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Outline

› Introduction – the research process
› Experimental Methods and Simulation
› Design/Prototyping Methods
› Survey Methods
› Qualitative/Interpretive Methods
Typical Research Methods in CS/IS

› Mathematical modelling and proof methods (using mathematical objects like finite state machines, petri nets, process algebra, formal semantics etc.)
› Simulation methods (in silico experiment – carrying out experiments by means of a computer simulation)
› (Laboratory) Experimental/Quasi-experimental Methods
› Engineering/ Prototyping methods
› Survey methods
› Qualitative/Interpretive Methods,

➢ several of these methods are often used in specific combinations.
Based on a 1990’s survey of a random sample of 400 CS papers, Tichy at al. classifies papers into 5 categories:

› Formal theory (12%)

› Modelling and design/systems prototypes – proposing a new system, model or a framework (70%) of which more than 40% had no evaluation component at all.

› Empirical work (collect, analyse, and interpret observations/data about known designs, systems or models or based on abstract theories etc.- 2%

› Hypothesis testing – specify testable hypotheses and describe experiments to test the hypotheses – 2%

› Others, especially survey papers – 12%
Research Process

› What is research?

› Key components
  - A (significant) problem, question or questions of interest
  - A claim/hypothesis
  - Evidence
  - Argument (linking evidence to claim)
  - Implications, applications, limitations, possible future research directions

› Systematic application of one or more research methods
At a general level, providing high quality answers to (non-trivial) questions that solves a problem,

In scientific research, you join a community and cumulative tradition with a set of interesting questions, tools and methods, practices, a style and language for writing up the research.

Research as conversation and ongoing social activity

Critically and carefully reading and evaluating published research (comprehensive review of the research literature prior to your own research)

Two quotes from Newton:

“If I have seen farther than others, it is because I have stood on the shoulders of giants”.

Plato is my friend, Aristotle is my friend, but my greatest friend is truth.

— Sir Isaac Newton (written in the margin of a notebook while a student at Cambridge. In Richard S. Westfall, Never at Rest (1980), 89)
Experiments

› Experiments to test scientific hypotheses at the heart of any science,
› The results of tested hypotheses becomes part of the accumulated body of knowledge of the field,

Examples of hypotheses?
Outline:

› Strategy of experimental research
› What are experiments and how to do experimental research,
› Different kinds of experimental designs.
Designing Experiments

- Need for careful design that does not tilt the results either way (tests should be fair),
- In testing hypotheses related to new algorithms, the baseline case has to be carefully chosen,
- Choice of datasets,
- Test the hypotheses under conditions that the hypotheses are least likely to hold,
- Ensuring that all other things are equal (level playing field!)
- Look for other possible interpretations of the results obtained.
- Measurements
- Describing the experiments
This is a cyclic process
(Source : Dror Feitelson, 2008)
› Ideas that look good don’t always work out in practice
› They need to be tested in realistic conditions
Experimental Research Strategy

- Systematic and precise method of scientific thinking
- Accumulative method of inductive inference
- Can contribute to rapid scientific progress
Steps in Experimental Research

1. Devise hypotheses (Existing theory)
2. Devise crucial experiments with alternative possible outcomes, each of which exclude one or more possible hypotheses, (Experiment)
3. Conduct the experiment, get a clean result, (Outcome)
4. Back to step 1, making sub-hypotheses, or sequential hypotheses to refine the possibilities, exclusion and induction (exclusion and building the inductive (logical) tree)
Inductive Inference

› Useful for exploring the unknown

› Distinct from deductive reasoning; letting “nature” provides us the answers

› Challenge is to pose the right questions; clever choice of hypothesis, experiment, outcome, and exclusion.
Origins of inductive inferencing

Francis Bacon (interconnecting theory and experiment) building the conditional inductive tree, consecutive inductive inferences)

Karl Popper, falsificationism, there is no such thing as proof in science, science advances through a series of disproofs or falsification. Assertions in science have to be falsifiable,

“.. it must be possible for all empirical scientific systems to refuted by experience”.

Fisher’ s work in the 1930’s and 40’s in the area of statistical inference/testing.
What is an experiment?

Manipulation of one or more variables by the experimenter to determine the effect of this manipulation on another variable.

Carefully designed and executed plan for data collection and analysis to test specific hypotheses; use of experimental controls

Examples of hypotheses?

   Eg. F2F collaboration can lead to better outcomes than remote collaboration

Well-designed experiments can permit us to make causal inferences
Information overload experiment
Information Overload

› Negative consequences widely recognised since middle ages,
› Effects exacerbated by developments in ICT,
› Over-abundance of published information on information overload across multiple disciplines,
› Focus mostly on characterising information overload and analysing its negative consequences.
Over-abundance can lead to diminution of organism’s control of the situation,

20th socio-technical advances leading to inundation of irrelevant and unnecessary information beyond what can be effectively processed and used,

Significant psychopathological (withdrawal, absurdity, alienation, helplessness, impaired judgement)

and economic (wasted human resources, reduced information worker productivity) effects
Simon’s cogent characterisation:

“...in an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever information consumes. What information consumes is rather obvious; it consumes the attention of its recipients. Hence the wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the over-abundance of information sources that might consume it” (Simon 1972, pp. 40-41).
Management:

› Focus on the subjective dimension of the effects and symptoms (feeling of stress, confusion, pressure, anxiety, withdrawal, cognitive strain, greater tolerance for error, low motivation and job satisfaction) *(O’Reilly 1980; McCune 1998; Haksever and Fischer 1996)*

› Methodological approach mostly interview and survey-based,

› Symbolic aspects of information acquisition and disposition
Three categories:

1. Characteristics and amount of the information inputs and information technologies,
2. Features of the processing subsystem,
3. Personal factors
› Negative effects of information overload on consumer decision making,
› Characteristics of information such as novelty, ambiguity, uncertainty, intensity, and complexity.
Key research questions

› What are some of human tendencies that can be attributed as the causes of information overload?

› Under what environmental conditions are these human behavioural bases stimulated to act as to cause information overload and how do they affect human decision making?

› What types of individuals are prone to act in ways that contribute to an over-supply of information?

› Focus on causal aspects of information overload
‘Aversion to loss’ as a significant construct w.r.t information overload,

Originally developed as part of the prospect theory framework developed in cognitive psychology (Kahneman and Tversky 1979)

Classical expected utility theory assumes that individuals choose between risky or uncertain prospects on a rational basis with the aim of utility maximisation.

In contrast, the prospect theory posits that people perceive gains and losses in terms of changes using their current position as a reference level. The central proposition of the theory - losses and disadvantages have greater impact on peoples’ preferences and choices than gains and advantages (Tversky and Kahneman 1991).
Application of ‘aversion to loss’ to information,

How does aversion to loss (of information) contribute to information overload?

Important evidence emerging that people tend to experience eliminating an option (from a set of options) as loss;

Tend to keep options (alternatives) open and invest in keeping the options open even when the options provide little value.
**H1:** People are likely to select a higher number of information artifacts for use in decision making when there is a threat of future unavailability of access to information.

**H2:** There is no significant relationship between the number of information artifacts selected (and processed) and the level of decision confidence.

**H3:** Decision satisfaction will be unrelated to the amount of information used in the decision making process.
Research Methodology

- Controlled laboratory experiment,
- Aversion to loss as independent variable with two treatment levels – threat of information unavailability (experimental group) and no threat of information unavailability (control group)
- Dependent variables – decision confidence and decision satisfaction) measured using standard multi-item instruments.
- The experimental task - decision making simulation involving a product choice scenario.
Aversion to loss operationalization

› a novel web-based system.

› The system presented a matrix of all the attributes of each product but the actual values of the attributes were hidden behind a URL and the subject had to click on each to expose the value.

› The control group (no threat of information unavailability) subjects were provided the opportunity to click and select the product attribute values (information units) throughout the experimental decision making task.

› In the ‘aversion to loss’ treatment condition, the threat of unavailability was operationalized by restricting the subjects to having the option to choose the product attribute values only at the start of the experiment.
### Product Alternatives

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**Information Unit**
Experimental Subjects

- Mixed pool of subjects drawn from undergrad and post-grad students,
- 91 subjects randomly assigned to the experimental (46 groups) and control (45 groups)
- Subjects provided with a small reward to encourage serious participation,
1: Participant required to complete a demographic survey. Application supports data collection.

2: Researchers randomly assigns Participant to test condition. Application simulates the appropriate treatment condition.

3: Under the application’s treatment condition simulation, the participant completes decision making tests.

**Figure 3: Experiment Application Design and Workflow**
Data Analysis and Results

One-way analysis of variance (ANOVA) tests

› The hypothesis on aversion to loss was strongly supported indicating that there is a statistically significant difference in the average number of information attributes or units processed by the experimental group of 41.33 (aversion to loss) as compared to the control group (no aversion to loss) of 32.26.

› The average score on overall decision satisfaction is significantly different with higher satisfaction recorded for the control group (3.43) as opposed to 3.2 for the treatment group.

› The difference in means in the decision confidence scores are not statistically significant at 5% significance level (4.09 for the control group and 3.92 for the treatment group).
### ANOVA Results

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<td>13.814</td>
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<td>486.889</td>
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<td>Total</td>
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<td>Decision Confidence</td>
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<td>Overall Decision Satisfaction</td>
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ICIS2009, Phoenix, AZ
ICIS2009, Phoenix, AZ
Aversion to loss (of information) as a causal contributor to information overload,
Concern that information will become unavailable leads people to acquire and hold more information than rationally justified – irrational pursuit of future flexibility,
Decision performance adversely affected.
1. Formulation of one or more hypotheses.
   - Usually deductions or derivations from theoretical explanations (of the behavioural phenomenon) or strongly supported speculation.

2. Translation of the hypotheses into a set of treatment conditions and appropriate experimental design.

3. Conduct the experiment, collect the data

4. Statistical analysis of the data, interpretation of the results and writing up.
Experimental Design

› Independent Variables:
The variable(s) manipulated in the experiment.
(also called manipulated variable, treatment variable or factor).
Typically nominal (categorical) variable.

› Dependent Variable(s)
Measure(s) that capture (performance) of the phenomenon
Control or Nuisance Variables

Undesired sources of variation in an experiment that affect the dependent variable measurement,

Typically of three types:
- organismic
- environmental
- experimental task.
Approaches to control the nuisance variable

› Random assignment of subjects to treatment groups,
› Holding the (pre-identified) nuisance variable constant for all subjects,
› Statistical control using Analysis of Covariance (ANCOVA).
Sources of Bias

› Experimenter cues
› Demand characteristics
› Evaluation apprehension
› Hawthorne Effect
› Negativistic subject
Experiments - Advantages

› Possibility of a variety of manipulative and statistical controls,
› Random assignment of subjects – greater precision and higher confidence in specifying and testing causal relationships,
› Manipulation Checks possible.
› May help identify issues and problems previously unrecognised.
Experiments - Disadvantages

› Problems associated with lab settings,
› Some phenomenon cannot be studied under controlled conditions,
› Limitations imposed by moral concerns.
Lab experiments

› High degree of precision and internal validity possible; internal validity is a measure of the degree to which the study establishes that the treatment actually produced the effect – causality.

› Potentially low external validity – questions about the extent to which the results are generalisable to other populations, settings, organisations, groups, times etc.
1. **Getting Ethics Committee Approval**
2. Cover Story – description and purpose
3. Recruiting participants
4. Sample selection
5. Reference to criterion population
6. Remuneration and motivation
7. Training the participants
8. Preparing the setting
9. Controlled manipulation of independent variable(s)
10. Manipulation checks
11. Precise measurement of dependent variable(s).
Computational Experiments

- Test environment should be designed to be seen to be reasonable
- Tests should be fair and not constructed to support your hypothesis
- Choose appropriate baseline for comparison
- Experiments should be severe .. Look for tests and datasets that are likely to reject the hypothesis (if it is false) – identify and try out cases where the hypothesis is least likely to hold

TREC evaluation and retrieval systems maintained by the National Institute for Standards and technology (NIST) for information retrieval experiments
Non-experimental studies

› Observational Studies
› Case Studies
› Surveys
› Correlational Studies
User Study Experiments

Steps:
› Define the systems goals,
› Create specific tasks that the sample users have to perform (to meet the goals),
› Select the sample of users (who are representative),
› Systematically observe them perform the tasks and collect data.
More rooted in engineering and ‘sciences of the artificial’ (Simon 1996)

Conceptualise and create artifacts (constructs, models, algorithms and methods, implemented prototype systems)

Experiment with and evaluate artifacts
Design Research Process

- Ideas that look good don’t always work out in practice
- They need to be tested in realistic conditions

(adapted from Dror Feitelson)
Types of research [Simon, 1996]:

- natural sciences: phenomena occurring in the world (nature or society)
- design sciences ~ sciences of the artificial:
  - all or part of the phenomena may be created artificially
  - studies artificial objects or phenomena designed to meet certain goals
- social sciences: structural level processes of a social system and its impact on social processes and social organization
- behavioural sciences: the decision processes and communication strategies within and between organisms in a social system
Nature of IS Research

- Confluence of people, organisation, and technology
- Socio-technical systems

- IT artifacts:
  Constructs, models, methods, and instantiations
  Providing system solutions, proof-of-concept
- IT artifact as an object of study.
Artifacts designed to solve previously unsolved problems

Constructs, models, methods, and instantiations.

Design sub-processes: build and evaluate (multiple iterations)

Co-evolution of the design process and product

Utility as one of the important criteria for evaluating design research
Simulation Research Method

- An imitation of a real world system or process (typically using computer systems)
- Generation of the synthetic representation of the system,
- Observations of the to draw inferences about the operating characteristics or behaviour of the real process or system (artifact) using the simulation model.
Develop the simulation model

Model expressed in the form of mathematical, logical or symbolic relationships between objects and entities of interest in the system being studied.

Validation of the model

Investigate what-if questions, make predictions, study performance etc.
In some cases, the model developed can be solved by mathematical methods. Such solutions are in the form of one or more numerical parameters (measures of performance of the system).

When the real world systems are complex, the models of the system cannot be solved mathematically. Computer-based simulations can be used to imitate the behaviour of the system in such situations.
› System
› System environment
› System components: entities, attributes, activities, events,
› System state
› Endogenous and exogenous activities and events
› Discrete and continuous systems
A model is a simplified representation of the system for the purpose of studying the system.

TYPES OF SIMULATION MODELS

- Static; dynamic
- Deterministic vs. stochastic
Simulation Study Steps

1. Problem Formulation
2. Objectives and overall project plan
3. Model Building
4. Data Collection
5. Coding or simulation software selection
6. Verification and validation
7. Experimental Design
8. Production Runs
9. Statistical Analysis
10. Reporting Results
2. Problem Relevance:

› Address real problems that matter to a constituent community
› Cognisant of constraints
Before a survey:

- Define the Questions to be answered.
- Objectives should be clear, specific and unambiguous
- Define the Sampling strategy.
- Design and Test the Questionnaire.
- Train the field workers.
- Define the technique for cross-validation.
- Define the final Analysis.
Conditions for a Survey

› Answer the Objectives
› Be Unbiased, Accurate
› Be Generalizable
› Be Ethical
› Be Economical
Planning

› Sampling strategy
› Dealing with non-response bias
› Ensuring that accurate answers are obtained
› How do you deal with response bias.
Design and Test the Questionnaire

› Sample design and selection
› Choosing methods, interviewers
› Handling non-response cases
› Clear concepts, unambiguous phrasing of questions; limited demands on memory.
› Length of questionnaire/type of questions
› Unit of analysis, the respondent
› Pre-testing the questionnaire
› Small-scale pilot study
Survey Methods

› Surveys:

Interviewer completion

Respondent completion

Types of surveys

1. Household
2. Telephone
3. Mail
4. Customer
5. Captive Group
6. Organisation
7. Web-based
Survey Methods

Issues:

Response rates
Biases and errors
Survey Methods

› Types of Questions

Open ended and pre-coded

Measurement of Attitudes and opinions:

Likert Scales

Attitude Statements

Semantic Differential
Survey Methods

› Questionnaire Construction
› Validity/Reliability issues
› Pilot Testing
› Sample selection
› Coding the data
› Statistical Analysis.
Sample surveys

- Too many poorly designed and executed surveys; GIGO; erroneous results and conclusions
- Designed to enable us to learn something about the population from which the sample is drawn
- Sample needs to be chosen scientifically so that the findings are generalisable to the population
- Standardised questions;
- Goal is to test hypotheses or to generate statistical profiles of the population
- Individual information is private
Survey Methods

Typically questionnaire-based surveys

Strengths:
Quantitative data
Transparency and some level of objectivity
Succinct and easily understood
Comparability/reproducibility
Can deal with complex problems/issues
Specific data gathering techniques

› Multiple unstructured, in-depth interviews with several key informants and participants.
› Interviews spread out over a few years
› Historical reconstruction of some of the aspects studied,
› Published documents such as reports, minutes of meetings, internal memos, company reports, newspaper and trade press articles etc.
› Iterative process of data collection, analysis, and interpretation.
Case Study

- Most common method for interpretive research
- Background and context – contributes to “richness”.
- Focus on IS strategy formation and implementation in a financial services firm in the UK over an extended period of time,
- Plausibility and cogency of inductive argumentation – is extrapolation possible from one or two case studies,
Field Studies:
Research takes place in “natural” or “real world” settings,
Data obtained from “real” organisations or work groups or users.
Qualitative/Interpretive Research

› Enables researchers to study organisational and social phenomena in the social and cultural contexts.

› Focus on generating “insights” based on one or few situations (ideographic) as opposed to the discovery and testing of general laws aimed at prediction and control (nomothetic)
Categories of Qualitative Research:

› Positivist (Yin 1994)
› Interpretivist (Walsham 1995)
› Critical (Burrel and Morgan 1979; Carr and Kemmis 1986)
Qualitative Methods

Focus on qualitative aspects – the essence or ambience of something; non-quantitative data.

Examples:

- Ethnography
- Participant Observation
- Action Research
- Case Studies, content analysis
- Archival Research, Historiography
Interpretive Research

- Positivistic approach to science based on assumptions of “objective” reality, testing hypotheses to arrive at (general) empirically valid laws (cause-effect relationships) – the natural science model

- Interpretive approach in contrast views reality as essentially constructed socially; research focused on interpreting this somewhat subjectively; researcher interacts with the human subjects to interpret events and human actions within a particular context; arguably can lead to a deeper “understanding” of the phenomenon being studied.
Principles for evaluating interpretive field studies:
Theoretical Framework

Contribute to the understanding of the “dynamic processes of service level agreement formulation and enactment

Key Components: context, content (of the strategy), and processes (cultural and political perspectives)
Ethnographic Research

› Immersion in the life of the people and events that the researcher is studying
› Derived from the discipline of social and cultural anthropology,
› Focus on human action in context; multiple perspectives interpreted.