Causal Research Design: Experimentation

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Concept of Causality

A statement such as "*X* causes *Y*" will have the following meaning to an ordinary person and to a scientist.

Ordinary Meaning	Scientific Meaning
***X* is the only cause of *Y*.**	***X* is only one of a number of possible causes of *Y*.**
***X* must always lead to *Y* (*X* is a deterministic cause of *Y*).**	**The occurrence of *X* makes the occurrence of *Y* more probable (*X* is a probabilistic cause of *Y*).**
It is possible to prove that *X* is a cause of *Y*.	**We can never prove that *X* is a cause of *Y*. At best, we can infer that *X* is a cause of *Y*.**

Conditions for Causality

- **Concomitant variation** is the extent to which a cause, *X*, and an effect, *Y*, occur together or vary together in the way predicted by the hypothesis under consideration.

- The **time order of occurrence** condition states that the causing event must occur either before or simultaneously with the effect; it cannot occur afterwards.

- The **absence of other possible causal factors** means that the factor or variable being investigated should be the only possible causal explanation.

Evidence of Concomitant Variation between Purchase of Fashion Clothing and Education

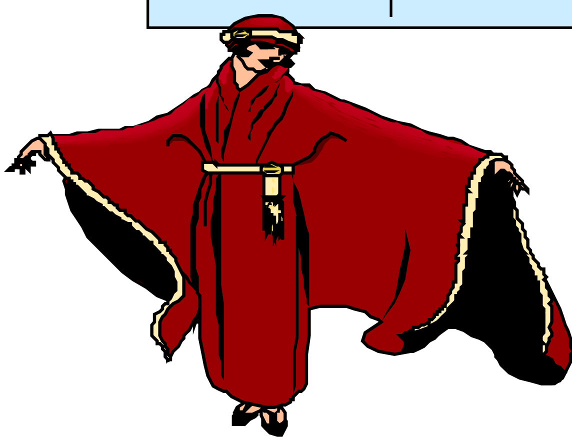
Purchase of Fashion Clothing, Y

Education, X	High	Low	
High	363 (73%)	137 (27%)	500 (100%)
Low	322 (64%)	178 (36%)	500 (100%)

Purchase of Fashion Clothing By Income and Education

Low Income

Education	Purchase: High	Purchase: Low	
High	122 (61%)	78 (39%)	200 (100%)
Low	171 (57%)	129 (43%)	300 (100%)



High Income

Education	Purchase: High	Purchase: Low	
High	241 (80%)	59 (20%)	300
Low	151 (76%)	49 (24%)	200

Definitions and Concepts

- **Independent variables** are variables or alternatives that are manipulated and whose effects are measured and compared, e.g., price levels.
- **Test units** are individuals, organizations, or other entities whose response to the independent variables or treatments is being examined, e.g., consumers or stores.
- **Dependent variables** are the variables which measure the effect of the independent variables on the test units, e.g., sales, profits, and market shares.

- **Extraneous variables** are all variables other than the independent variables that affect the response of the test units, e.g., store size, store location, and competitive effort.

Experimental Design

An **experimental design** is a set of procedures specifying

- the test units and how these units are to be divided into homogeneous subsamples,
- what independent variables or treatments are to be manipulated,
- what dependent variables are to be measured, and
- how the extraneous variables are to be controlled.

Validity in Experimentation

- **Internal validity** refers to whether the manipulation of the independent variables or treatments actually caused the observed effects on the dependent variables. Control of extraneous variables is a necessary condition for establishing internal validity.

- **External validity** refers to whether the cause-and-effect relationships found in the experiment can be generalized. To what populations, settings, times, independent variables and dependent variables can the results be projected?

Extraneous Variables

- **History** refers to specific events that are external to the experiment but occur at the same time as the experiment.
- **Maturation** (*MA*) refers to changes in the test units themselves that occur with the passage of time.
- **Testing effects** are caused by the process of experimentation. Typically, these are the effects on the experiment of taking a measure on the dependent variable before and after the presentation of the treatment.
- The **main testing effect** (*MT*) occurs when a prior observation affects a latter observation.

Extraneous Variables

- In the **interactive testing effect** (IT), a prior measurement affects the test unit's response to the independent variable.
- **Instrumentation** (I) refers to changes in the measuring instrument, in the observers or in the scores themselves.
- **Selection bias** (SB) refers to the improper assignment of test units to treatment conditions.
- **Mortality** (MO) refers to the loss of test units while the experiment is in progress.

Controlling Extraneous Variables

- **Randomization** refers to the random assignment of test units to experimental groups by using random numbers. Treatment conditions are also randomly assigned to experimental groups.
- **Matching** involves comparing test units on a set of key background variables before assigning them to the treatment conditions.
- **Statistical control** involves measuring the extraneous variables and adjusting for their effects through statistical analysis.
- **Design control** involves the use of experiments designed to control specific extraneous variables.

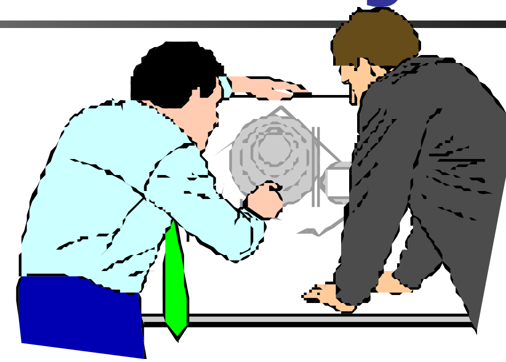
A Classification of Experimental Designs

- **Pre-experimental designs** do not employ randomization procedures to control for extraneous factors:
  - The one-shot case study, the one-group pretest-posttest design, and the static-group.
- In **true experimental designs**, the researcher can randomly assign test units to experimental groups and treatments to experimental groups:
  - The pretest-posttest control group design, the posttest-only control group design, and the Solomon four-group design.

A Classification of Experimental Designs

- **Quasi-experimental designs** result when the researcher is unable to achieve full manipulation of scheduling or allocation of treatments to test units but can still apply part of the apparatus of true experimentation:
  - Time series and multiple time series designs.
- A **Statistical design** is a series of basic experiments that allows for statistical control and analysis of external variables:
  - Randomized block design, Latin square design, and factorial designs.

A Classification of Experimental Designs



Experimental Designs

- Pre-experimental
  - One-Shot Case Study
  - One Group Pretest-Posttest
  - Static Group
- True Experimental
  - Pretest-Posttest Control Group
  - Posttest: Only Control Group
  - Solomon Four-Group
- Quasi Experimental
  - Time Series
  - Multiple Time Series
- Statistical
  - Randomized Blocks
  - Latin Square
  - Factorial Design

One-Shot Case Study

$X \quad O_1$

- A single group of test units is exposed to a treatment *X.*
- A single measurement on the dependent variable is taken (O_1).
- There is no random assignment of test units.
- The one-shot case study is more appropriate for exploratory than for conclusive research.

(History, Maturation, Selection & Mortality)

One-Group Pretest-Posttest Design

$O_1 \quad X \quad O_2$

- A group of test units is measured twice.
- There is no control group.
- The treatment effect is computed as $O_2 - O_1$.
- The validity of this conclusion is questionable since extraneous variables are largely uncontrolled.

  (History, Maturation, Testing, Instrumentation, Selection, Mortality, & Regression)

Static Group Design

EG: X 0_1

CG: 0_2

- A two-group experimental design.
- The experimental group (EG) is exposed to the treatment, and the control group (CG) is not.
- Measurements on both groups are made only after the treatment.
- Test units are not assigned at random.
- The treatment effect would be measured as 0_1 - 0_2. (Selection & Mortality)

True Experimental Designs: Pretest-Posttest Control Group Design

EG:	R	0_1	X	0_2
CG:	R	0_3		0_4

- Test units are randomly assigned to either the experimental or the control group.
- A pretreatment measure is taken on each group.
- The treatment effect (TE) is measured as: $(0_2 - 0_1) - (0_4 - 0_3)$.
- Selection bias is eliminated by randomization.
- The other extraneous effects are controlled as follows:

  $0_2 - 0_1 = TE + H + MA + MT + IT + I + SR + MO$

  $0_4 - 0_3 = H + MA + MT + I + SR + MO$

  $= EV$ (Extraneous Variables)
- The experimental result is obtained by:

  $(0_2 - 0_1) - (0_4 - 0_3) = TE + IT$
- Interactive testing effect is not controlled.

Posttest-Only Control Group Design

EG : $R \quad X \quad 0_1$

CG : $R \qquad\quad 0_2$

- The treatment effect is obtained by $TE = 0_1 - 0_2$
- Except for pre-measurement, the implementation of this design is very similar to that of the pretest-posttest control group design.
  - (Selection Bias & Mortality)

Quasi-Experimental Designs: Time Series Design

$O_1 \quad O_2 \quad O_3 \quad O_4 \quad O_5 \quad X \quad O_6 \quad O_7 \quad O_8 \quad O_9 \quad O_{10}$

- There is no randomization of test units to treatments.
- The timing of treatment presentation, as well as which test units are exposed to the treatment, may not be within the researcher's control.

Multiple Time Series Design

EG : O_1 O_2 O_3 O_4 O_5 X O_6 O_7 O_8 O_9 O_{10}

CG : O_1 O_2 O_3 O_4 O_5 O_6 O_7 O_8 O_9 O_{10}

- If the control group is carefully selected, this design can be an improvement over the simple time series experiment.
- Can test the treatment effect twice: against the pretreatment measurements in the experimental group and against the control group.

Statistical Designs

Statistical designs consist of a series of basic experiments that allow for statistical control and analysis of external variables and offer the following advantages:

- The effects of more than one independent variable can be measured.
- Specific extraneous variables can be statistically controlled.
- Economical designs can be formulated when each test unit is measured more than once.

The most common statistical designs are the Completely randomised design, Randomised block design, the Latin square design, and the Factorial design.

Completely Randomised Design

Pricing Decision Facing Manager of Adani Retail.

- He wants to know what should be the ideal price difference between their in-store brand and the national brands like Maggi or Kissan.
- Sets up an experiment involving eighteen Adani Retail Stores and three price spreads (treatment levels) of Rs.7, Rs.12 & Rs.17 between the in store brand and the national brands.
- Six stores are assigned randomly to each of the price spread.
- The price difference is maintained for a period, then tally is made of Sales volume & Gross profits for each group of stores.

Completely Randomised Design

- This can be diagrammed as

$$\begin{array}{cccc} R & O_1 & X_1 & O_2 \\ R & O_3 & X_2 & O_4 \\ R & O_5 & X_3 & O_6 \end{array}$$

O_1 O_3 & O_5 is gross profits of instore brand for a month before the test

O_2 O_4 & O_6 is gross profits of instore brand for a month after the test

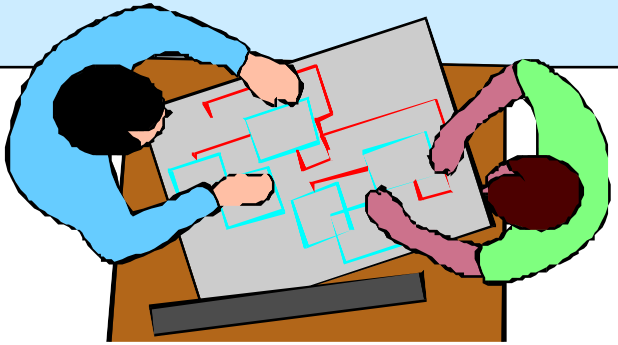
Assumption is randonmisation of stores to the three treatment level is sufficient to make the three store group equivalent.

Randomized Block Design

- Is useful when there is only one major external variable, such as store size, that might influence the dependent variable.
- The test units are blocked, or grouped, on the basis of the external variable.
- By blocking, the researcher ensures that the various experimental and control groups are matched closely on the external variable.

Randomized Block Design

		Treatment Groups		
		Price Difference		
Block Number	Customer Income	Rs. 7	Rs. 12	Rs. 17
		R	R	R
1	Heavy	X_1	X_2	X_3
2	Medium	X_1	X_2	X_3
3	Low	X_1	X_2	X_3



Factorial Design

- Is used to measure the effects of two or more independent variables at various levels.
- A factorial design may also be conceptualized as a table.
- In a two-factor design, each level of one variable represents a row and each level of another variable represents a column.

Factorial Design

2 x 2 FACTORIAL DESIGN illustrating effects of gender and Ad on believability

Gender	Ad A	Ad B	
Men	X_1Y_1 60	X_1Y_2 70	65
Women	X_2Y_1 80	X_2Y_2 50	65
	70	60	

Main Effects of Gender

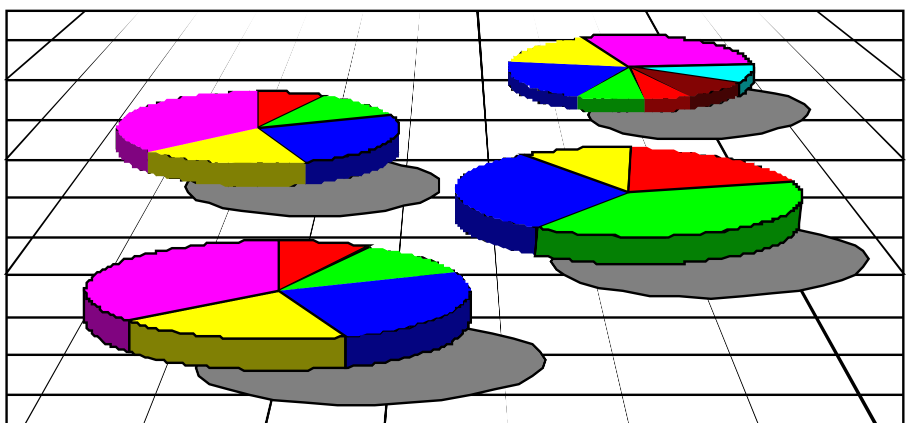
Main Effects of Ads

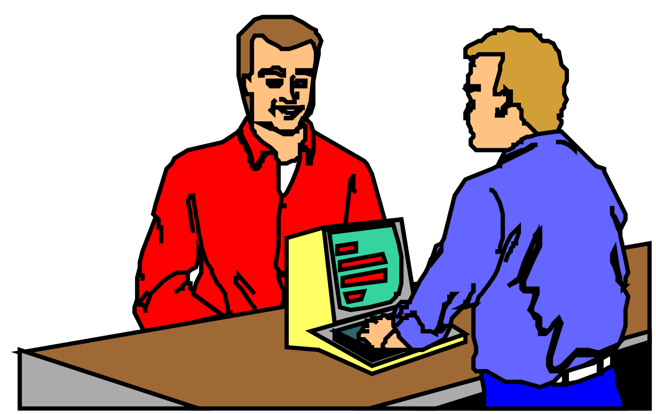
Latin Square Design

- Allows the researcher to statistically control two **non-interacting** external variables as well as to manipulate the independent variable.
- Each external or blocking variable is divided into an **equal** number of blocks, or levels.
- The independent variable is also divided into the same number of levels.
- A Latin square is conceptualized as a table, with the rows and columns representing the blocks in the two external variables.
- The levels of the independent variable are assigned to the cells in the table.
- The **assignment rule** is that each level of the independent variable should appear only once in each row and each column, as shown in Table

Latin Square Design

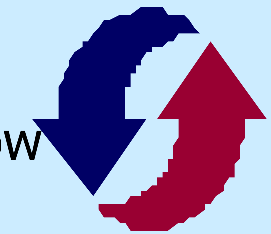
	Customer Income		
Store Size	High	Medium	Low
Large	X_3	X_1	X_2
Medium	X_2	X_3	X_1
Small	X_1	X_2	X_3

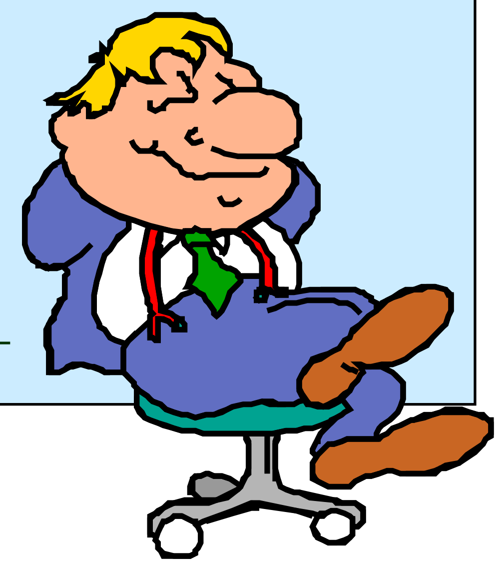




Laboratory versus Field Experiments

Factor	Laboratory	Field
Environment	Artificial	Realistic
Control	High	Low
Reactive Error	High	Low
Demand Artifacts	High	Low
Internal Validity	High	Low
External Validity	Low	High
Time	Short	Long
Number of Units	Small	Large
Ease of Implementation	High	Low
Cost		Low



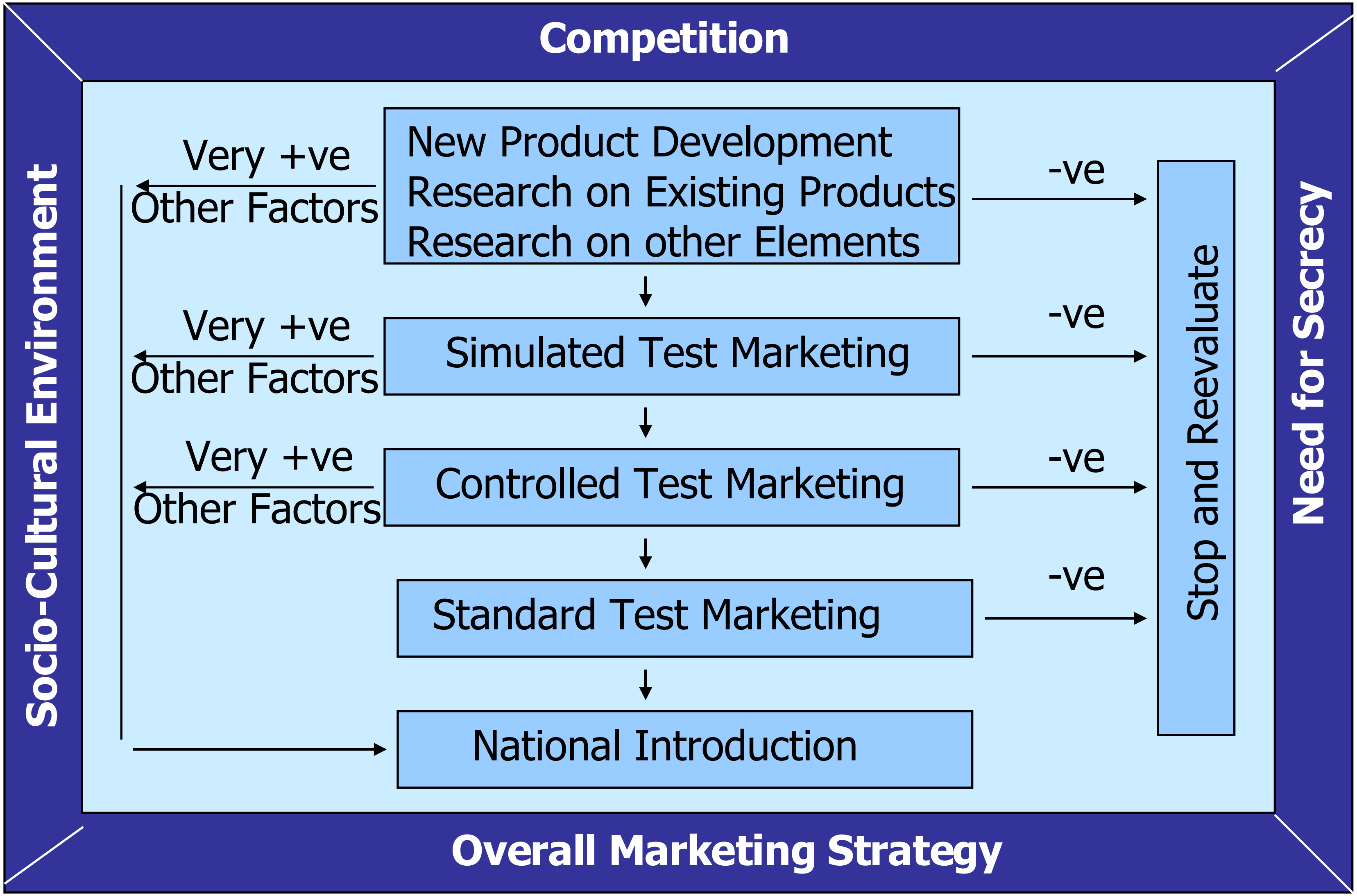


Limitations of Experimentation

- Experiments can be time consuming, particularly if the researcher is interested in measuring the long-term effects.
- Experiments are often expensive. The requirements of experimental group, control group, and multiple measurements significantly add to the cost of research.
- Experiments can be difficult to administer. It may be impossible to control for the effects of the extraneous variables, particularly in a field environment.
- Competitors may deliberately contaminate the results of a field experiment.

THANK YOU

Selecting a Test-Marketing Strategy



Criteria for the Selection of Test Markets

Test Markets should have the following qualities:

2) Be large enough to produce meaningful projections. They should contain at least 2% of the potential actual population.
3) Be representative demographically.
4) Be representative with respect to product consumption behavior.
5) Be representative with respect to media usage.
6) Be representative with respect to competition.
7) Be relatively isolated in terms of media and physical distribution.
8) Have normal historical development in the product class
9) Have marketing research and auditing services available
10) Not be over-tested