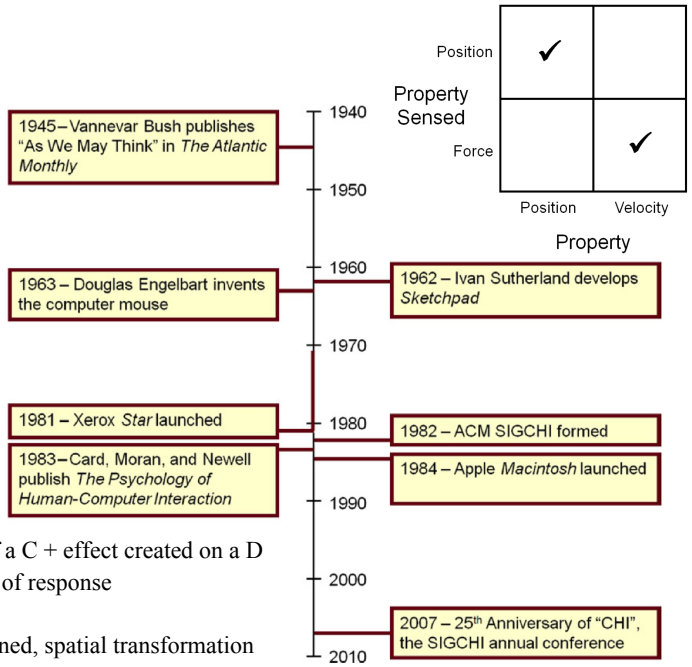
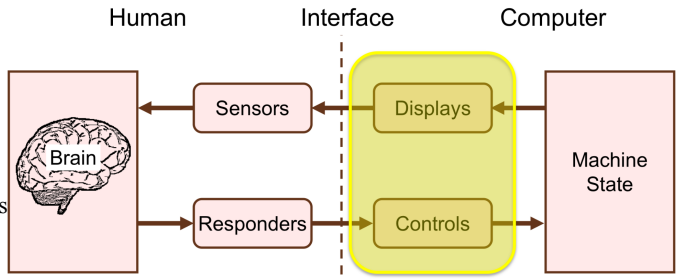
CHAPTER 1: HISTORICAL CONTEXT

- User study: an experiment with human participants
- XEROX star, first OO language (star), first commercial personal computer
- two -finger gestures, 1978; single-stroke text input, 1993
- Acceleration-sensing, 1998; Wheel mouse, 1993



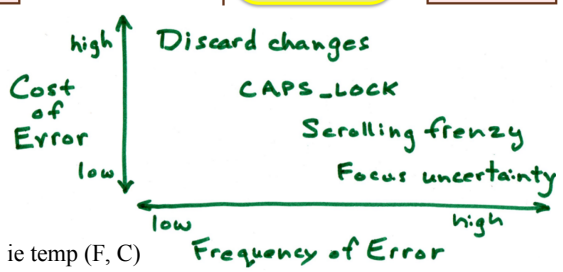
CHAPTER 3: INTERACTION ELEMENTS

- Interaction: occurs when a human performs a task using computing tech
  - Ie task with goal, send email, burn CD
  - Ie task without goal, browse web, chat with friends on social media
- Newell's *Time Scale of Human Action*; deliberate acts ~100mx
  - Operations ~1 s Unit tasks ~10 s
- CD (Control Display) ie knobs is C & dials is D
- Hard control, physical & single purpose devices
- Soft control, interfaces created in software, rendered on **display**
- Todays graphical displays are malleable
- Sometimes soft controls and displays are blurred, ie scrollbar slider
- Control-Display Relationships, aka mappings: relationship between operation of a C + effect created on a D
  - Spatial: mouse/cursor - dynamic, how controller affects speed of response
  - - whether response is movement or force is C
- Natural, spatial congruence (C and D direction are equal) - learned, spatial transformation
- 3D, 6 degrees of freedom (DOF) (3 position (x, y, z) & 3 orientation (pitch, yaw, roll)
- CD gain, amount of display movement for given amount of controller movement (non-linear gains term transfer function is used)
- Latency aka lag: delay between input action + corresponding response on display **speed accuracy trade-off
- Property sensed; position (phone), displacement (mouse), force (joystick)
- Order of control: property of display controlled, position of cursor/object, velocity of cursor/object
- Joystick 2 types: isotonic, senses displacement (typical type); isometric, senses force (little red one on windows comp.)
- Mental models: physical understanding of interface techniques based on real-world
- Mode: functioning arrangement or conditions (ie key variations)
- If C DOF < D DOF, modes necessary to fully access D DOF
- Touch input challenged, occlusion accuracy "fat finger problem"
- Accelerometers enable tilt/motion as input primitive

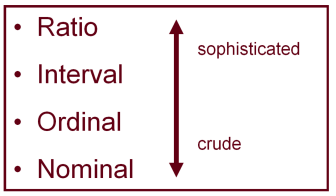


CHAPTER 4: SCIENTIFIC FOUNDATIONS

- Research: investigation/experimentation aimed at discovery & interpretation of facts
  And revision of accepted theories/laws in light of new facts
- Engineers & designers bring together form (design) & function (engineering)
- Empirical research: can be verified/disproved by observation/experiment
- PUBLISH OR PERISH - research must be reproducible
- Observational method: HCI usability evaluation, high relevance, low precision
- Experimental method: HCI user study, low relevance, high precision -> causal relationships
- Correlational method: looks for relationships between variables -> circumstantial relationships
- Measurement scales: nominal, ordinal, interval, ratio
  - Nominal aka categorical data - ordinal data is order/rank ie greater/less than
  - Interval data have equal distances between adjacent values, no absolute zero, ratio !possible ie temp (F, C)
  - Ratio data, have absolute zero, support many calculations to summarize, compare and test data

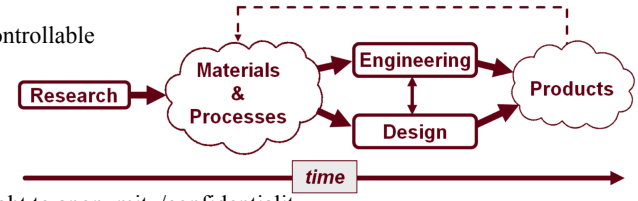


- Internal validity: extent to which effects observed are due to test conditions
  - Statistically, difs in means are due to inherent properties of test conditions, variances are due to participant difs ("pre-dispositions"), other variance are controlled or exist equally or randomly across test conditions
- External validity: extent to which experimental results are generalizable to other people/situations
  - People: participants representative of intended population
  - Situations: test environment and experimental procedures representative of real world where technique is used
  - Improved if experimental procedure mimics expected usage
    - More test and procedures mimic the real-world aka released, then results are uncontrollable
- Causal aka cause-and-effect relationship - Circumstantial relationship (not causal)



CHAPTER 5: DESIGNING HCI EXPERIMENTS

- Methodology: way an experiment is designed and carried out
  - Allen Newell "Science is method. Everything else is commentary"
- Critical for ethics approval: research methodology, risks/benefits, right not to participate, right to anonymity/confidentiality
- Independent v.: circumstance/characteristic is manipulated in experiment to elicit change in response while interacting with comp
  - Must have at least 2 levels (aka different things to test)
- Dependent v.:any observable, measured human behavior, depends on what participant does
  - Must be clearly defined
- Control v.: circumstance (not under investigation) kept constant while testing effect of an IV



Independent variables	Effects					Total
	Main	2-way	3-way	4-way	5-way	
1	1	-	-	-	-	1
2	2	1	-	-	-	3
3	3	3	1	-	-	7
4	4	6	3	1	-	14

- Random v.: circumstance allowed to vary randomly (more variability introduced in measures (bad) but results generalizable (good))
- Confounding v.: circumstance varies systematically with IV
- Experiment task must "elicit a change"
  - good task represent, discriminate
- Procedure: encompasses everything occurs with participants
- # participants
  - too few - experimental effects fail to achieve stat significance
  - Too many - statistical significance for effects of no practical value

Variable	Advantage	Disadvantage
Random	Improves external validity by using a variety of situations and people.	Compromises internal validity by introducing additional variability in the measured behaviours.
Control	Improves internal validity since variability due to a controlled circumstance is eliminated	Compromises external validity by limiting responses to specific situations and people.

- Within-subjects aka repeated measures, each test condition are repeated for each participant
  - Advantages: fewer participants, less "variation", no need to balance groups (because only 1) - disadvantages: order effects
- Between-subjects separate group of participants for each test condition
  - Advantages: no order effects - disadvantages: more participants, more variation, need to balance groups
- Order effects is offset by counterbalancing: participants divided into groups, test conditions administered in diff order to each group, order of test conditions uses Latin square
- Balanced latin square, each condition precedes and follows each other condition an equal # of times

2 x 2

A	B
B	A

3 x 3

A	B	C
B	C	A
C	A	B

4 x 4

A	B	C	D
B	C	D	A
C	D	A	B
D	A	B	C

5 x 5

A	B	C	D	E
B	C	D	E	A
C	D	E	A	B
D	E	A	B	C
E	A	B	C	D

CHAPTER 6: HYPOTHESIS TESTING

- Null hypothesis assumes there will be no difference, stats procedures either reject or accept it
- Statistical procedures for hypothesis testing come in two flavors: parametric and non-parametric tests
  - Parametric: data assumed to come from a distribution, ie normal, t-distribution, etc.
    - ANOVA (analysis of variance), used for ratio+interval data, most common in HCI
      - Goal is to determine if IV has sig effect on DV
  - Non-parametric: data not assumed to come from distribution
    - Chi-square, used for nominal (ones below are used for ordinal data)
    - Mann-Whitney U, Wilcoxon Signed-Rank, Kruskal-Wallis, + Friedman tests
- ANOVA results: F-statistic, DOF for f-stat, P value
- ANOVA assumptions
  1. population from sample drawn is normally distributed
  2. Independence of cases (sample cases are independent of each other)
  3. Homogeneity of variance: variance among groups is approx equal
  4. ONLY FOR REPEATED MEASURES, sphericity assumption
     - Condition where variances of differences between all possible pairs within-subject conditions (ie levels of IV) are equal
- Chi-square tests investigate relationships between nominal data
  - Data is organized in a contingency table
  - Compares observed values against expected values (these assume no dif)
  - X^2 is significant if it exceeds the critical value
- Between-subjects generate independent samples because different Participants are tested with each condition
- Within subjects designs generate correlated samples because the same Participants are tested with each conditio

Measurement Scale	Defining Relations	Examples of Appropriate Statistics	Appropriate Statistical Tests
Nominal	• Equivalence	• Mode • Frequency	• Non-parametric tests
Ordinal	• Equivalence • Order	• Median • Percentile	
Interval	• Equivalence • Order • Ratio of intervals	• Mean • Standard deviation	• Parametric tests • Non-parametric tests
Ratio	• Equivalence • Order • Ratio of intervals • Ratio of values	• Geometric mean • Coefficient of variation	

ANOVA Table for Dependent Variable (units)

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Subject	15	81.109	5.407				
Test Condition	3	182.172	60.724	4.954	.0047	14.862	.896
Test Condition * Subject	45	551.578	12.257				

- There was a significant effect of Test Condition on the dependent variable ($F_{3,45} = 4.95, p < .005$)
- Degrees of freedom p =< 0.5 means significant
  - If n is the number of test conditions and m is the number of participants, the degrees of freedom are…
  - Effect → $(n - 1)$ | **For this example, 4 – 1 = 3**
  - Residual → $(n - 1)(m - 1)$ | **For this example, (4-1) * (16 -1)=45**
  - Note: single-factor, within-subjects design

Design	Conditions	
	2	3 or more
Between-subjects (independent samples)	Mann-Whitney U	Kruskal-Wallis
Within-subjects (correlated samples)	Wilcoxon Signed-Rank	Friedman