respondent  
(data point)



# Can Money Buy Happiness?

## Example 2. NHST – Linear Association, adjusted

- Sometimes we want to adjust for other variables that might explain a linear association.
- With the *income-happiness association* for example, maybe people who are higher educated are happier, or people who have stronger religious beliefs.
- Other variables may explain a linear association better, or in part

# *Can Money Buy Happiness?*

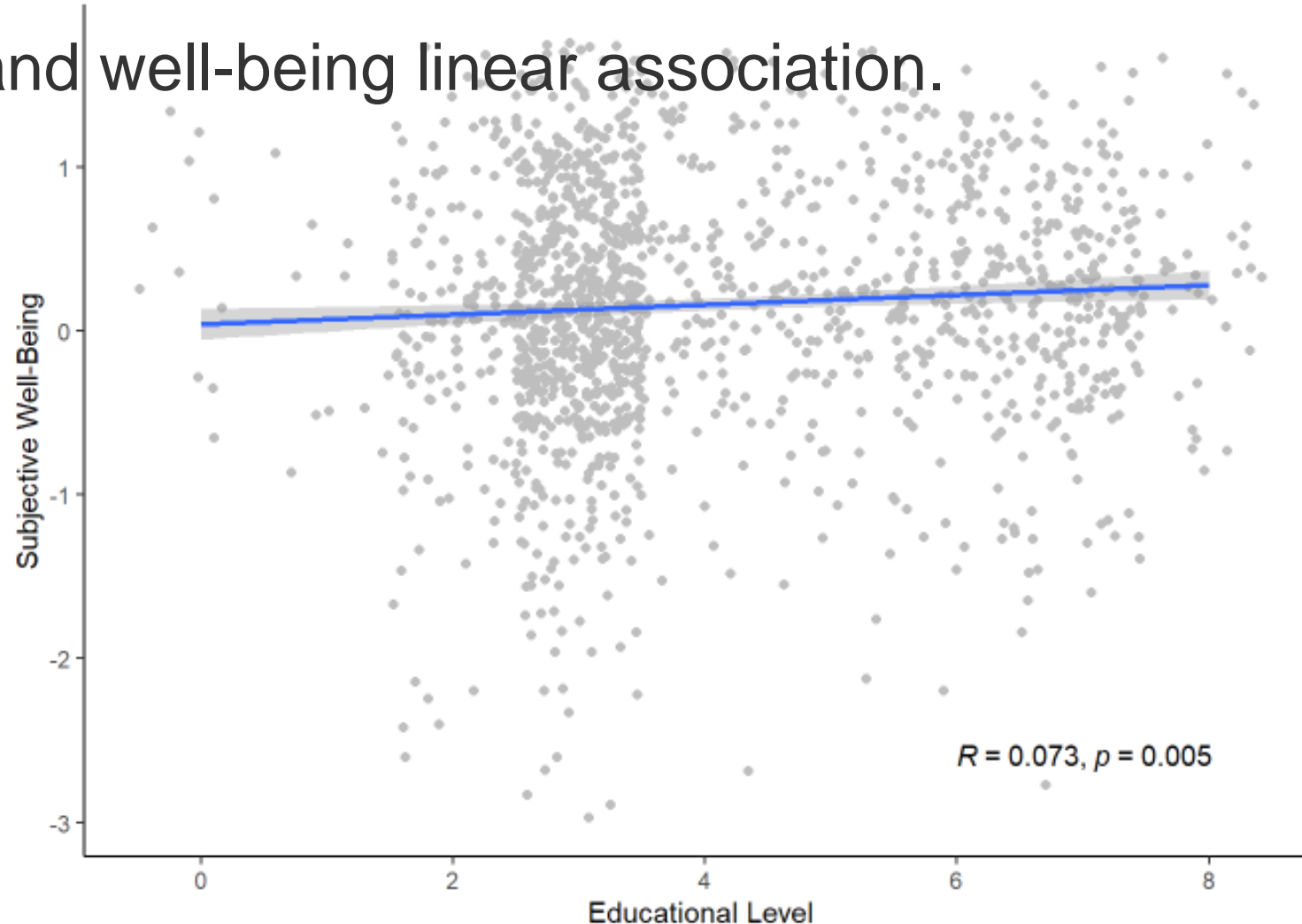
## Example 2. NHST – Linear Association, adjusted

- Education\* and well-being linear association.

# Can Money Buy Happiness?

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# *Can Money Buy Happiness?*

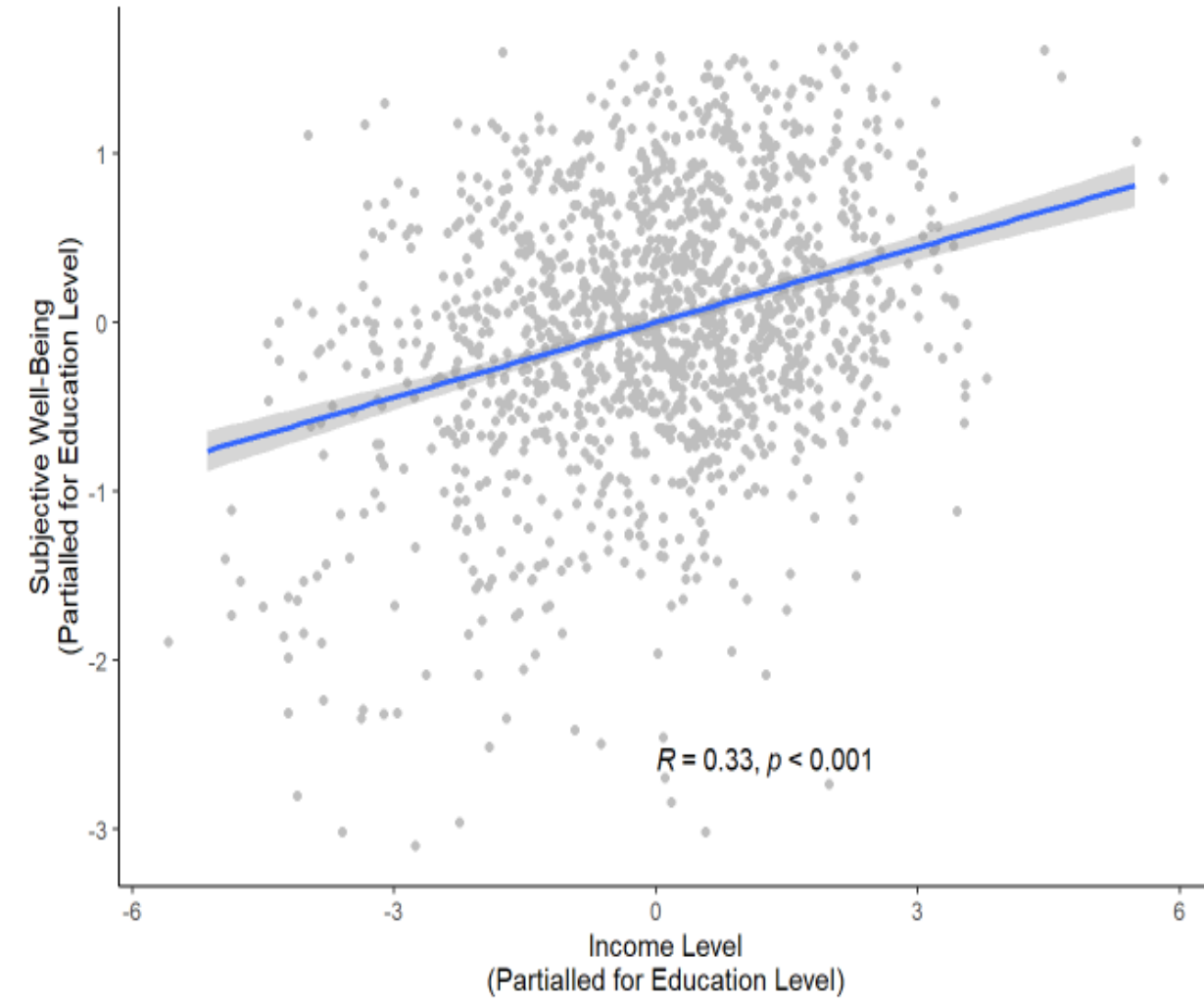
## Example 3. NHST – Linear Association, adjusted

- One option is a **partial correlation**
- This procedure:
  - Compute residuals for  $x$  (dependent)  $\sim z$  (independent) model
  - Compute residuals for  $y$  (dependent)  $\sim z$  (independent) model
  - Compute correlation between the residuals
- In other words:

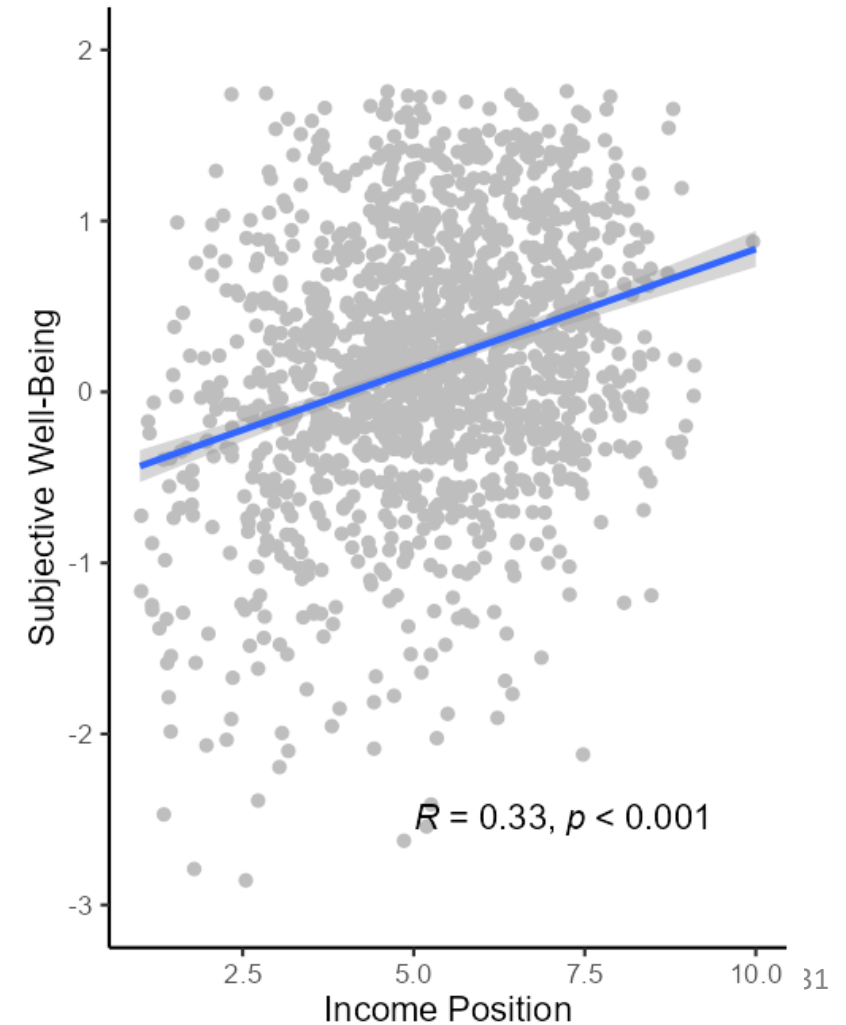
A partial correlation is what remains of a linear association after removing the portion of that association that can be explained by a third variable

# Does Education affect the *income-happiness* association in Germany?

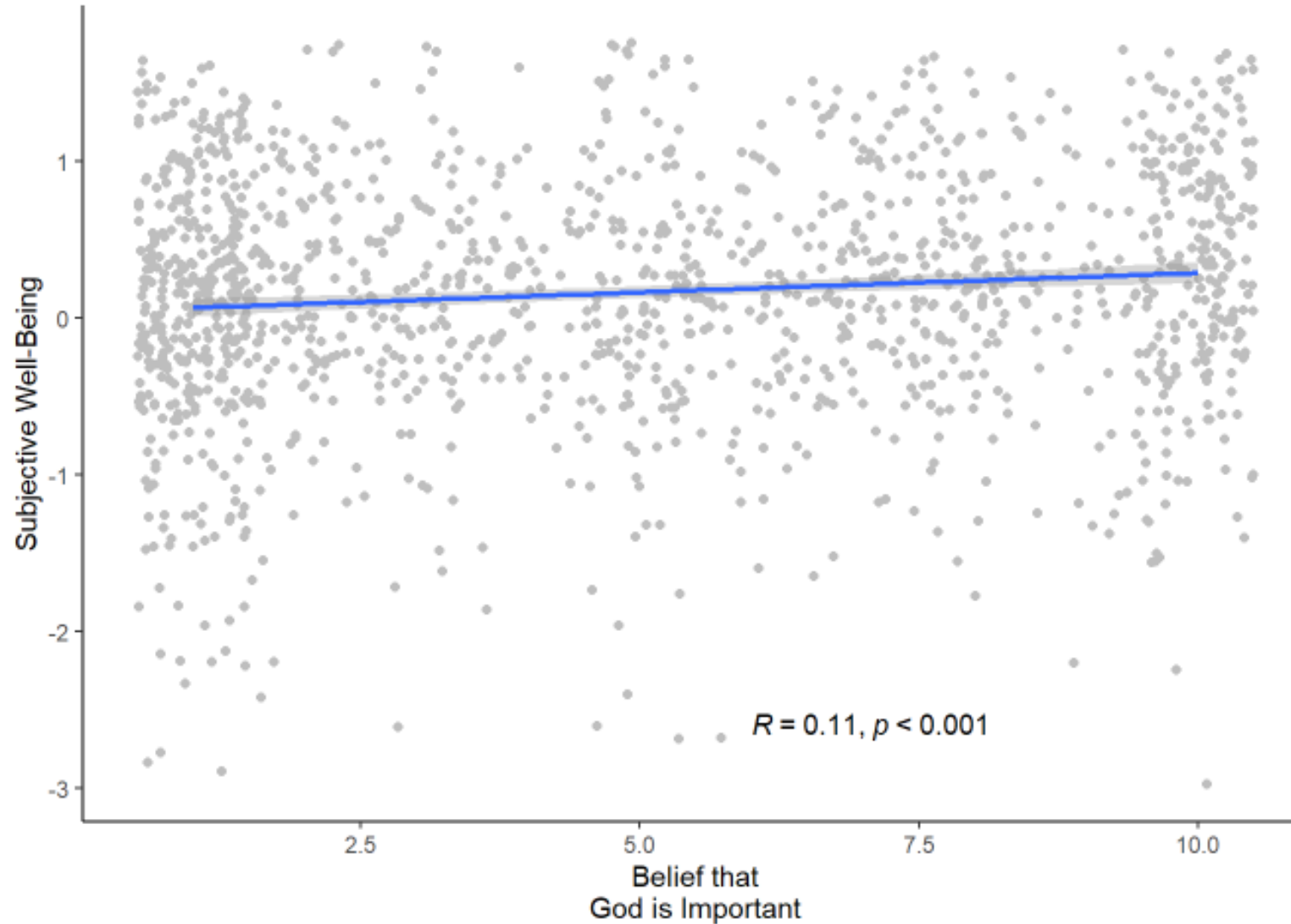
Adjusted Linear Association



Unadjusted Linear Association



# Importance of God and Happiness?





# *Can Money Buy Happiness?*

## Example 3. NHST – Linear Association, adjusted

- One option is a **partial correlation**
- Another option is a **linear regression**
  - Advantage is that it can adjust for many variables
  - Computer does the work
  - Statistical software provides results/p-values

# Can Money Buy Happiness?

## Example 3. NHST – Linear Association, adjusted

- Germany – 3 regressions

	Model 1	Model 2	Model 3
Income	0.14 *** (0.01)	0.15 *** (0.01)	0.15 *** (0.01)
Education		-0.02 (0.01)	-0.02 (0.01)
God Importance			0.03 *** (0.01)
N	1445	1445	1445
R2	0.11	0.11	0.13

\*\*\* p < 0.001; \*\* p < 0.01; \* p < 0.05.

# Can Money Buy Happiness?

## Example 3. NHST – Linear Association, adjusted

• Compare:

Ethiopia

Vietnam

	Model 1	Model 2	Model 3
Income	0.05 *** (0.01)	0.05 *** (0.01)	0.05 *** (0.01)
Education		-0.02 (0.01)	-0.02 (0.01)
God Importance			0.01 (0.03)
N	1222	1222	1222
R2	0.01	0.02	0.02

	Model 1	Model 2	Model 3
Income	0.06 *** (0.01)	0.07 *** (0.01)	0.07 *** (0.01)
Education		-0.06 *** (0.01)	-0.06 *** (0.01)
God Importance			0.01 (0.01)
N	1200	1200	1200
R2	0.02	0.04	0.04

\*\*\* p < 0.001; \*\* p < 0.01; \* p < 0.05.

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