Experimental Research

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Aim of the Session

- Understand the nature of experimental research
- Be able to understand IS journal papers that use an experimental method

- Terms & concepts
- Experimental designs
- An example

Science

- Three main classes of investigation

- Descriptive studies
  - variables or phenomena are described
- Correlational studies
  - relationships between variables are identified
- Experiments
  - manipulation and measurement of variables to infer causality

Research Questions

- Research is the process of asking important questions and answering them in a way that is convincing and defensible

- Any question that is capable of being confirmed or refuted is a potential target for experimentation
- Methods should be guided by the questions

Variables

- Independent variables
  - Variable whose effect we are interested in
  - Manipulated by the researcher
  - Levels - ways manipulated
  - Subject variables - selected not manipulated
- Dependent variables
  - The response or behaviour
  - Measures the influence of the independent variable
- Intermediate variables
- Extraneous variables
  - A variable, other than the independent variable, capable of affecting the dependent variable
  - Confounding variables or confounds

Groups

- Experimental group
  - Treatment group
  - Group that receives the experimental treatment
- Control group
  - Does not receive treatment
- Groups should be equivalent
  - Control extraneous variables
  - Random assignment
  - Matched pairs

Hypotheses

- Predictions about the effect of the independent variable on the dependent variable
- Research hypotheses
  - Alternative hypotheses
  - H_1
  - What the researcher expects
  - Two-tailed, difference
  - One tailed, direction is important
- Null hypotheses
  - H_0
  - What the researcher doesn't expect
  - No significant difference

Significant Difference

- Not sufficient to simply have a difference between the groups in an experiment to argue that the independent variable can affect the dependent variable in a causal way

- The difference between two descriptive statistics that is of such magnitude that it is unlikely to have occurred by chance

- Significance level
  - 95% or $p <= 0.05$ is acceptable
  - 99% or $p <= 0.01$ is a strong result

Experiments

- Investigations where groups are treated identically except for a manipulation of the independent variable. Changes in the dependent variable may be attributed to the difference in the independent variable.

- Laboratory experiments
- Quasi-experiments
- Field experiments
- Single-case experiments

Reliability and Validity

- Internal validity
  - extent to which it is the effect of the independent variable and not a confounding variable that has caused the change in the dependent variable
- External validity
  - extent to which the results of the experiment can be generalised to other entities other than the subjects used in the experiment.
- Construct validity
  - extent to which the measure of the concept or construct actually measures the construct.
- Statistical validity
  - using the correct statistical tests to measure the dependent variable.
- Practical validity
  - are the results of personal or practical significance

Experimental Design 1

- Between-subjects design
  - each group receives a different level of the independent variable
- Within-subjects design
  - repeated measures design, pretest-posttest designs
  - each subject receives each level of the independent variable

Experimental Design 2

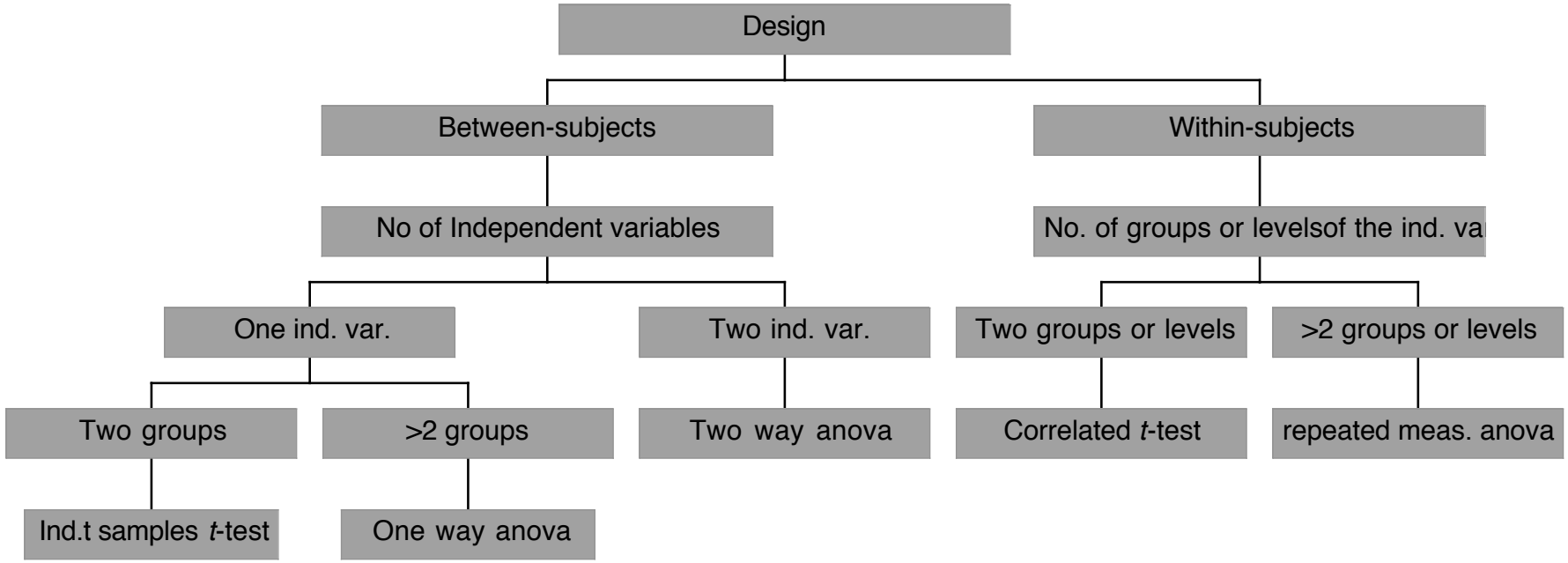
- After-only design
  - dependent variable is only measured after the manipulation of the independent variable

- Before-after design
  - dependent variable is measured before and after the manipulation and the effect of the independent variable is the difference between the two measures

Experimental Design 3

- Two group, between-subjects design
  - classical experimental design
- Between-subjects, one independent variable with many experimental groups
- Factorial design
  - study of the effect of two or more independent variables on a dependent variable as well as the interaction between the independent variables
- Within-participants after-only design
- Mixed factorial design
  - combines between-subjects and within-subjects designs

Statistical Tests



Quasi-Experiments

- Halfway between true experiments and correlation studies
- Don't meet all requirements for controlling extraneous variables
- Why?
  - true experiments are not possible
  - ethics
  - practicalities
- Internal validity
  - pretest posttest designs
  - time series designs

Field Experiments

- Type of quasi-experiment
- Naturalistic setting
- Trade off between internal and external validity

Single-Subject Research

- Case study
- Single-case study
- One-shot case study
- Small-n
- Single-n
- Single-subject designs
- Single-subject experiments
- Positivist case study

Single vs Multiple Subjects

- Can be more accurate to record systematic single subject than group data
- Treatments often result in some cases improving, some worsening, and some staying the same
- Doesn’t distort the professional reality
- Multiple subjects may cost too much and take too long
- May only have one subject

Single-Subject Experiments

- Type of quasi-experiment
- Measure baseline behaviour (A), introduce treatment (B), measure behaviour after treatment
- Control of independent variable difficult
- AB results caused by maturation, testing, or treatment
- ABA or reversal design
- Multiple-baseline design
- Reversal of treatment may be unethical and impossible

A Multiple Baseline Design

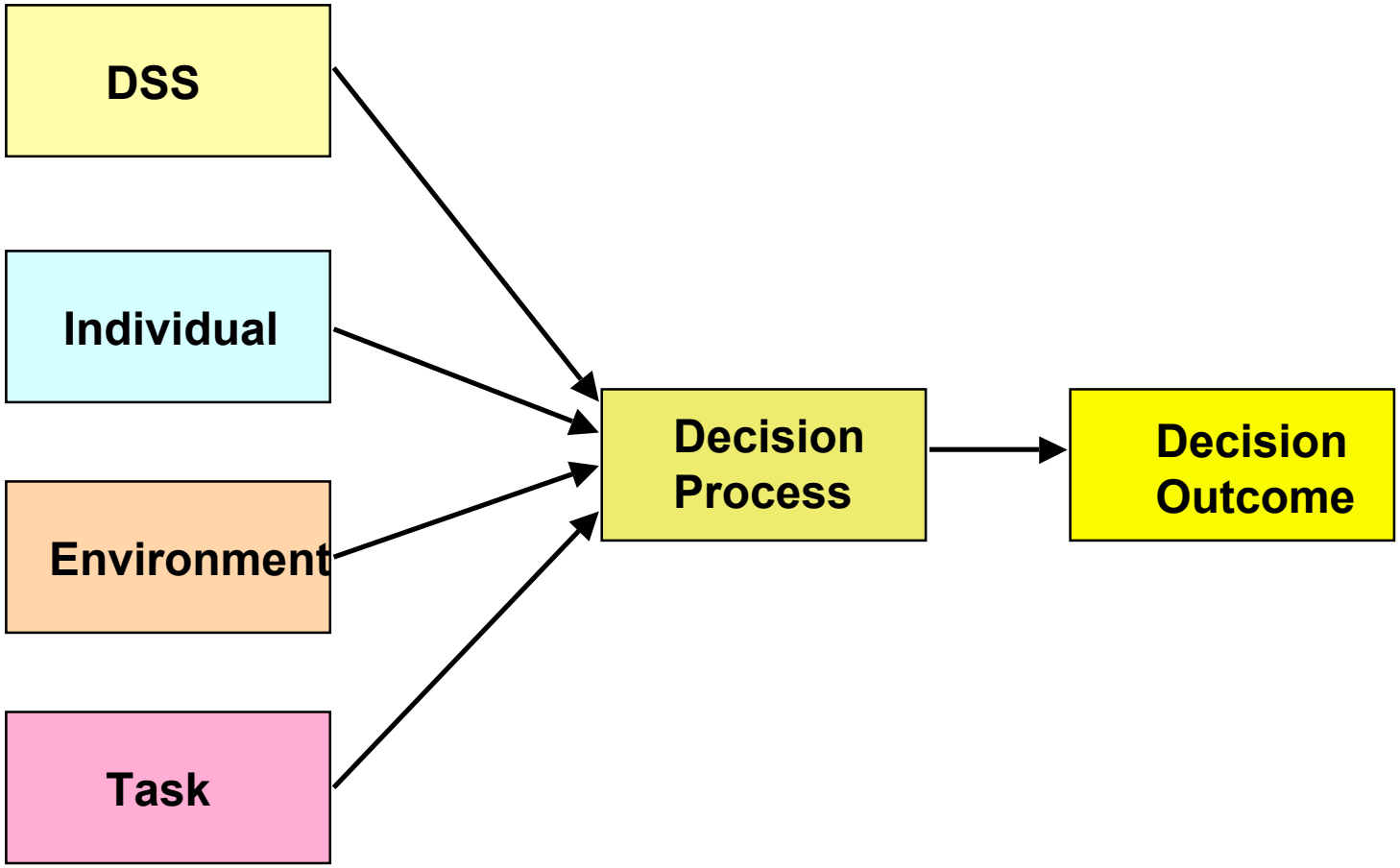
A	Baseline	**Treatment**	Baseline	Baseline	Baseline
B	Baseline	Baseline	**Treatment**	Baseline	Baseline
C	Baseline	Baseline	Baseline	**Treatment**	Baseline
D	Baseline	Baseline	Baseline	Baseline	**Treatment**

Subject: Vice-president of marketing
Treatment: DSS aimed at debiasing decision making
Behaviours:
A only considering confirming information
B incorporating base rate data
C framing effects
D anchoring and adjustment

Monash DSS Laboratory

How should an analyst develop an information system to support the work of a manager such that the process and outcome of decision making is improved?

A General DSS Research Model



DSS Lab Research Methods

- Interpretive case studies
- Design science (design research)
- Focus groups
- Surveys
- Literature analysis
- Philosophy
- Single-subject experiments (positivist case studies)
- Quasi-experiments
- Laboratory experiments

A Research Question

What is the desirable scale of the first version of a DSS in an evolutionary development process?

An Experimental Project

- The Impact of a Simple Decision Support System on the Forecast of Exponential Growth

- Researchers
  - David Arnott & Peter O'Donnell
- Research Assistants
  - Vincent Yeo & Gemma Dodson

Forecasting Exponential Growth

- Humans find it difficult to extrapolate exponential functions.
- Experiments present subjects with a series and ask for a future element in the series.
- Bias is resistant to training, presentation mode, direction, and amount of information.
- May be due to
  - anchoring and adjustment
  - misapplication of models
  - failure to aggregate data sources

What can a DSS do to help?

- Support visualisation
  - interacting numerical and graphical representations
- Humans may extrapolate linear series correctly
  - support logarithmic transformation
- Support the answering task
- Allow play

Hypotheses

H_1: Subjects using a decision aid will have better forecast accuracy than subjects using a report.

H_2: Subjects presented with a combined representation will have better forecast accuracy than those presented with a normal representation.

H_3: Subjects using a decision aid with a combined representation will have better forecast accuracy than those using a decision aid with a normal representation.

H_4: Subjects using a report with a combined representation will have better forecast accuracy than those using a report with a normal representation.

Design

- 2 independent variables, 2 levels
  - support (report, decision aid)
  - representation (normal, combined)
- Dependent variable: forecast accuracy

  forecast accuracy = |normative solution - forecast|
- The task
  - Data series, population index 1870 to 2020
  - Estimate required for 2050
- 73 subjects - 39 reports, 34 decision aids
- Third year undergraduate students
- No incentives, no time restrictions

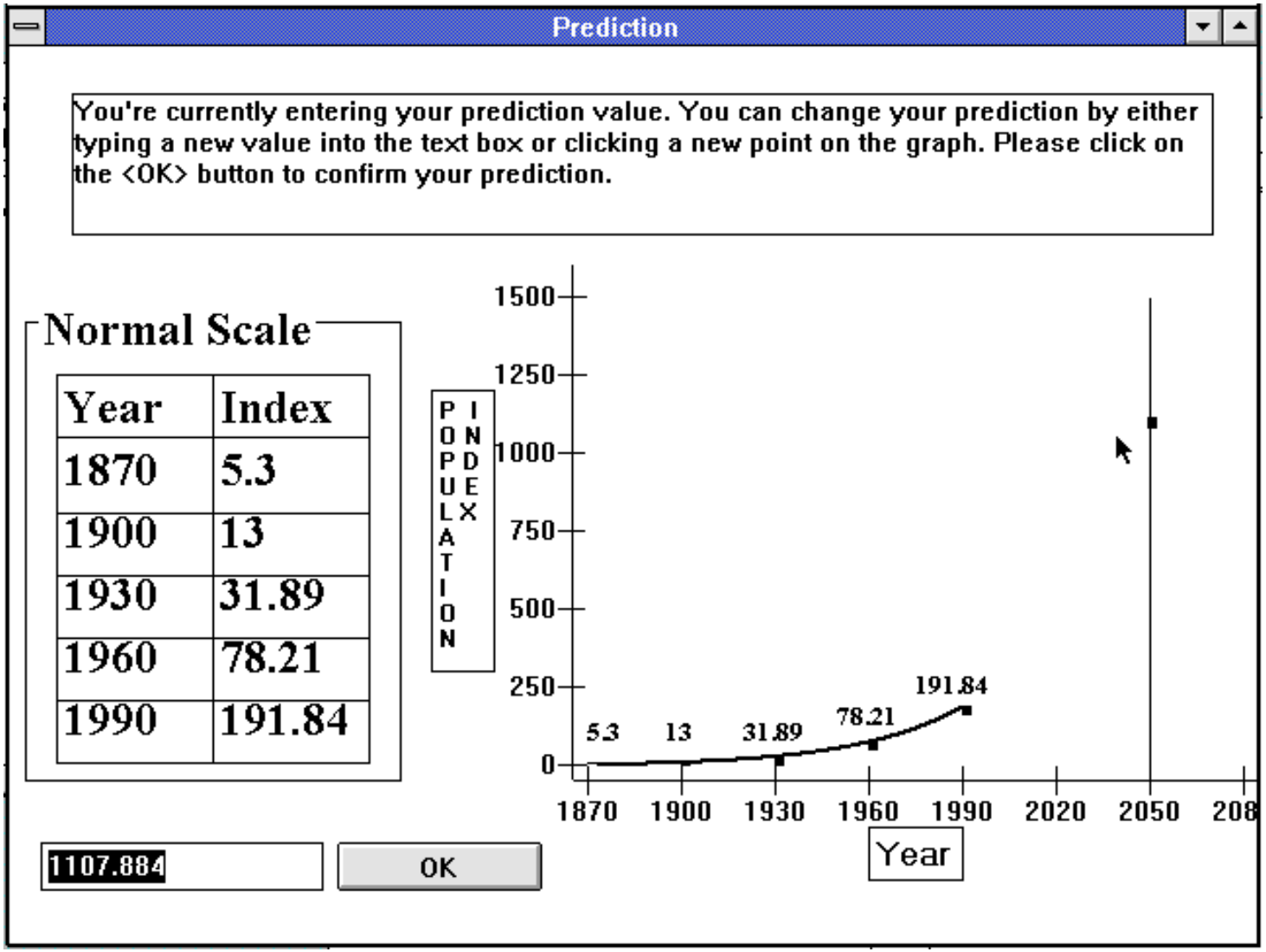
Factorial Design

- Effect of two or more independent variables on a dependent variable
- Test several hypotheses simultaneously
- Main and interaction effects
- Popular behavioural science design

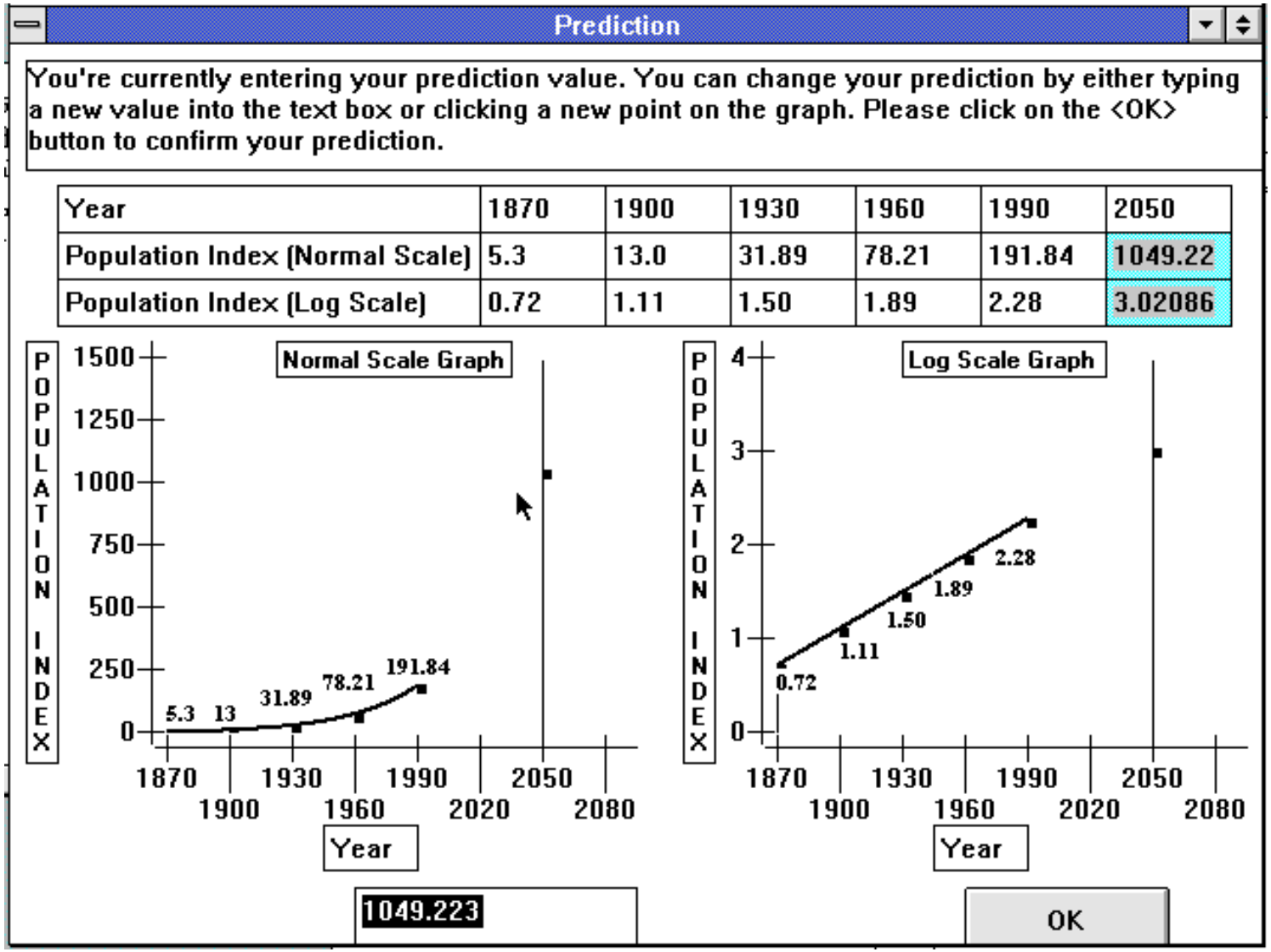
The Decision Aids

- Simplest possible support
- Three screens
  - explain nature of task
  - decision support
  - collect demographic data
- Similar to paper-based support
- Two decision aids
  - D1, normal representation
  - D2, combined representation

D1- Normal Representation



D2 - Combined Representation



Results I

	Count	Mean	Std. Dev.	Std. Err.
Decision Aid, Combined	19	192.637	428.007	98.192
Decision Aid, Normal	15	110.200	610.780	157.703
Report, Combined	20	371.630	217.937	48.732
Report, Normal	19	547.726	326.028	74.796

Results II

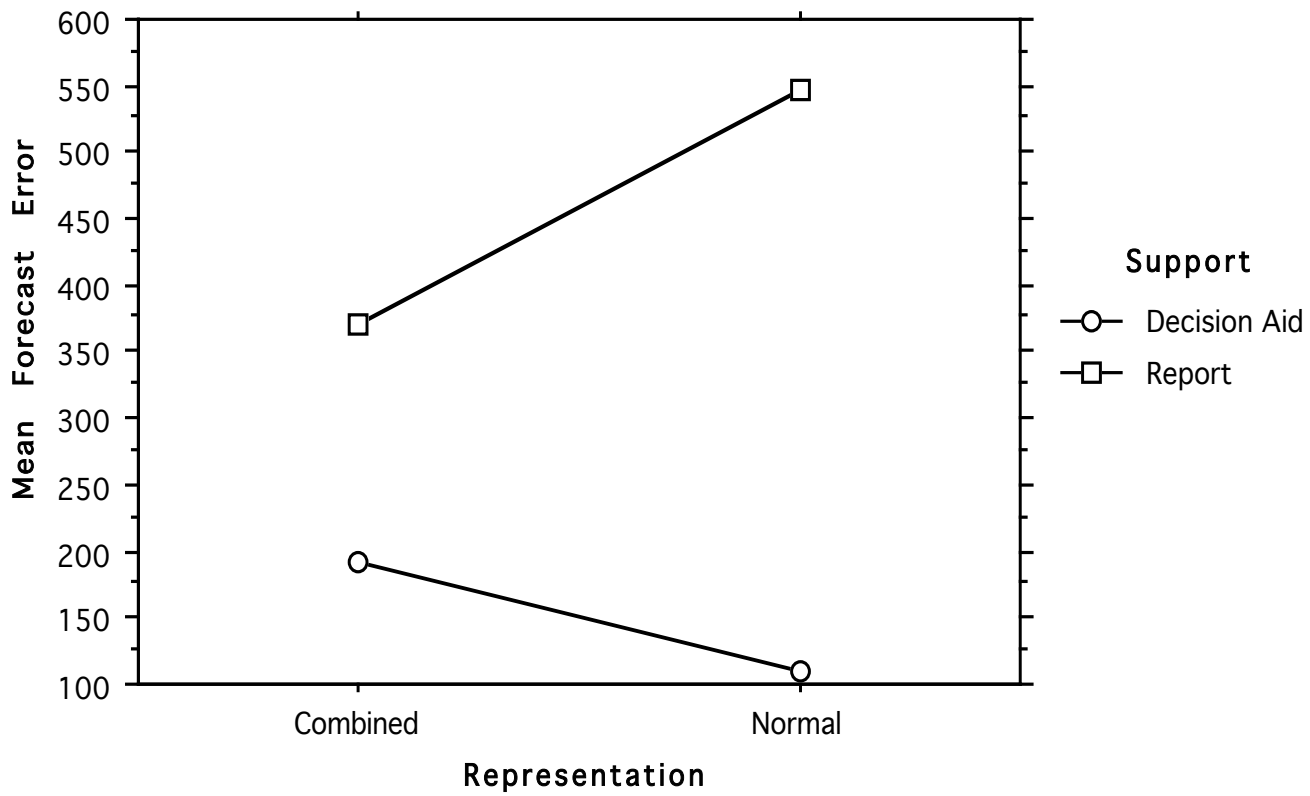
Adjusted ANOVA

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Support	1	1712686.712	1712686.712	10.425	.0019
Representation	1	39526.445	39526.445	.241	.6253
Support * Representation	1	301173.553	301173.553	1.833	.1802
Residual	69	11335885.643	164288.198		

Tests

- H_1 (support: aid v. report) supported p=.0019
- H_2 (represent: comb v. norm) rejected
- H_3 (aid: combined v. norm) rejected
- H_4 (report: combined v. norm) rejected

Interaction Plot of Mean Forecast Error for Support * Representation



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Interpretation

- Use of a minimal DSS improves performance in forecasting exponential growth (negates bias)
- Use of DSS not transformation has significant effect
- “Complex” DSS worse than “simple” DSS, but not significant

- Cognitive effort vs. decision accuracy
- Level of assistance to enable play

- Start DSS evolution as simply as possible

Limitations

- Use of student subjects
- Artificial problem
- Subjects not stakeholders

Current Work

- New experiment
  - Equal group size
- New problem
  - Forecasting CD sales
  - More understandable
  - MBA students who are managers as subjects
    - Control for music purchases
- Better aids
  - Nicer design

Experimental Research

- Important part of social research
- Unique contribution is testing causal propositions
- Design is very difficult
- Often based on descriptive research
- Can lead to other styles of research

On my bookcase

- Christensen, L. (1989). *Experimental methodology* (7th ed.). Boston: Allyn and Bacon.
- Schweigert, W.A. (1994). *Research methods and statistics for psychology*. Pacific Grove, CA: Brooks/Cole.
- Barlow, D.H., & Hersen, M. (1984). *Single case experimental designs: Strategies for studying behavior change* (2nd ed.). Boston: Allyn and Bacon.

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