1 **Experimental Design**

2 **Outline**

- Research question and hypothesis
- Setting up a good research hypothesis
- Principles of experimental design
- Examples
- Group work
- Presentations

3 **Research Begins with a Question**

- Question:Does mass of an object affect the time needed to fall?
- Hyphothesis: Time to fall is not affected by the mass of objects
- A research hypothesis is the proposed answer to the research question

4 **Setting Up a Good Research Hypothesis**

Hypothesis are statements about the relationship between variables in an experiment

5 **Setting Up a Good Research Hypothesis**

- Psychological hypotheses can be the most difficult but the most influential
- Ungerleider and Mishkin in 1982 suggested that visual information processed in two distint pathways
  - A ventral occipitotemporal pathway that processes object features (what)
  - A dorsal occipitoparietal pathway that processes spatial properties (where)

6 **Principles of Experimental Design**

- Experiment is a procedure carried out to support, refute or validate a hyphothesis
- Researchers use experiments to answer questions
- To test the hypothesis scientists design experiments

7 **Principles of Experimental Design**

- Experimental design is the way scientists set up the manuplations and measurements in an experiment.
- Comparative experiment
  - A direct comparison between the manuplations/treatments of interest.
  - We can design experiments to minimize any bias in the comparison.
  - We can design experiments so that the error in the comparison is small.
  - *We are in control of experiments, we may make inferences about causation.*

8 **Principles of Experimental Design**

To support a causal relationship:

- Consistency; all other things being equal, the relationship between two variables is consistent
- Responsiveness; we can go into a system, change the causal variable, and watch the response variable change accordingly.
- Mechanism; we have a step-by-step mechanism leading from cause to effect.

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❑Mechanism; we have a step-by-step mechanism leading from cause to effect.

9 **Principles of Experimental Design**

❑Independent Variables(IVs): Aspects of the experimental design that are manuplated by the researcher (e.g: The mass of the objects in Galileo’s experiment)

❑Depends on the hypothesis

❑Different values of an IV is often called conditions or levels (light and heavy).

10 **Principles of Experimental Design**

❑Dependent variables (DVs) : The data measured by the experimenter (e.g: The time taken to travel a given distance in Galileo’s experiment)

❑ functional Magnetic Resonance Imaging (fMRI), EEG…

❑ Reaction time

❑ Error rate

11 **Principles of Experimental Design**

❑Within-subject manipulations:

❑Each subject participates in all experimental conditions

❑Statistical comparisons are made between different conditions

❑Between-subjects manipulations:

❑Allows inferences between groups

❑Statistical comparisons are made between groups (and also between different conditions)

❑

12 **Principles of Experimental Design**

❑There must be at least two independent variables; faces, tools

❑A measurable dependent variable; fMRI, EEG etc.

❑Setting up a task and control condition is the easiest way

❑

13 **Confounding Factors**

❑Confounding Factor is any property that co-varies with the independent variable within the experiment

❑How should we deal with confounding factors?

❑Randomization; e.g. experimental trials should be in random order

❑Counterbalancing; matching values across conditions

❑Substraction; task-control

❑

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Are the independent variables appropriate?

15 **Example-1:**
Time Perception and Working Memory

Question:
Which distinct brain areas are responsible for time perception and working memory?

Hypothesis:
The working memory would induce activation in the prefrontal and parietal cortex, and that time perception would activate the prefrontal cortex, cerebellum and BG.

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16 **Time Perception and Working Memory**

Question:
How are the neural networks responsible for these processes interact with each other?

Hypothesis:
The neural networks required for working memory and time perception would partially overlap.

17 **METHODS**

15 healthy adults (7 female, 8 male), mean age = 22.4 years (replication)

Experimental design was a visual task called foreperiod paradigm which was designed using MATLAB software

Participants performed the tasks while undergoing fMRI scan (dependent variable).

The task consisted 4 different conditions (independent variables):
- Control
- Time perception
- Working memory
- Dual (time-memory)

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20 **METHODS**

Neuroimaging

3T Siemens Magnetom Trio MRI Scanner was used for fMRI acquisition.

The visual stimuli were projected onto a screen which was visible via a mirror.

Analysis of data was performed using SPM8 software.

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Time Perception and Working Memory

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22 **RESULTS**

Time perception:
Comparison by substraction (time-control)

22

Comparison by substraction (time-control)

❑Prefrontal and Parietal Cortex
❑Insular Cortex
❑Anterior Cingulate Cortex/ Supplementary Motor Area
❑Basal Ganglia

23 **RESULTS**

Working memory (memory-control):
❑Parietal and Prefrontal Cortex
❑Anterior Cingulate Cortex
❑Basal Ganglia and Thalamus

24 **Time Perception and Working Memory**

Question:
How are the neural networks which responsible for these processes interact with each other?

Hypothesis:
The neural networks required for working memory and time perception would partially overlap.

25 **RESULTS**

Interaction (Time perception - Working Memory):

◦ Inferior Parietal Lobe
◦
◦ Posterior Cingulate Cortex

26 **CONCLUSION**

1.
❑Timing processes engage a distributed brain network mainly revolving around the frontoparietal as well as the subcortical areas.
1.
❑The parietal cortex and posterior cingulate cortex might play a role as an interface between timing and working memory
1.

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28 **Example-2**

Question: Does salted drinking water affect blood pressure (BP) in mice?

Experiment:
1. Provide a mouse fed with water containing 1% NaCl.
2. Wait 14 days.
3. Measure BP.

29 **Comparison/control**

Good experiments are comparative.

29 **Comparison/control**

Good experiments are comparative.

- Compare BP in mice fed salt water to BP in mice fed plain water.
- Compare BP in strain A mice fed salt water to BP in strain B mice fed salt water.

Ideally, the experimental group is compared to concurrent controls (rather than to historical controls).

30 **Replication**

31 **Why replicate?**

Reduce the effect of uncontrolled variation (i.e., increase precision)
Quantify uncertainty.

A related point:

An estimate is of no value without some statement of the uncertainty in the estimate.

32 **Randomization**

Experimental subjects ("units") should be assigned to treatment groups at random.

One needs to explicitly randomize using

- A computer, or
- Coins, dice or cards.

33 **Why randomize?**

Avoid bias.

- For example: the first six mice you grab may have intrinsically higher BP.

Control the role of chance.

- Randomization allows the later use of probability theory, and so gives a solid foundation for statistical analysis.

34 **Counterbalancing (or stratification)**

Suppose that some BP measurements will be made in the morning and some in the afternoon.
If you anticipate a difference between morning and afternoon measurements:

- Ensure that within each period, there are equal numbers of subjects in each treatment group.
- Take account of the difference between periods in your analysis.

35 **Group work**

- ❑ Go to a private virtual room with your group
- ❑ Ask a research question?
- ❑ Propose a testable hypothesis
- ❑ Design an experiment
  - ❑ Variables; IVs, DVs
  - ❑ Between or within-subject; One or more groups…
  - ❑ Animal or human research
- ❑ Come back to the main room and present your project (one speaker each group)
  - ❑