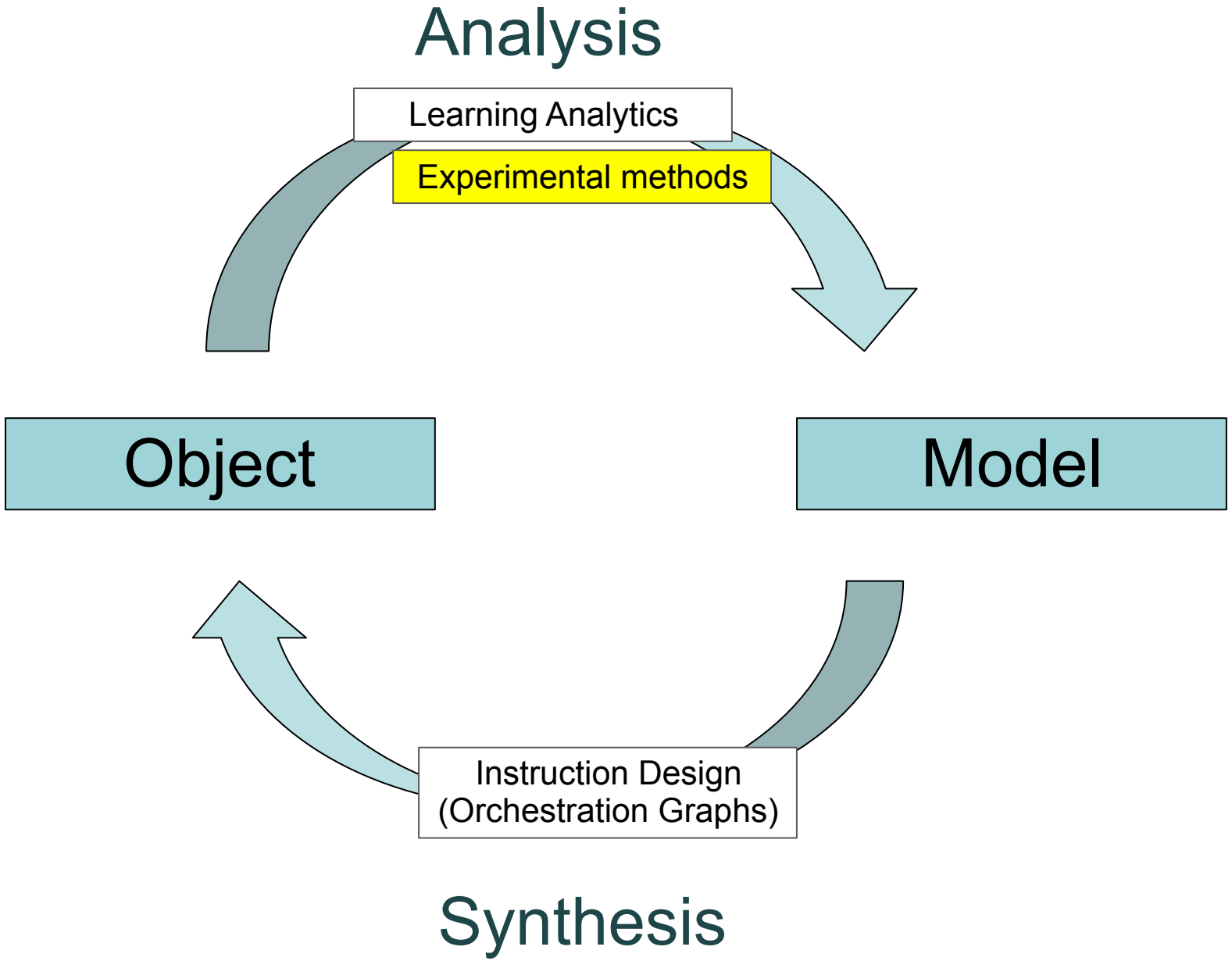
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

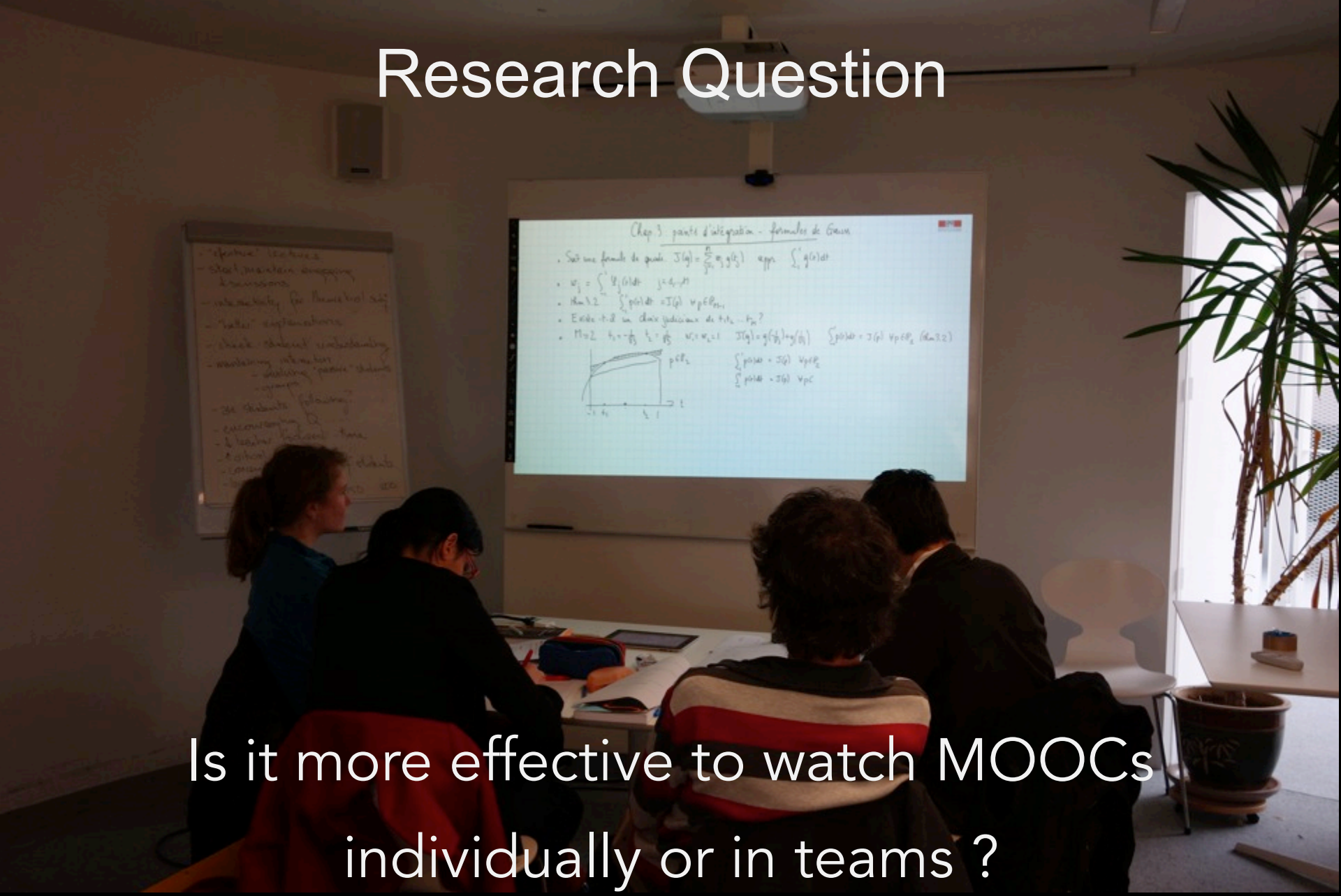
CS-411 : Digital Education & Learning Analytics

Chapter 9:

Measuring learning effects


Analysis
Learning Analytics
Experimental methods
Object
Model
Instruction Design
(Orchestration Graphs)
Synthesis

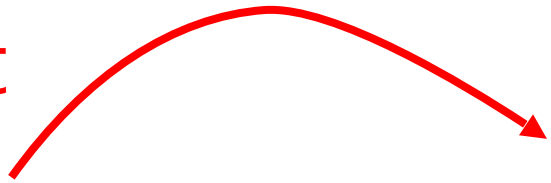
Research Question



Is it more effective to watch MOOCs individually or in teams ?

Independent Variable

Solo / Team



Dependent Variable

Test Score

Depending Variables

Test Score : *retention*, *understanding*, *application*, *extrapolation* (taxonomy)

(PostTest Score – PreTest Score)= Learning Gain

Differential effects

(DelayedPostTest Score – PostTest Score)= Retention

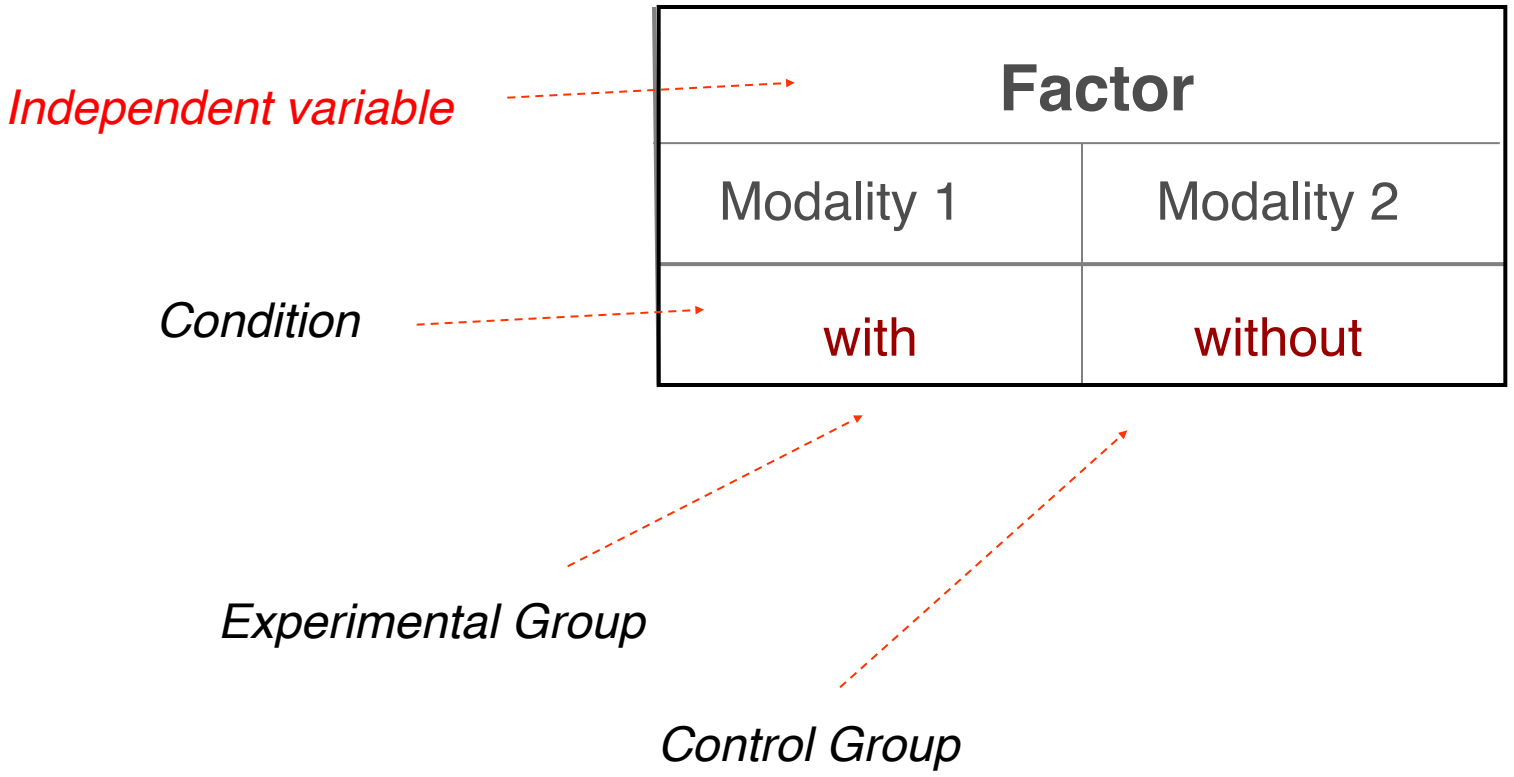
(PostTest Score – PreTest Score)-/100 – PreTest Score)= RelativeLearning Gain

Floor or Ceiling effects

Transfer Score

Job ?, Salary, Happiness,…

Experimental Plan: Between Subjects, 1 dimension



Research Question

Is it more effective to watch MOOCs individually or in small teams ?

Research Sub Questions

It depends on the size of the group

It depends on the school culture

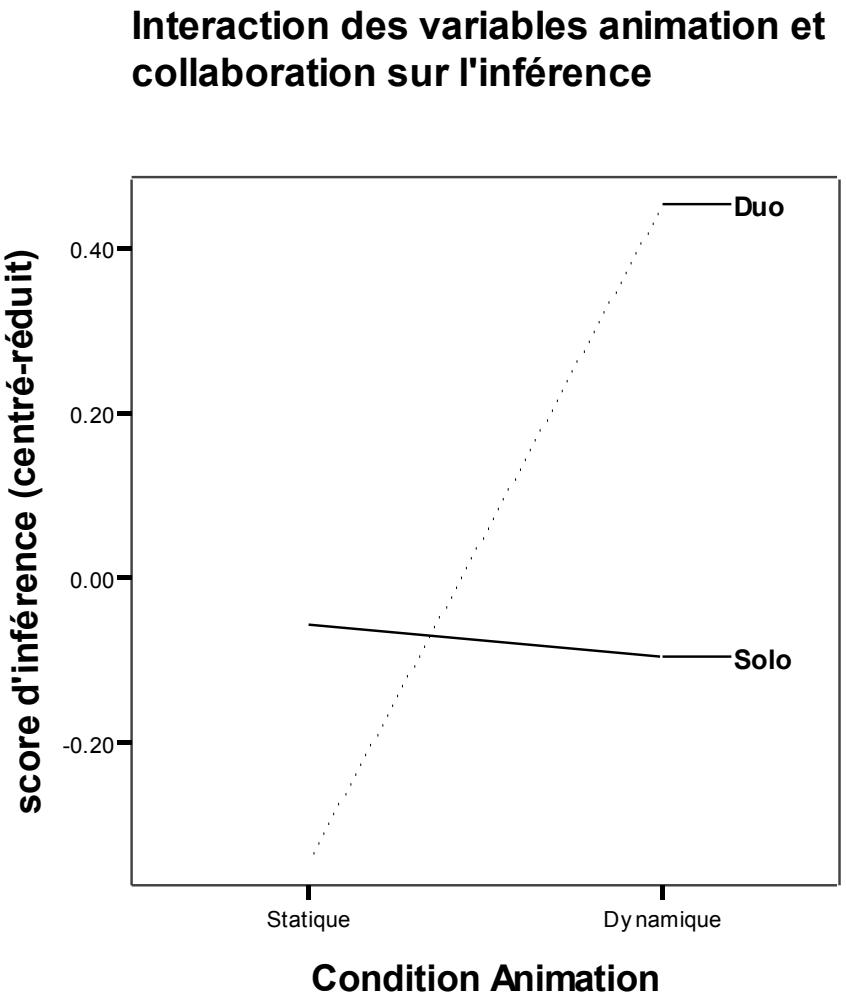
It depends on difficulty of the video

It depends how well the group members know each other

It depends …

Experimental Plan: Between Subjects, 2 dimensions

		Factor 1	
		Modality 1.1	Modality 1.2
Factor 2	Modality 2.1	Group A	Group E
	Modality 2.2	Group B	Group D
	Modality 2.3	Group C	Group F



Interaction Effects

The effect of

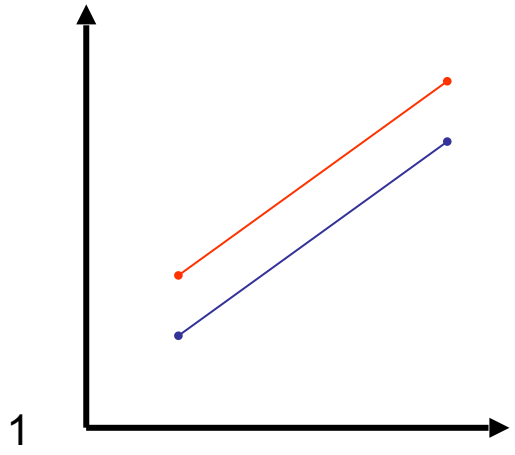
one independent variable

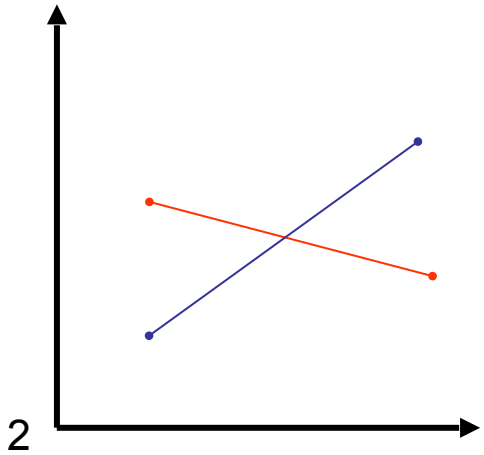
on the dependent variable

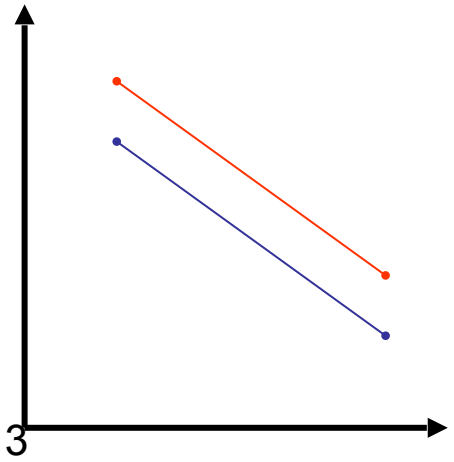
depends upon

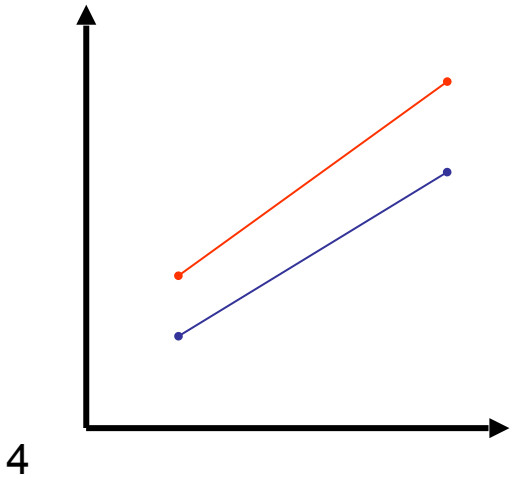
the other independent variable

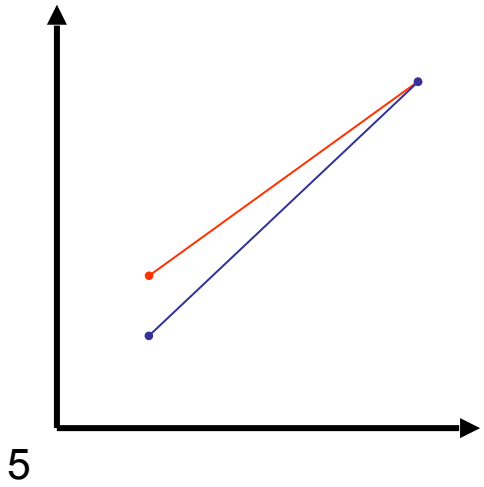
Interaction Effect ?

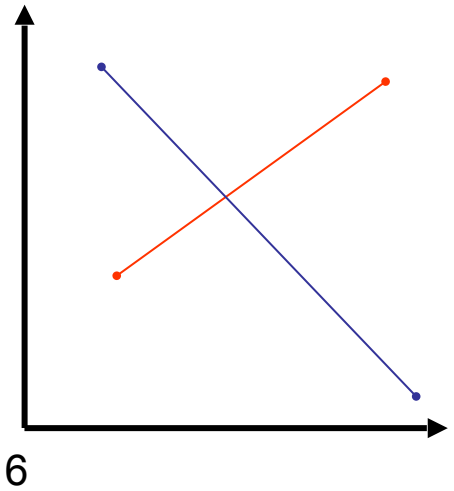












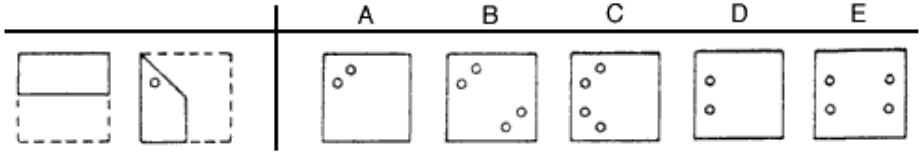
Experiment Biases

Were the groups really equivalent at the beginning ?

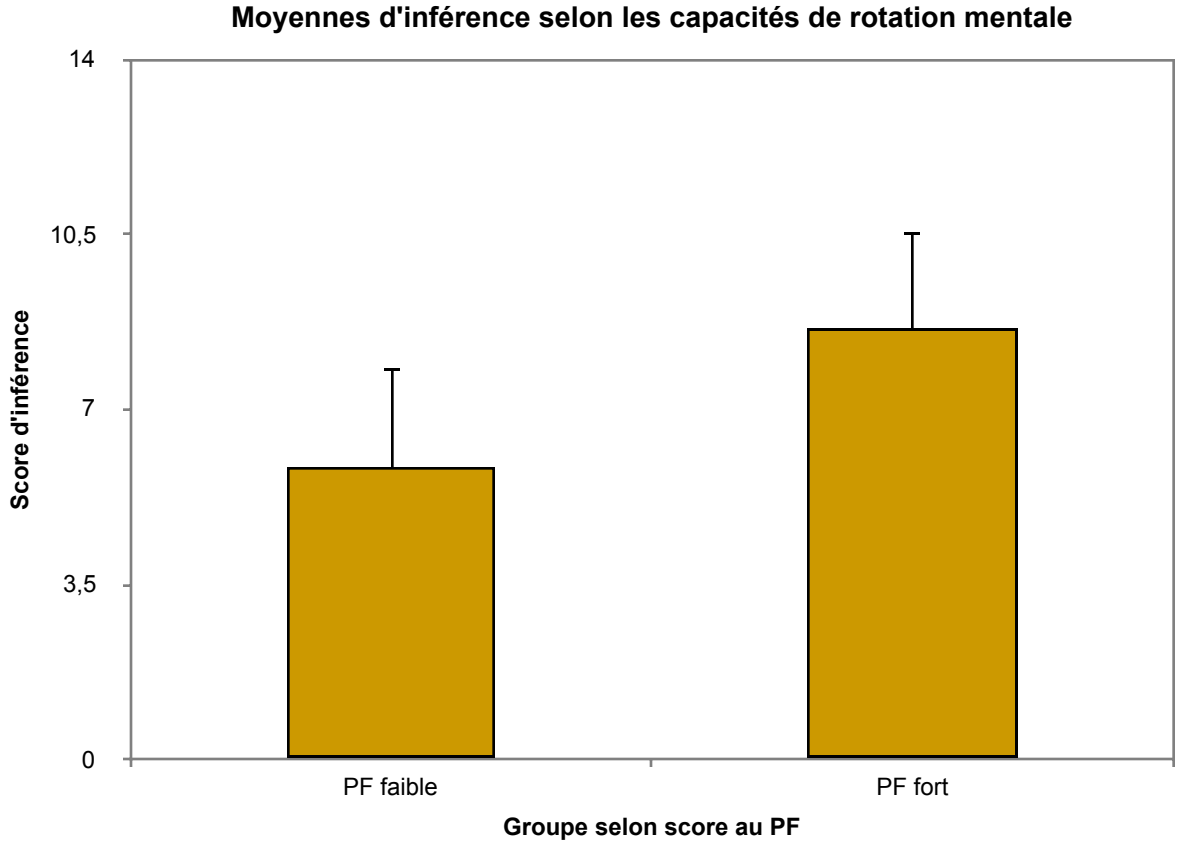
- same age (in average) ➔ Questionnaire
- same gender ratio ➔ Questionnaire
- same socio-cultural level ➔ Questionnaire
- same school level ➔ Recruitment
- same background knowledge ➔ Pre-test
- same level for mutual knowledge (friends?) ➔ Recruitment
- same level of intelligence ➔ Pre-test
- same spatial reasoning ➔ Pre-test

Paper Folding Test

The two figures on the left represent a square piece of paper being folded. In the second figure a small circle shows where a hole has been punched through all of the thicknesses of paper. Choose the drawing on the right that shows where the holes are after the paper has been unfolded.



Eliot and Smith (1983)



Were the groups really equivalent at the beginning ?

SOLUTIONS

(1) Control before forming groups

➔ When assigning subjects to conditions

distribute Equally among conditions: controlled variables

(2) Control after the experiment

➔ Verify that the groups do not differ significantly: randomized variables

➔ If the groups differ significantly, use covariate analysis

(3) Use “repeated measures” also called “within subjects”

The same subjects pass in both conditions

Experimental Plan: **Within** Subjects, 1 dimension

	Factor	
	Modality 1	Modality 2
Subjects 1, 3, 5	First	Second
Subjects 2, 4, 6	Second	First

COUNTER-BALANCING

(avoiding the order effect)

Pro: fewer subjects, samples are equivalent

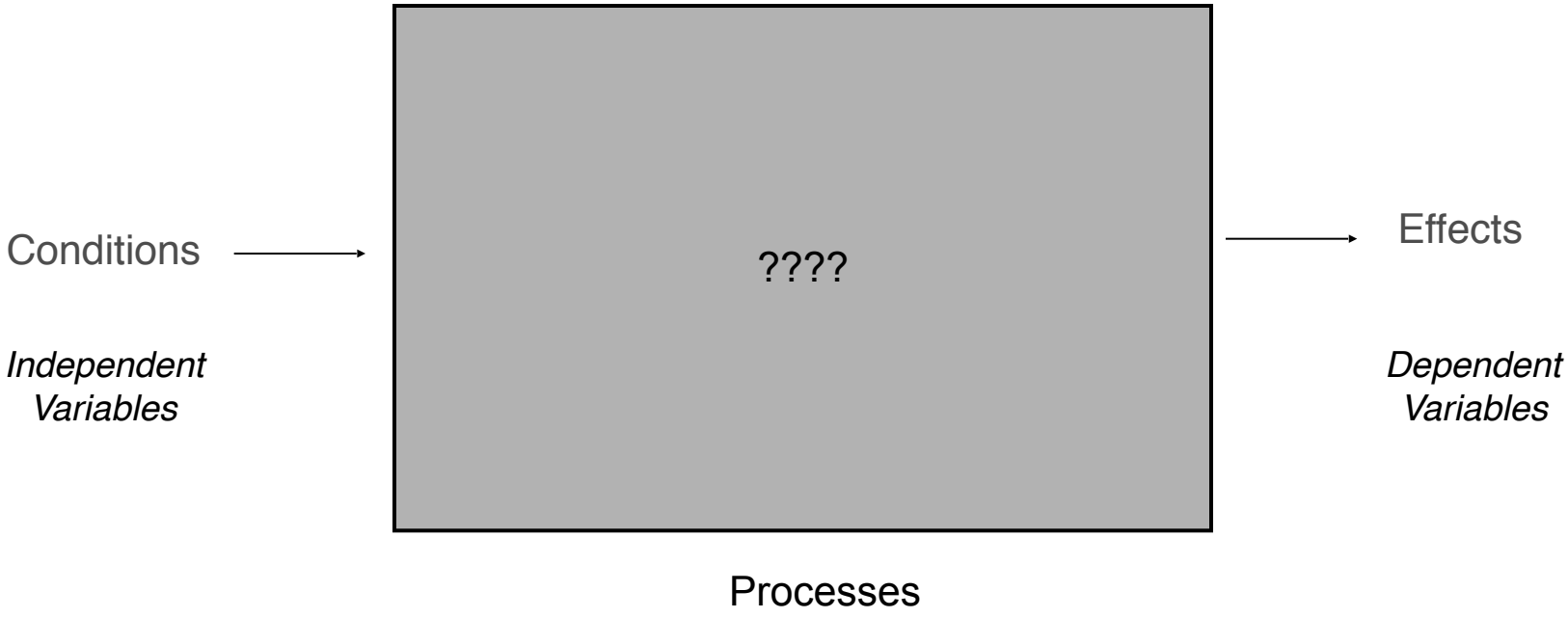
Cons: complex order effects

Research Sub Questions

Is it more eff… …ch MOOCs
ind… …n small teams ?

2. Why are they better ?

3. Why are they better ?



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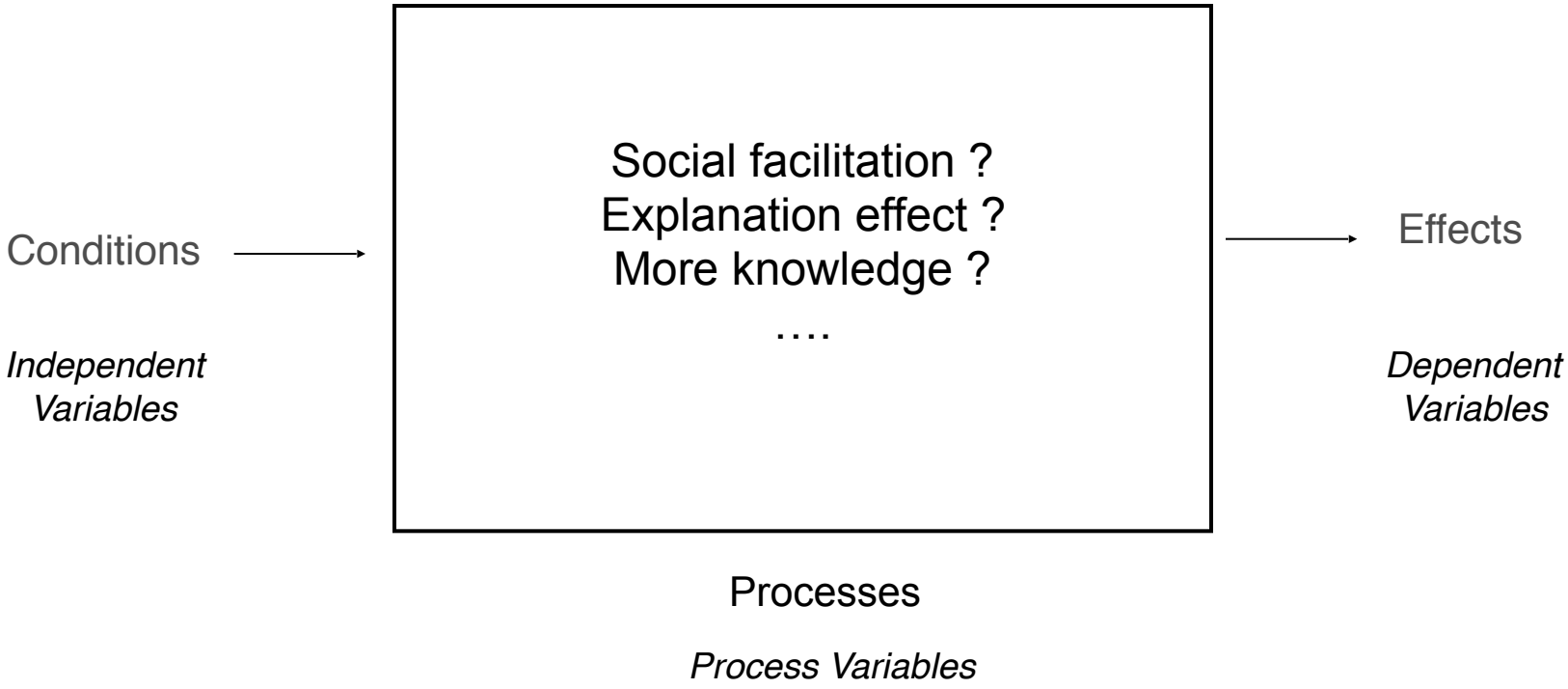

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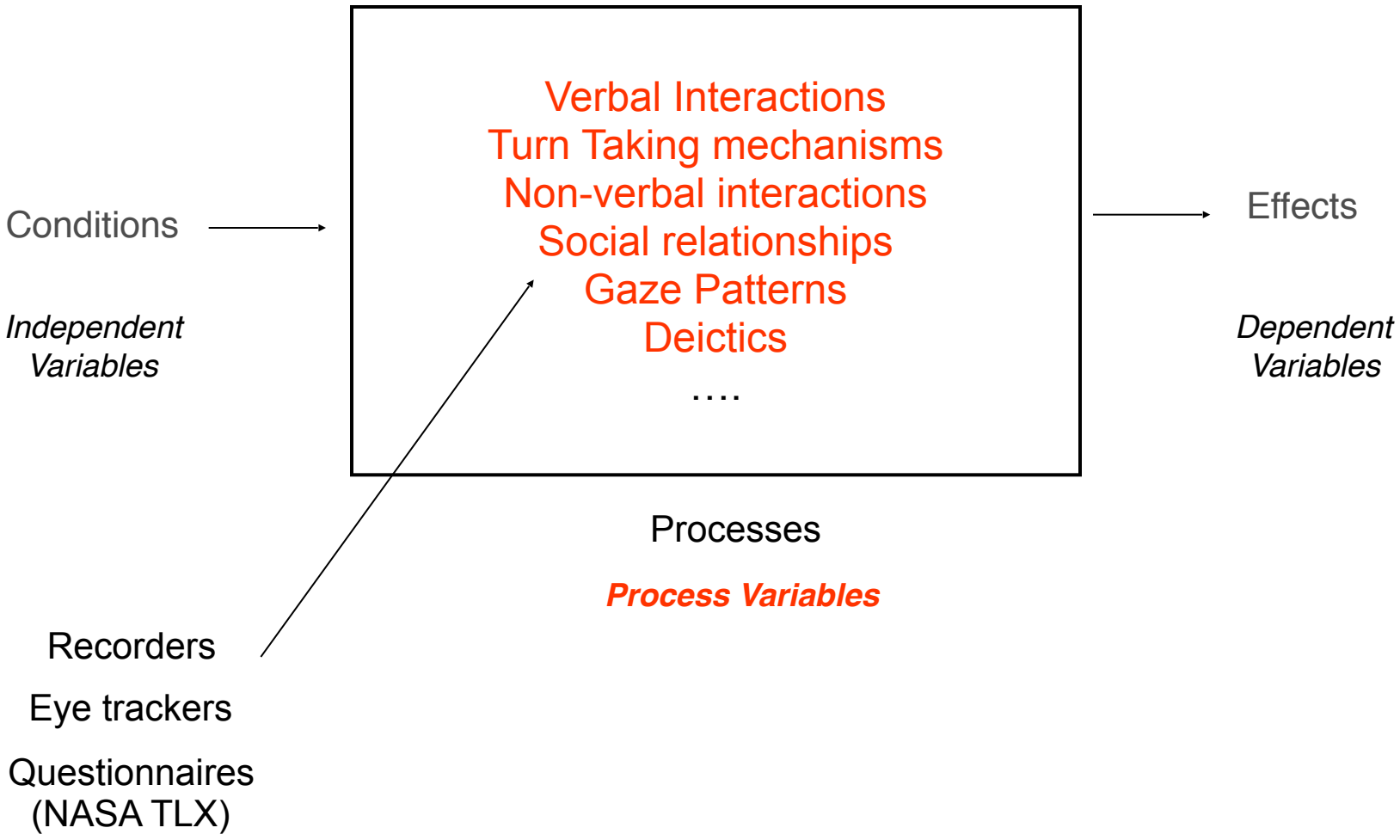
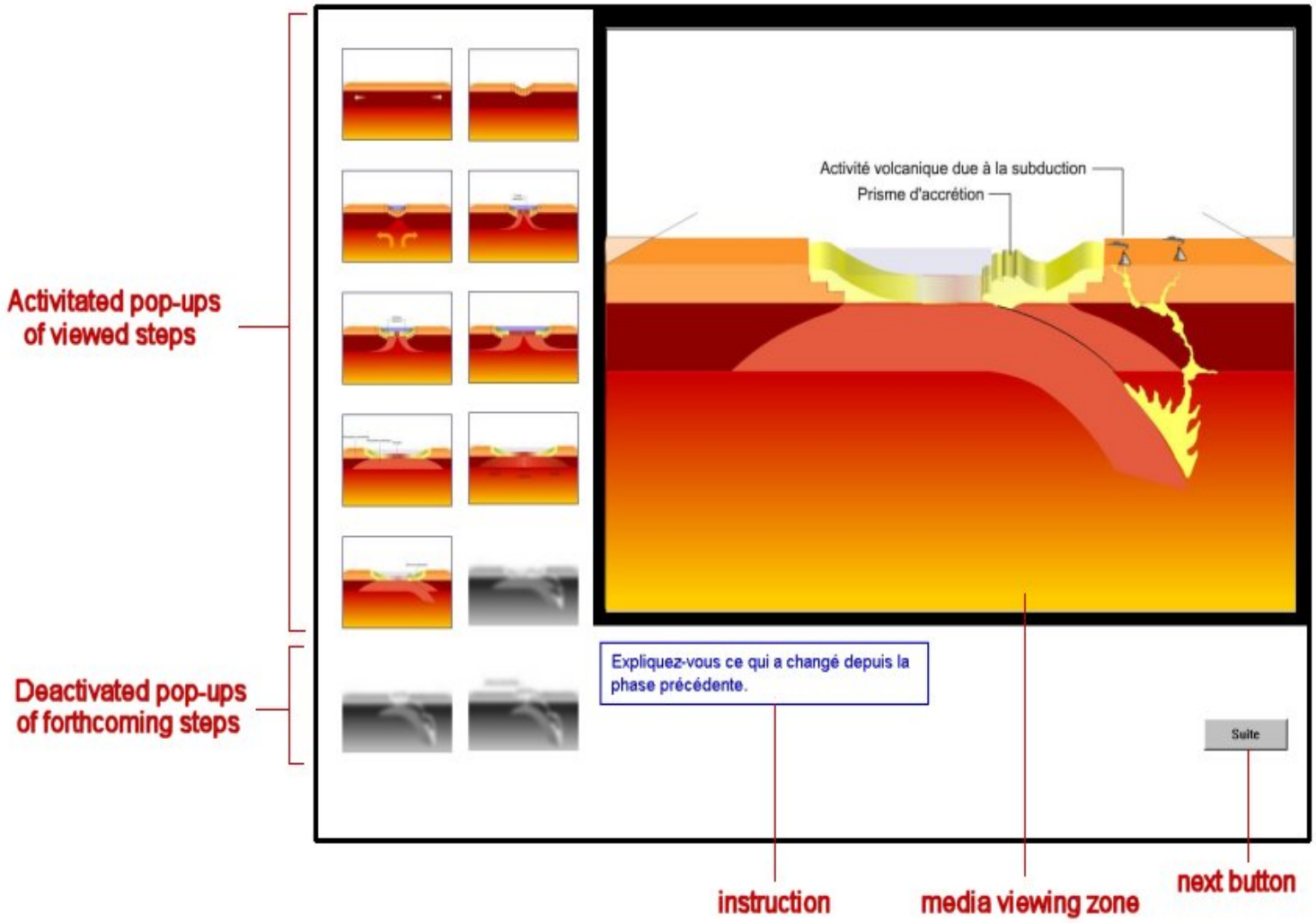
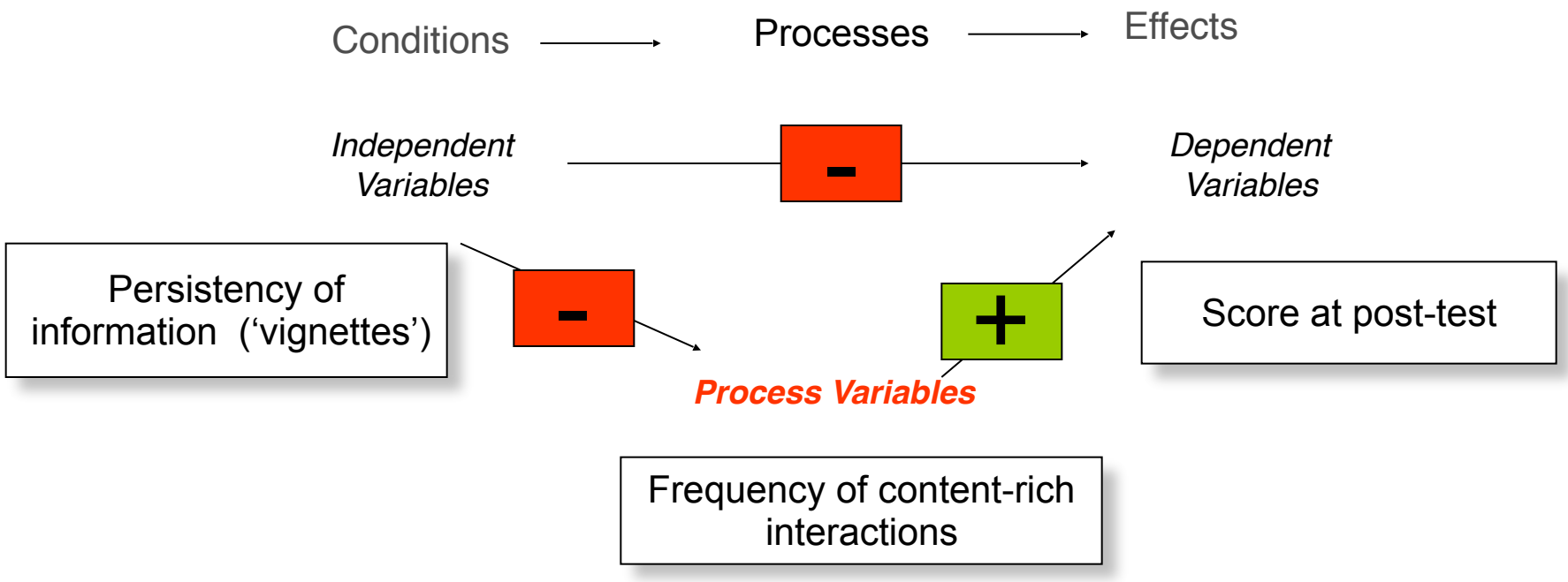


Example : The effect of persistency of information



3. Why are they better ?



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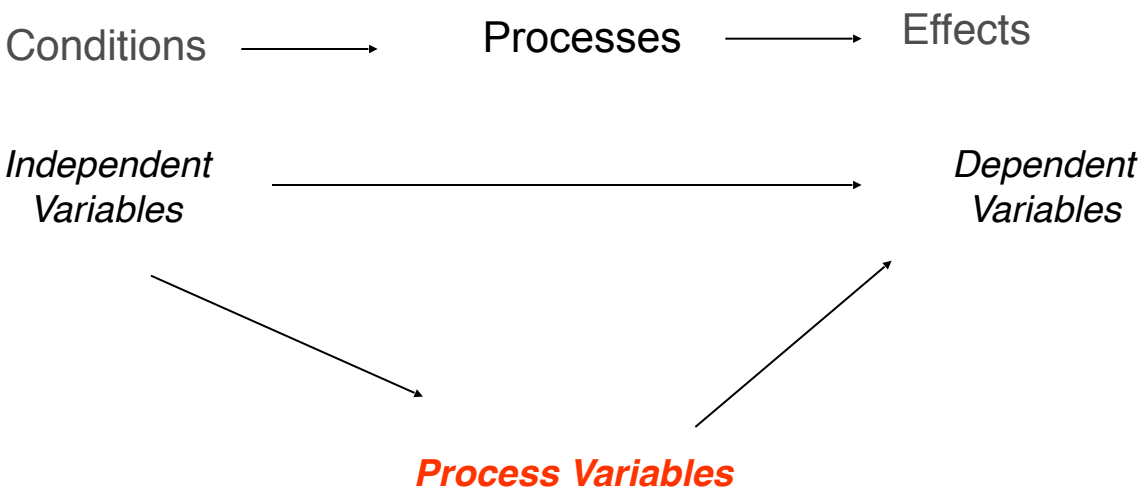
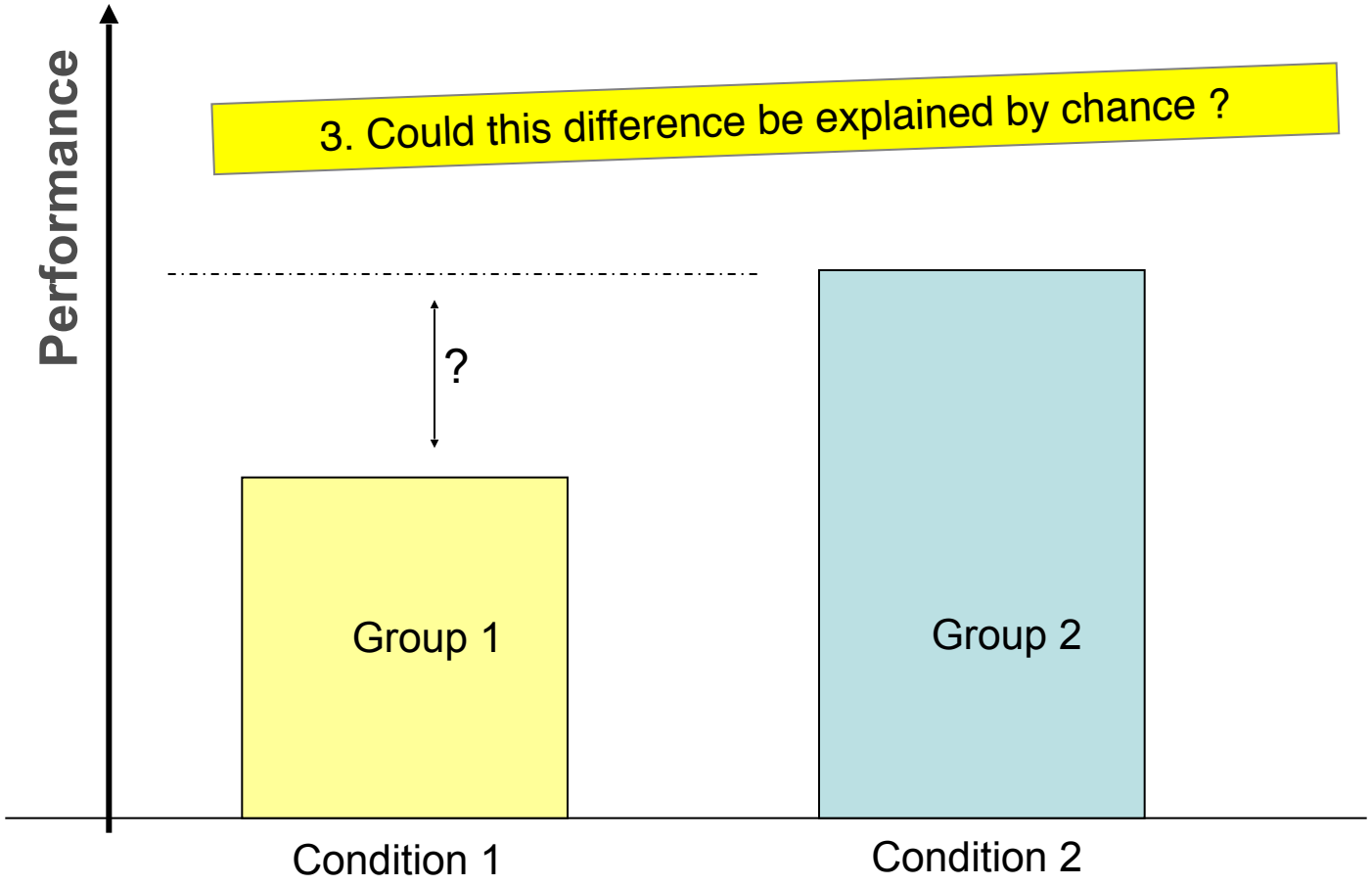


Mediation Effect

Research Sub Questions

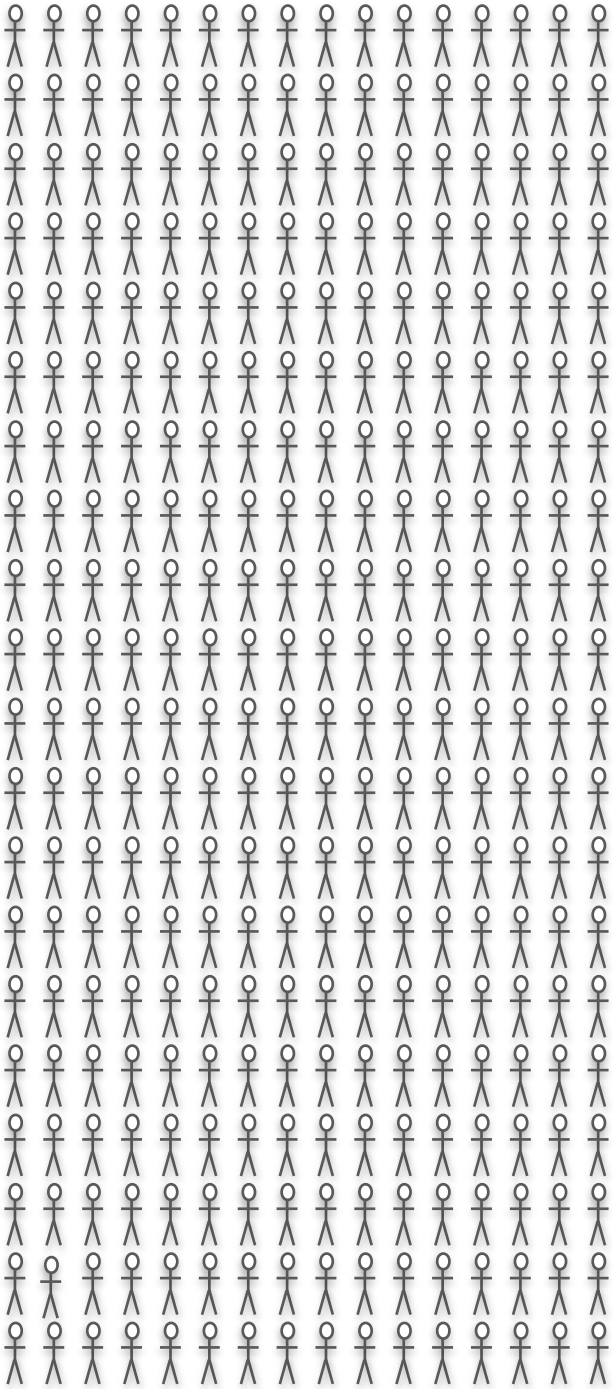
Is it more effective to watch MOOCs
individually or in small teams ?

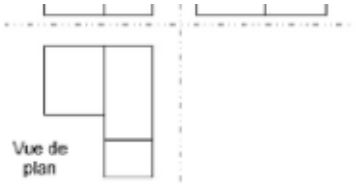
3. Could this difference be explained by chance ?



Is this difference in group means due to **sampling** or is it the effects of condition changes?

If group 2 had been in condition 1 and group 1 in condition 2, would group 2 still get a higher performance ?



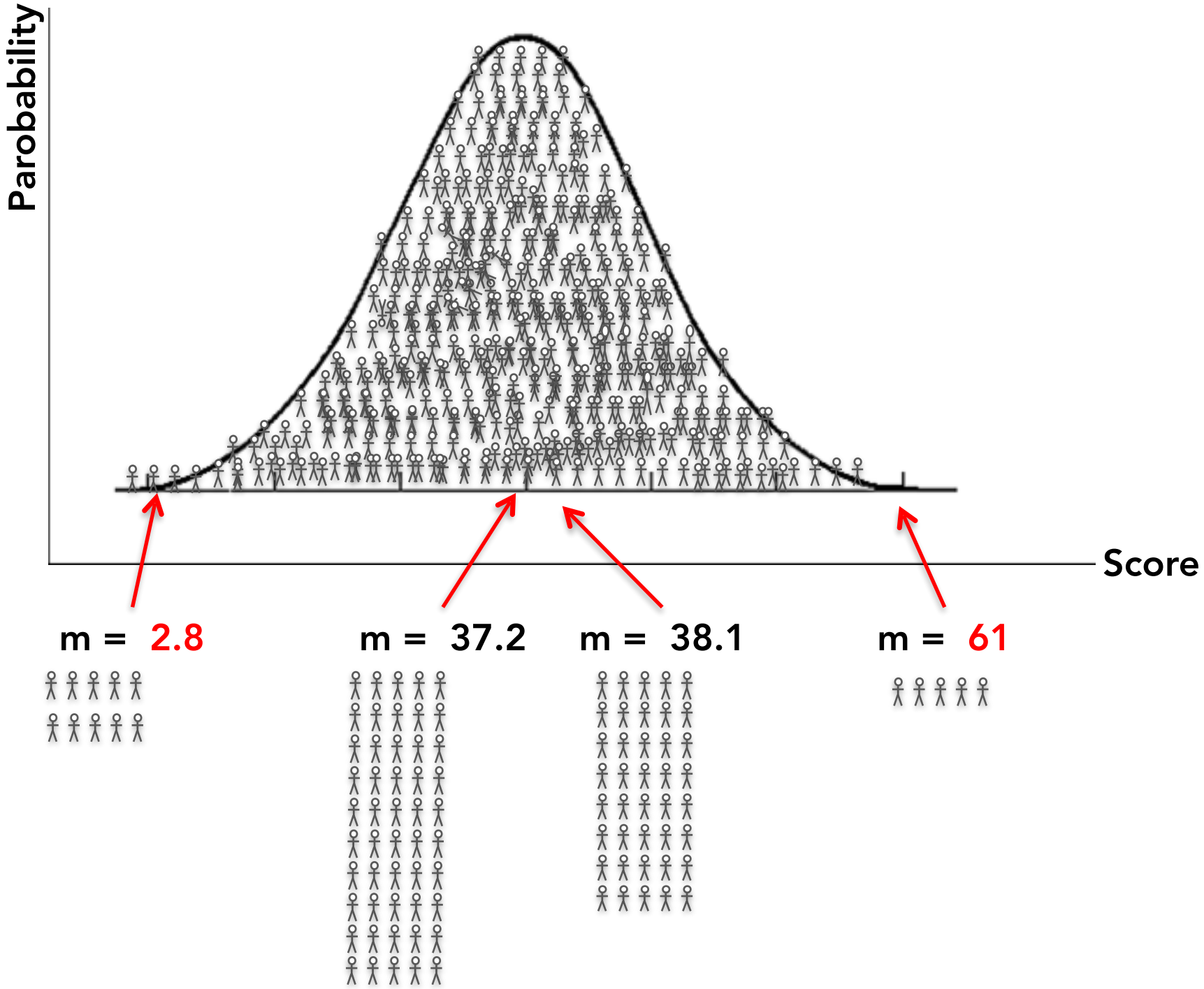


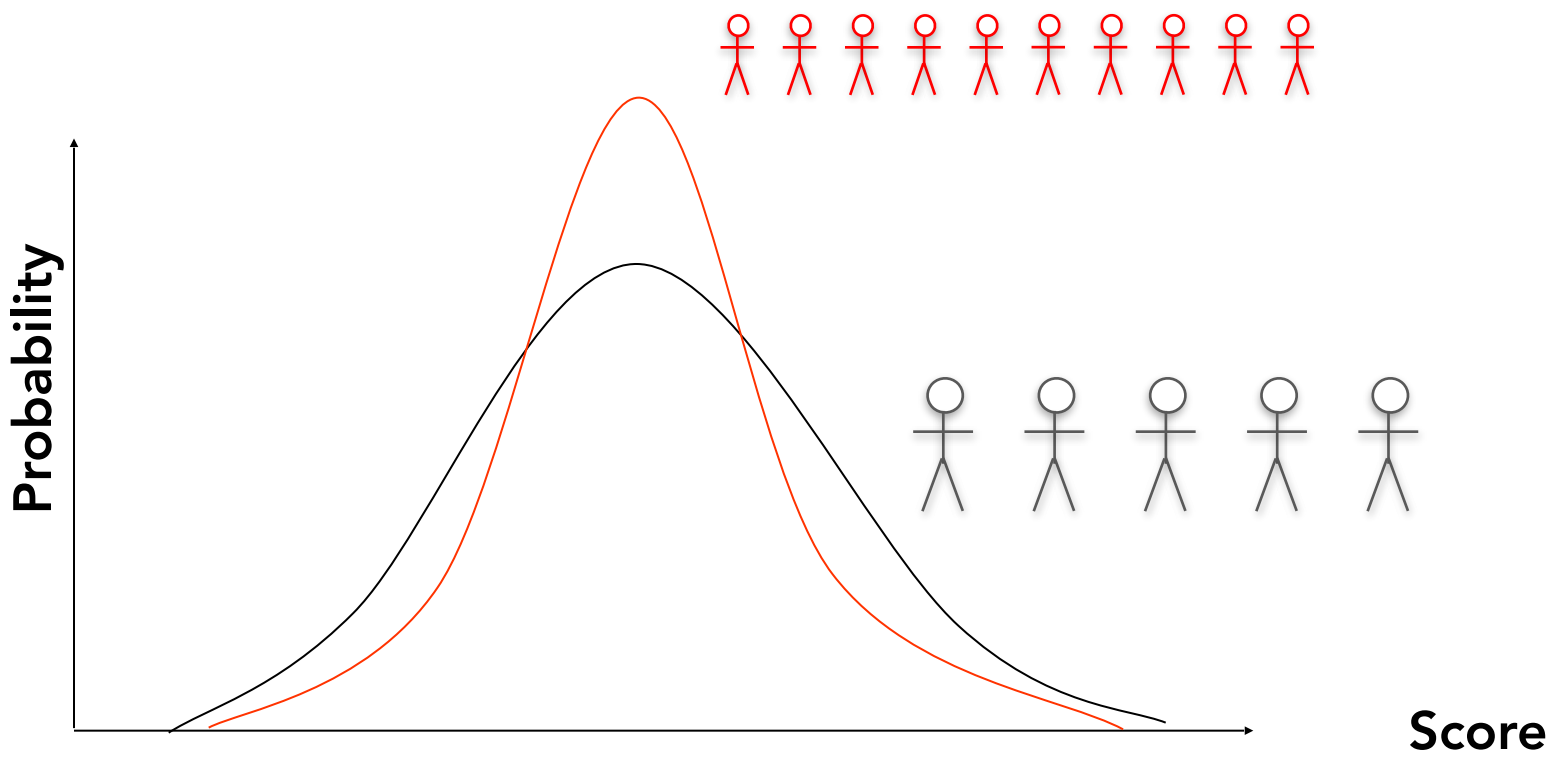
Score

m = 37.2

m = 38.1

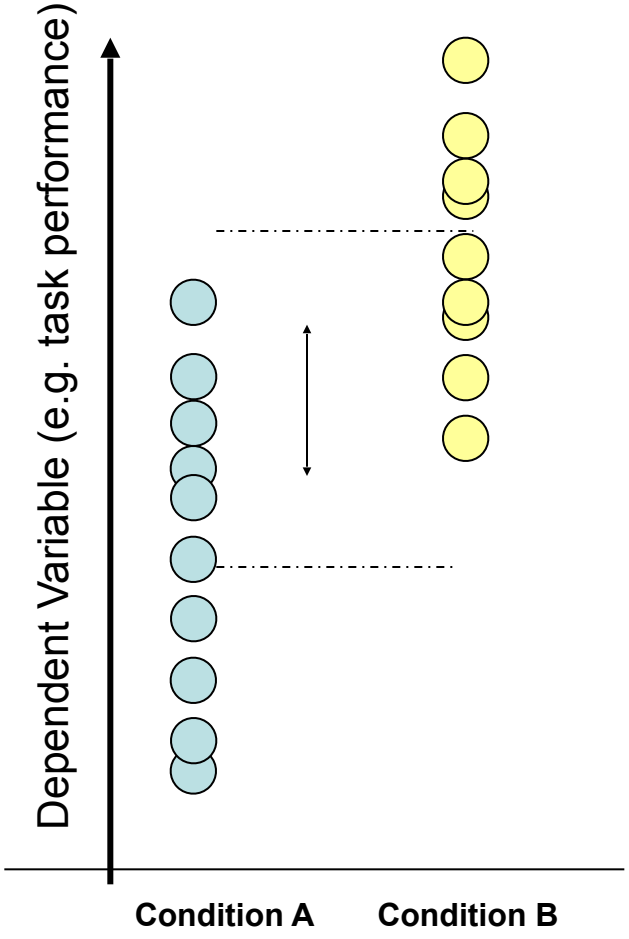
m = 2.8

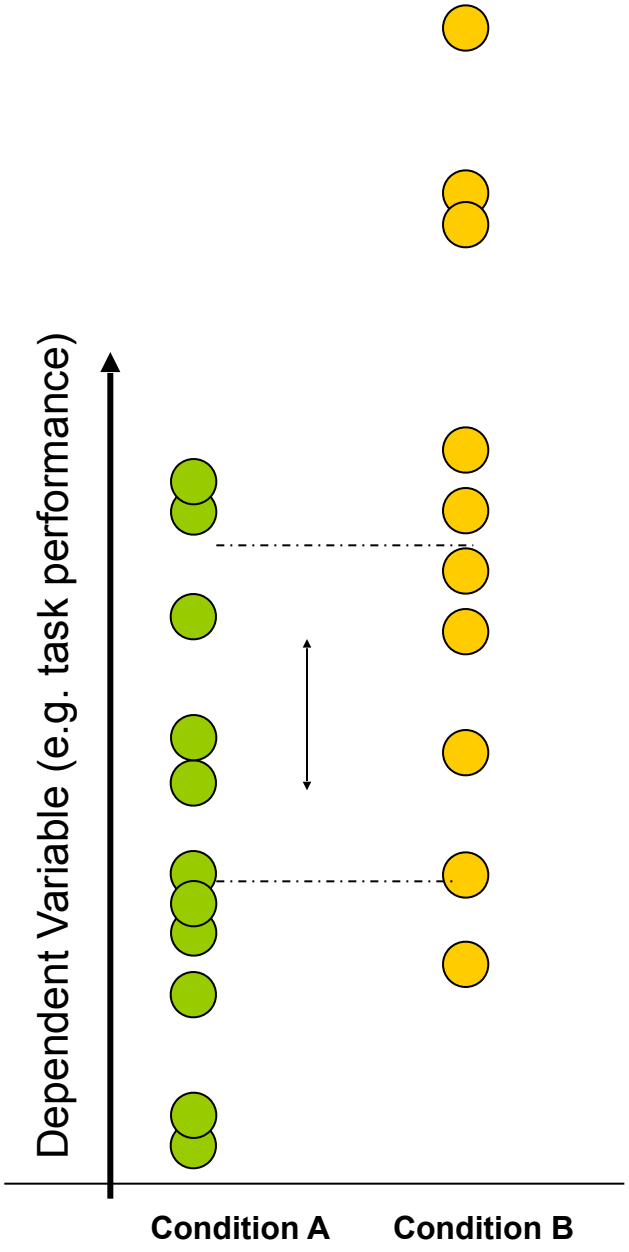

Parobability
Score
m = 2.8
m = 37.2
m = 38.1
m = 61



The sample size reduces the probability to get by chance a sample mean that is far from the population means

The differences of mean are the same, but which one is more significant ?





“Significant” does not mean “large” !

Age
Gender
Row in classroom
Teacher: A or B ?
Learning style
IQ Test
Mental Rotation test
Motivation test
Level (low, medium, high)
Opinions
Pre-test score
Post-test score
Learning gain
Response time
Balance of participation
Number of help requests
Total fixarion time on X
Gaze paths
Sequences of actions

≠ types of variables

➔≠ distributions

➔ ≠ analyses

1. Nominal, discrete
2. Ordinal, ordered
3. Metric, continuous, normal (?)
4. Times series

Age
Gender
Row in classroom
Teacher: A or B ?
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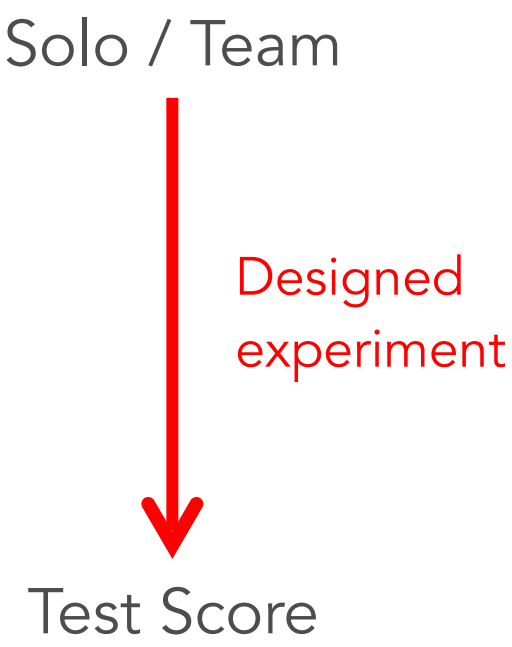
➔ ≠ analyses

1. Nominal, discrete
2. Ordinal, ordered
3. Metric, continuous, normal (?)
4. Times series

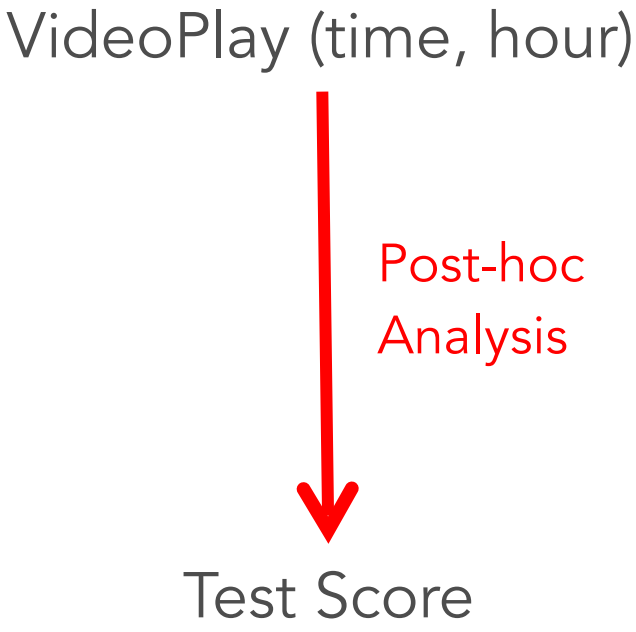
	Categories (Discrete)	Ordinal (Scale)	Metric (Continous)
Single Value	Ind: LearnStyle= Surface Dep: Style = Leader	Ind: Motivation= Low Dep: CodeQuality= Low	Ind: IQ= 142 Dep: Score= 23
Time Series	Ind: {play pause back…} Dep: gaze {O_1 O_3 O_1 O_2…}	Ind: Attention {3 3 5 …} Dep: {low low med …}	Ind: HeartRate {60 90 …} Dep: RespTime {33 22 10…}
2D & More		Gaze {(X_1 Y_2, α_1, T_1}, …. }	

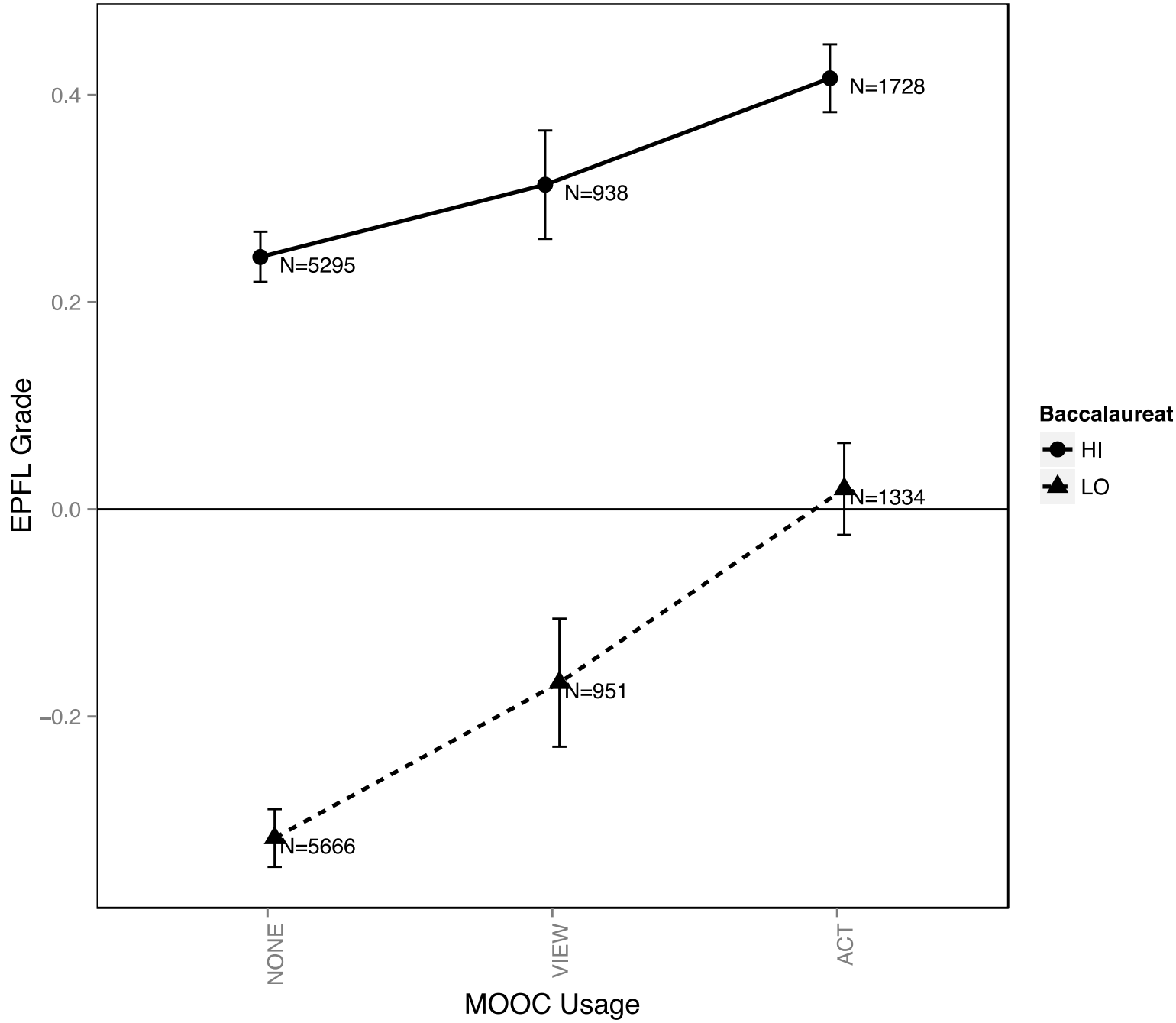
Independent Variable	Dependent Variable: Categories (Discrete)	Dependent Variable: Ordinal (Scale)	Dependent Variable: Metric (Continous)
Categories (Discrete)	CHI-SQUARE	KRUSKALL	ANOVA
Ordinal (Scale)	CHI-SQUARE		ANOVA
Metric (Continous)	Supervised Learning	Supervised Learning	REGRESSION

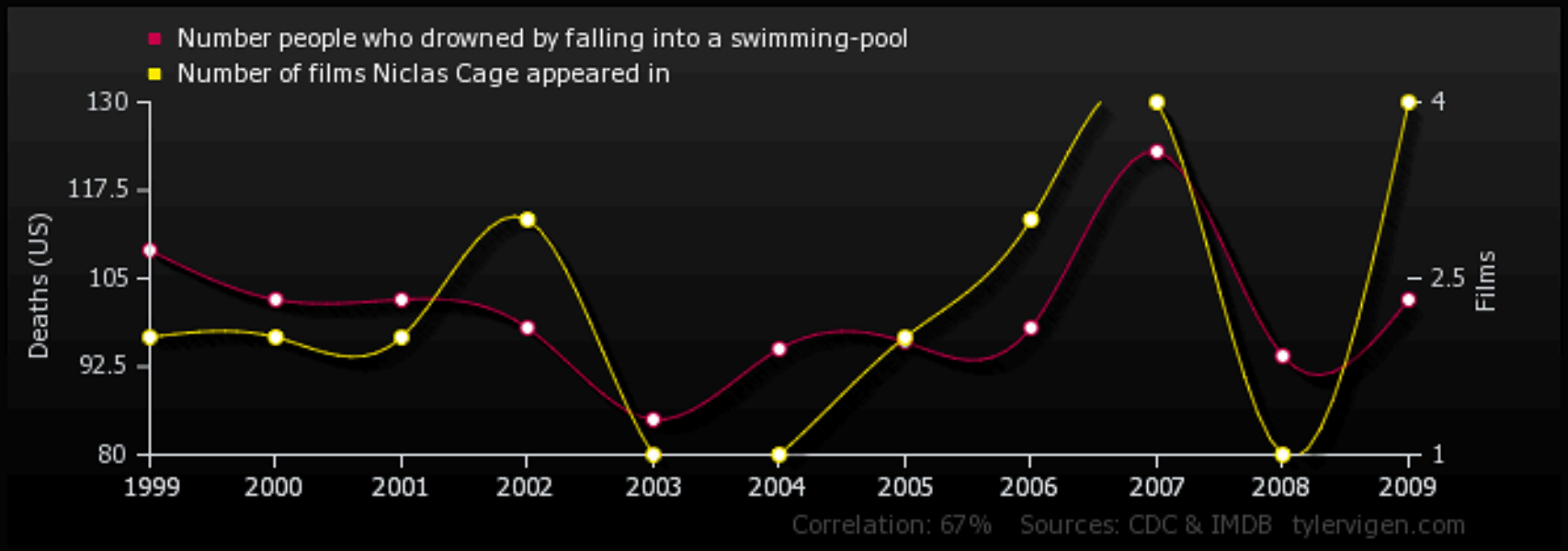
Is learning in teams more effective than learning alone ?

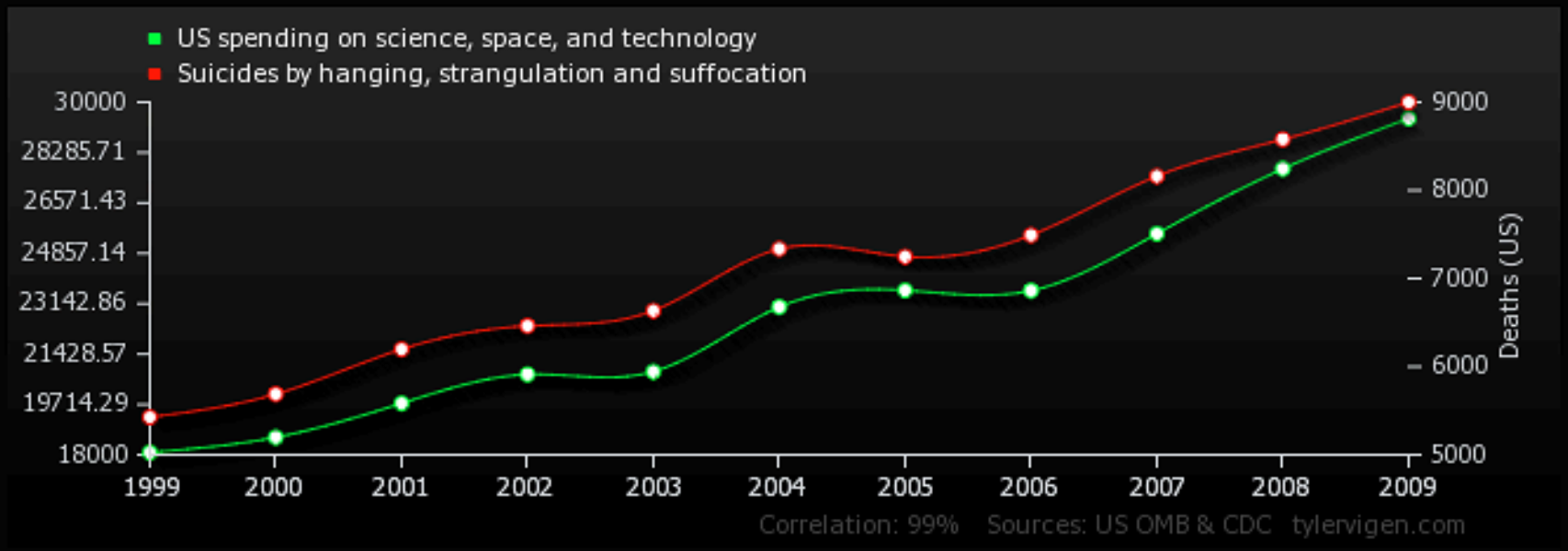


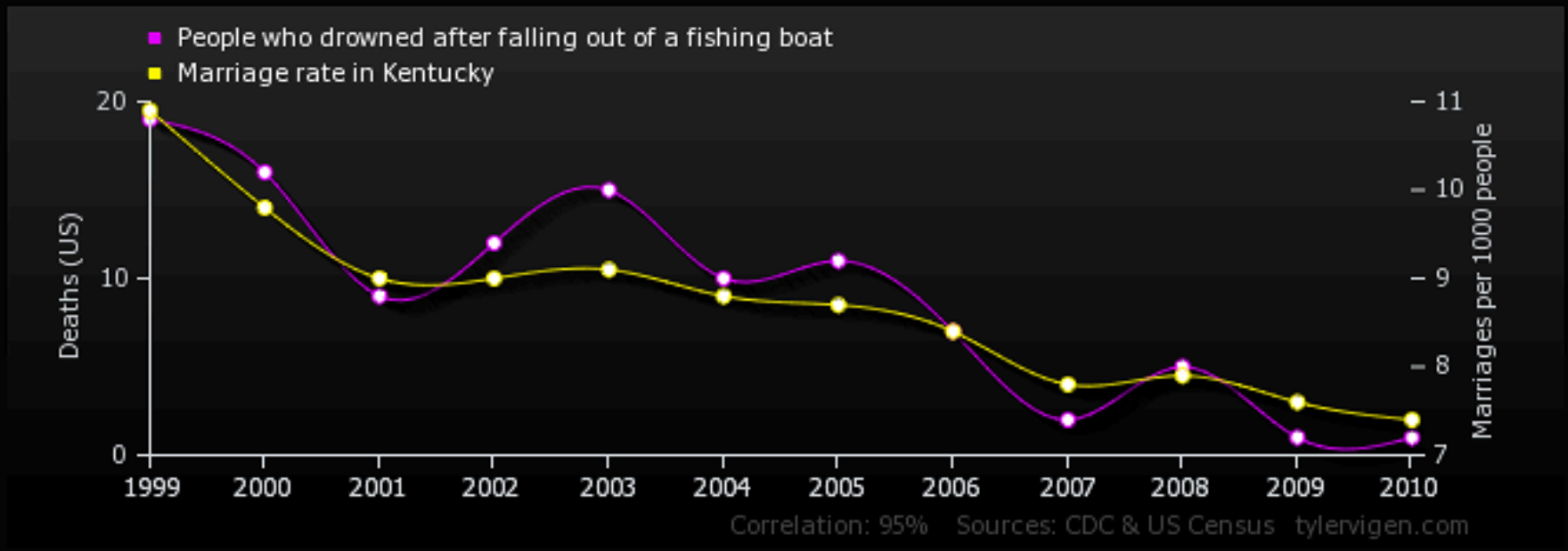
Do students who watch the MOOC faster succeed better?



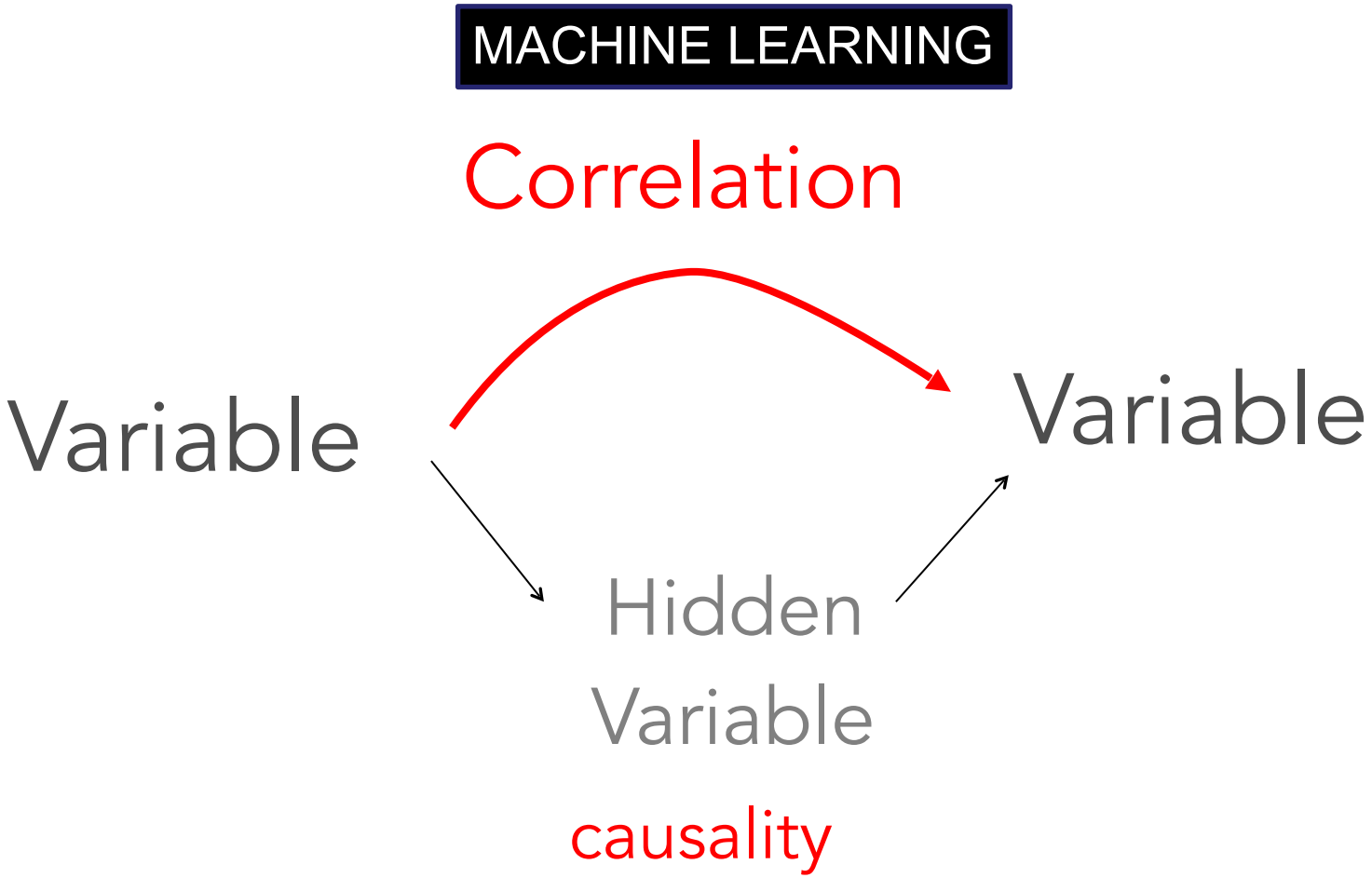

0.4
0.2
0.0
−0.2
EPFL Grade
N=1728
N=938
N=5295
N=1334
N=951
N=5666
NONE
VIEW
ACT
MOOC Usage
Baccalaureat
HI
LO


Number people who drowned by falling into a swimming-pool
Number of films Niclas Cage appeared in
Deaths (US)
130
117.5
105
92.5
80
Films
4
2.5
1
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Correlation: 67%
Sources: CDC & IMDB
tylervigen.com


US spending on science, space, and technology
Suicides by hanging, strangulation and suffocation
30000
28285.71
26571.43
24857.14
23142.86
21428.57
19714.29
18000
9000
8000
7000
6000
5000
Deaths (US)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Correlation: 99%
Sources: US OMB & CDC
tylervigen.com


People who drowned after falling out of a fishing boat
Marriage rate in Kentucky
Deaths (US)
Marriages per 1000 people
20
10
0
11
10
9
8
7
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Correlation: 95%
Sources: CDC & US Census
tylervigen.com

Correlation ≠ Causality



Summary

• Research Question	To be answered by the experiment
• Hypothesis	Expected results (A > B); an affirmation
• Independent variables	What one varies between the conditions (or Factor)
• Modality	Value of a factor
• Condition	Set of (factor, modality) per group of subjects
• Control group	The reference against which one will compare
• Dimension	Number of factors
• Dependent variables	How does one measure the effects ?
• Controlled variables	Things you try to keep constant or to randomize
• Intermediate variables	Explain the link from Independent to Dependent Variables
• “Significant” difference	Probably (<5%) not due to sampling error
• Interaction effect	The effect of one IV on the DV depends upon another IV
• Between/Within subject	Do subjects pass in one or several conditions ?
• Counterbalancing	Inverting the order of conditions for within-subject plans