hci+d lab.

Week 08

Designing HCI Experiments
Ubiquitous Computing / HRI

HCI 연구방법론 2019 Fall

Human-Computer Interaction+Design Lab _ Joonhwan Lee

오늘 다룰 내용

- HCI Research
- Variables
- Tasks
- Study Design and Procedure
- Study Example

- Ubiquitous Computing / HRI Overview

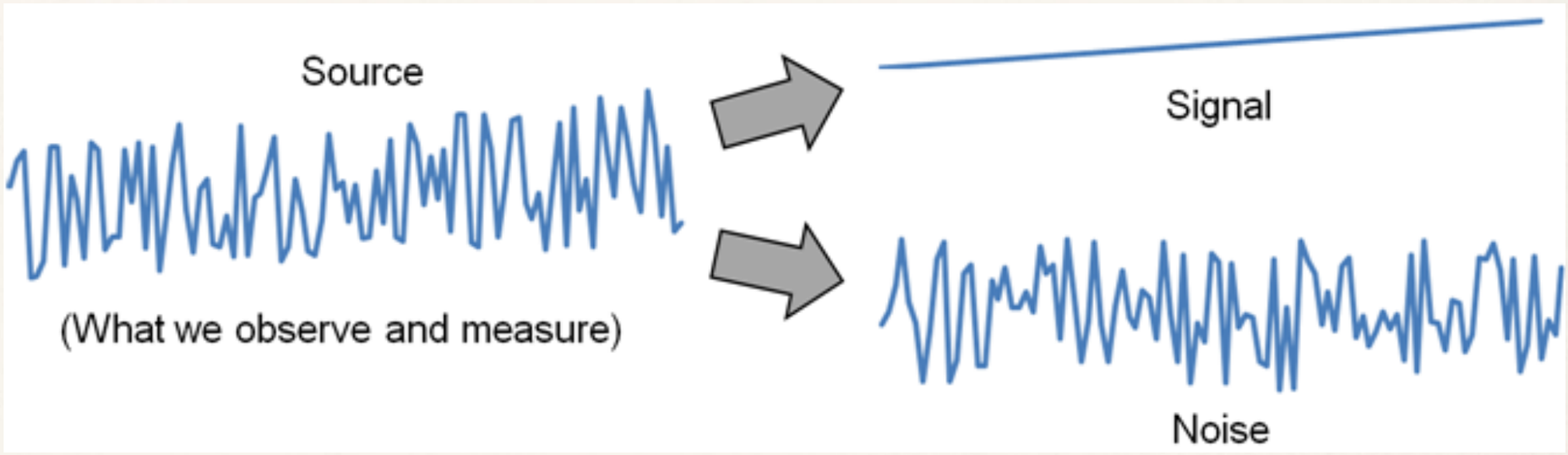
HCI Research

HCI Experiment Design

- *Experiment design* is the process of deciding what **variables** to use, what **tasks** and **procedures** to use, how many **participants** to use and how to solicit them, and so on

Signal and Noise Metaphor

- Signal and noise metaphor for experiment design:



- Signal → a variable of interest
- Noise → everything else (random influences)
- Experiment design seeks to enhance the signal, while minimizing the noise

Ethics in Research

- Ethics approval is a crucial step that precedes every HCI experiment
- HCI experiments involve humans, thus…
  - Researchers must respect the safety, welfare, and dignity of human participants in their research and treat them equally and fairly.
- Proposal submitted to ethics review committee
  → IRB (Internal Review Board) Approval
- Criteria for approval
  - research methodology
  - risks or benefits
  - the right not to participate, to terminate participation
  - the right to anonymity and confidentiality

Getting Started With Experiment Design

- Transitioning *from the creative work* in formulating and prototyping ideas *to experimental research* is a challenge
- Begin with…
  - What are the experimental variables?
- Remember research questions:
  - Can a task be performed more quickly with my new interface than with an existing interface?
- Properly formed research questions inherently identify experimental variables (can you spot the independent variable and the dependent variable in the question above?)

Variables

Independent Variable

- An *independent variable (IV)* is a circumstance or characteristic that is manipulated in an experiment to elicit a change in a human response while interacting with a computer.
- “Independent” because it is independent of participant behavior (i.e., there is nothing a participant can do to influence an independent variable)

Independent Variable

- Examples:
  - interface, device, feedback mode, button layout, visual layout, age, gender, background noise, expertise, etc.
- The terms *independent variable* and *factor* are synonymous

Test Conditions

- An independent variable (IV) must have at least two levels
- The levels, values, or settings for an IV are the test conditions
- Name both the factor (IV) and its levels (test conditions):

Factor (IV)	Levels (test conditions)
Device	mouse, trackball, joystick
Feedback mode	audio, tactile, none
Task	pointing, dragging
Visualization	2D, 3D, animated
Search interface	Google, custom

Human Characteristics

- Human characteristics are *naturally occurring attributes*
- Examples:
  - Gender, age, height, weight, handedness, grip strength, finger width, visual acuity, personality trait, political viewpoint, first language, shoe size, etc.
- They are legitimate *independent variables*, but they *cannot be "manipulated"* in the usual sense
- Causal relationships are difficult to obtain due to unavoidable confounding variables

How Many IVs?

- An experiment must have at least one independent variable
- Possible to have 2, 3, or more IVs
- But the number of “effects” increases rapidly with the size of the experiment:

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
5	5	10	6	3	1	25

- Advice: Keep it simple (1 or 2 IVs, 3 at the most)

Dependent Variable

- A *dependent variable* is a measured human behavior (related to an aspect of the interaction involving an independent variable)
- "Dependent" because it depends on what the participant does
- Examples:
  - task completion time, speed, accuracy, error rate, throughput, target re-entries, task retries, presses of backspace, etc.
- Dependent variables must be clearly defined
- Research must be reproducible!

Unique DVs

- Any observable, measurable behavior is a legitimate dependent variable (provided it has the potential to reveal differences among the test conditions)
- So, feel free to “roll your own”
  - Example: *negative facial expressions*[1]
    - Application: user difficulty with mobile games
    - Events logged included frowns, head shaking
    - Counts used in ANOVA, etc.
    - Clearly defined → reproducible

[1] Duh, H. B.-L., Chen, V. H. H., & Tan, C. B. (2008). Playing different games on different phones: An empirical study on mobile gaming. Proceedings of MobileHCI 2008, 391-394, New York: ACM.

Data Collection

- Obviously, the data for dependent variables must be collected in some manner
- Ideally, engage the experiment software to log timestamps, key presses, button clicks, etc.
- Planning and pilot testing important
- Ensure conditions are identified, either in the filenames or in the data columns

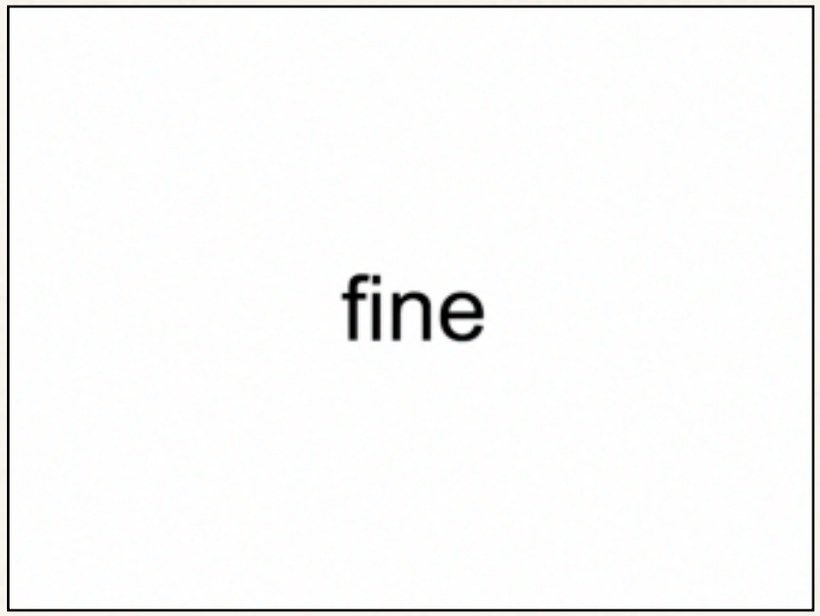
Collected Data Example

	A	B	C	D	E	F	G	H
1	id	subjID	stimID	value	created_at	updated_at	energy	mood
2	5	3	15	6,6	05:04.9	05:04.9	6	6
3	6	3	25	5,4	05:41.6	05:41.6	4	5
4	7	3	22	3,3	06:04.0	06:04.0	3	3
5	8	3	3	5,6	06:24.9	06:24.9	6	5
6	9	3	27	3,3	07:01.8	07:01.8	3	3
7	10	3	17	6,7	07:17.2	07:17.2	7	6
8	11	3	11	7,6	07:32.8	07:32.8	6	7
9	12	3	8	2,4	07:56.9	07:56.9	4	2
10	13	3	12	3,4	08:32.2	08:32.2	4	3
11	14	3	16	3,5	09:00.4	09:00.4	5	3
12	15	3	1	3,5	09:22.6	09:22.6	5	3
13	16	3	19	3,5	09:48.9	09:48.9	5	3
14	17	3	5	3,6	10:02.2	10:02.2	6	3
15	18	3	14	3,5	10:22.2	10:22.2	5	3
16	19	3	23	2,6	10:39.5	10:39.5	6	2
17	20	3	26	3,3	10:57.4	10:57.4	3	3
18	21	3	6	4,6	11:33.4	11:33.4	6	4
19	22	3	2	2,6	11:45.1	11:45.1	6	2
20	23	3	24	3,2	12:08.5	12:08.5	2	3
21	24	3	7	2,5	12:29.7	12:29.7	5	2
22	25	3	21	2,3	12:40.9	12:40.9	3	2
23	26	3	10	2,3	12:52.7	12:52.7	3	2
24	27	3	4	5,5	13:10.1	13:10.1	5	5
25	28	3	9	7,7	13:29.1	13:29.1	7	7
26	29	3	13	3,6	13:55.2	13:55.2	6	3
27	30	3	18	6,6	14:15.6	14:15.6	6	6
28	31	3	20	2,2	14:37.0	14:37.0	2	2
29	32	4	1	2,6	37:21.0	37:21.0	6	2
30	33	4	8	3,5	37:56.8	37:56.8	5	3
31	34	4	15	6,4	38:33.7	38:33.7	4	6
32	35	4	12	2,5	39:19.3	39:19.3	5	2

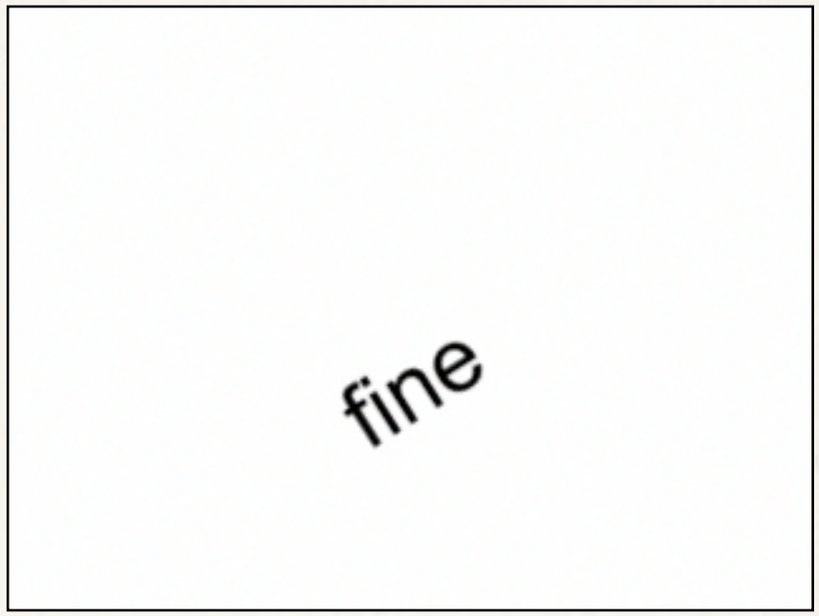
Control Variable

- A control variable is a circumstance (not under investigation) that is kept constant while testing the effect of an independent variable
- More control means the experiment is less generalizable (i.e., less applicable to other people and other situations)

Kinetic Typography Example



angry



happy

sad

joyous

Control Variable

- Research question:

  Is there an effect of **font color** or **background color** on **reading comprehension**?

- Independent variables: font color, background color
- Dependent variable: comprehension test scores
- Control variables
  - Font size (e.g., 12 point)
  - Font family (e.g., Times)
  - Ambient lighting (e.g., fluorescent, fixed intensity)
  - Etc.

Random Variable

- A random variable is a circumstance that is allowed to vary randomly
- More variability is introduced in the measures, but the results are more generalizable
- Research question: Does **user stance** affect **performance** while playing Guitar Hero?
  - Independent variable: stance (standing, sitting)
  - Dependent variable: score on songs
  - Random variables
    - Prior experience playing a real musical instrument
    - Prior experience playing Guitar Hero
    - Amount of coffee consumed prior to testing
    - Etc.

Control vs. Random Variables

- There is a trade-off which can be examined in terms of internal validity and external validity (see below)

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.

Tasks

Experiment Task

- Recall the definition of an independent variable:
  - a circumstance or characteristic that is manipulated in an experiment to *elicit a change in a human response* while interacting with a computer
- The experiment task must "*elicit a change*"
- Qualities of a good task: **represent, discriminate**
  - **Represent** activities people do with the interface
    - Improves external validity (but may compromise internal validity)
  - **Discriminate** among the test conditions
    - Increases likelihood of a statistically significant outcome (i.e., the sought-after "change" occurs)

Task Examples

- Usually the task is self-evident (follows directly from the research idea)
- Research idea → a new graphical method for entering equations in a spreadsheet
  - Experiment task → insert an equation using (a) the graphical method and (b) the conventional method
- Research idea → an auditory feedback technique for a GPS device
  - Experiment task → guide to a destination location using (a) the auditory feedback method and (b) the visual method

Knowledge-based Tasks

- Most experiment tasks are *performance-based* or *skill-based* (e.g., inserting an equation, guide to a destination location)
- Sometimes the task is *knowledge-based* (e.g., “Use an Internet search interface to find the birth date of Albert Einstein.”)
- In this case, participants become contaminated (in a sense) after the first run of task, since they have acquired the knowledge
- Experimentally, this poses problems (beware!)
- A creative approach is needed (e.g., for the other test condition, slightly change the task; “…of William Shakespeare”)

Study Design and Procedure

Procedure

- The *procedure* encompasses everything that occurs with participants
- The procedure includes the experiment task (obviously), but everything else as well…
  - Arriving, welcoming
  - Signing a consent form
  - Instructions given to participants about the experiment task (next slide)
  - Demonstration trials, practice trials
  - Rest breaks
  - Administering of a questionnaire or an interview

Instructions

- Very important (best to prepare in advance; write out)
- Often the goal in the experiment task is “to proceed as quickly and accurately as possible but at a pace that is comfortable”
- Other instructions are fine, as per the goal of the experiment or the nature of the tasks, but…
- Give the same instructions to all participants
- If a participant asks for clarification, do not change the instructions in a way that may cause the participant to behave differently from the other participants

Study Protocol Example

Study Protocol

— *Welcome message and introduction to the study*
  - copy text from previous study

— *Explain the content of consent form briefly*

— **Get signed consent form**

— *Message about initial questionnaire*

— **Initial questionnaire (see below)**

— *Explain study procedure*

— *Explain baseline study*

(VIDEO CAPTURE START)
(WiiMOTE CONNECT)

— **Baseline study**
  - Driving simulated game
  - Sample dashboard image (from any car, different from our designs), still image
  - (maybe) with 2 or 3 sample voice commands

— *Explain main study*

— **Main study**
  - 5~6 min each
  - 6 designs
  - randomized or counterbalanced

Study Protocol Example

Aesthetics and Usability of Car Dashboard Displays

Study Protocol Example

Thank you for participating in our **Aesthetics and Usability of Car Dashboard Displays** experiment. We have a lot of information to present and instructions to go over, but first, we need to actually show these instructions, rather than just telling them to you, so that we are sure that everyone who participates in this experiment gets the same information.

(Please say **“NEXT PAGE”** when you finish reading.)

Study Protocol Example

We are researchers in the Human-Computer Interaction Institute at Carnegie Mellon University. We are developing new dashboard designs. The results of this study will be used to improve our dashboard design.

Study Protocol Example

Consent Form

Here is the consent form of our experiment.

Read it carefully and sign the form if you agree.

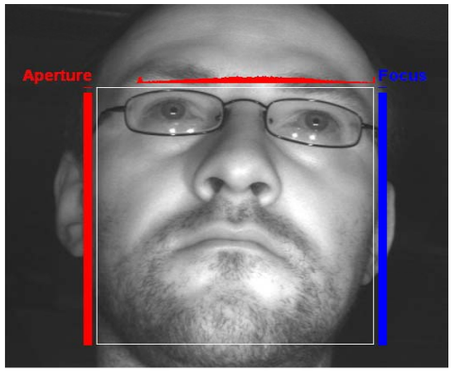
Study Protocol Example

Camera setup

Since we are collecting your gaze information with eye-tracker, we need to create your eye profile first. It will take few minutes to complete.

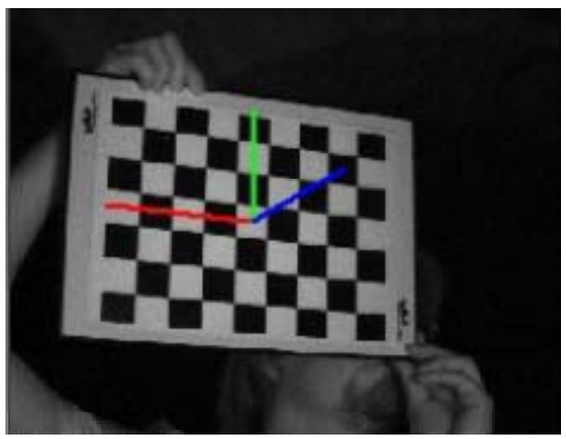
Study Protocol Example

1. Please **have & align your seat** with steering wheel.



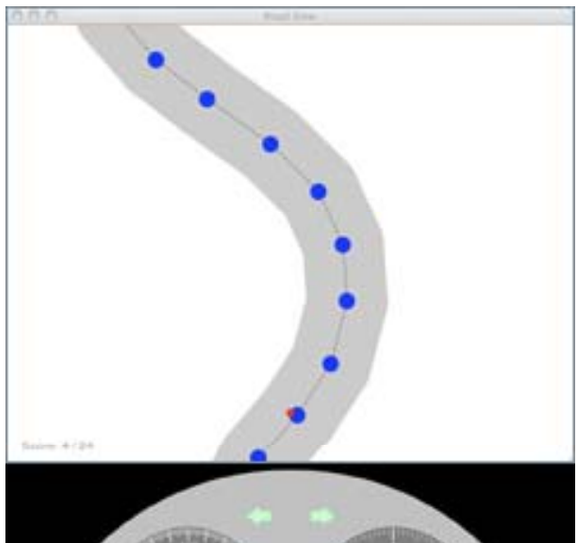
Bottom center : (0, 0, - 0.11) m
Screen size : (0.32, 0.388) m
Resolution : 1024 x 1280
Calibration points : 9

2. Please **give your seat** to the experimenter for a while.



Study Protocol Example

First, there is a display in front of you. In this screen, you will be presented a simple driving game and a dashboard screen. When the driving game starts, you will see a red dot and a road in the game. The red dot represents your vehicle. And you can move the red dot left and right with the steering wheel in front of you.



Study Protocol Example

End of the Study

Please sign this receipt to show that you participated and received your $15.

Thank you very much. If you have any questions or comments that you think of later on, please feel free to contact any one of us.

Participants

- Researchers want experimental results to apply to people not actually tested – a population
- Population examples:
  - Computer-literate adults, teenagers, children, people with certain disabilities, left-handed people, engineers, musicians, etc.
- For results to apply generally to a population, the participants used in the experiment must be…
  - Members of the desired population
  - Selected at random from the population
- True random sampling is rarely done (consider the number and location of people in the population examples above)
- Some form of *convenience sampling* is typical

How Many Participants?

- Too few → experimental effects fail to achieve statistical significance
- Too many → statistical significance for effects of no practical value
- Use the same number of participants as used in similar research[1]

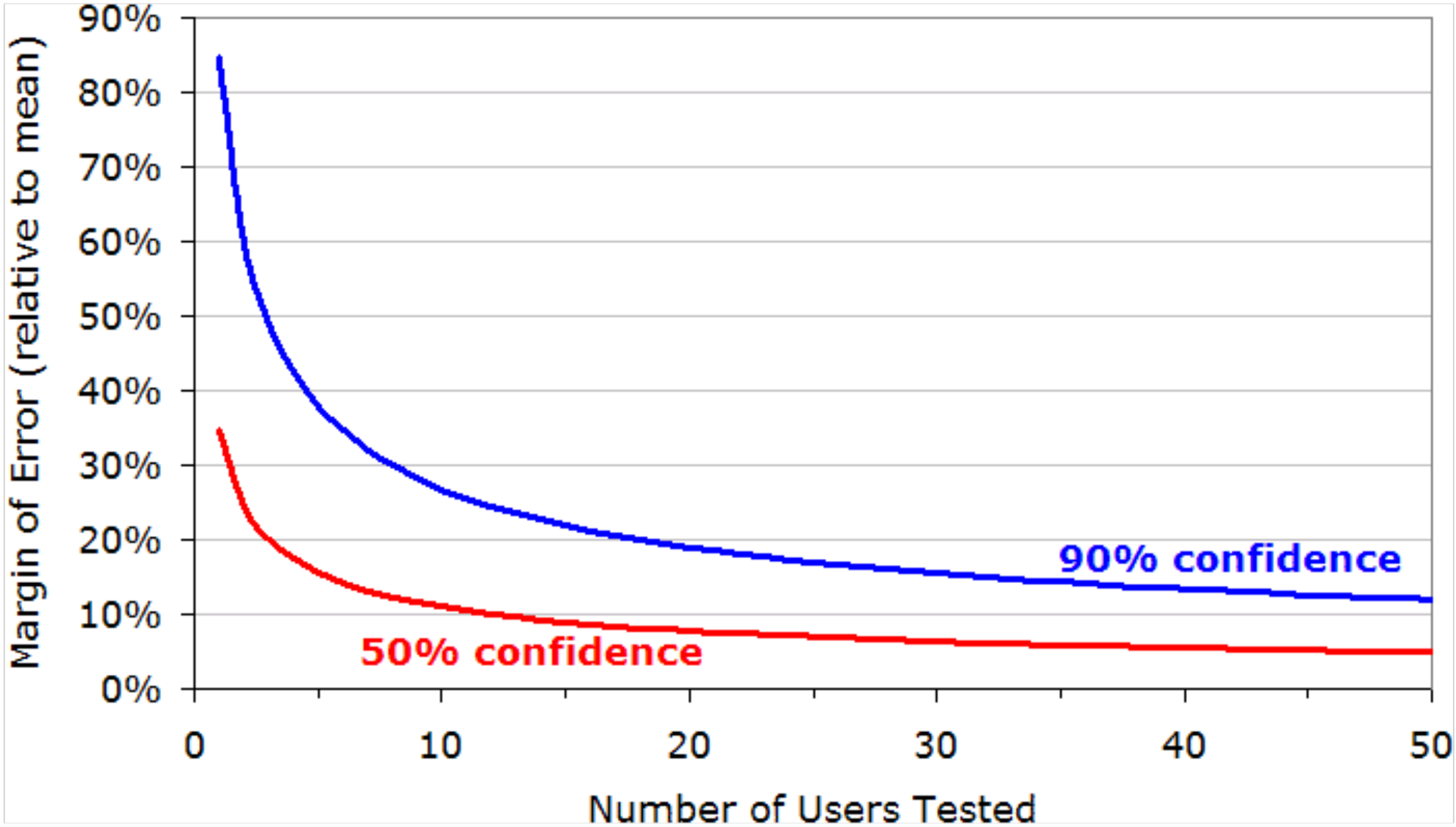
[1] Martin, D. W. (2004). Doing psychology experiments (6th ed.). Pacific Grove, CA. Belmont, CA: Wadsworth.

How Many Participants?

- How many participants do we need?
  - for most usability test, 5 is enough to cover more than 85% of usability problems
  - Qualitative study: 5 - 15
  - Quantitate study: 20 is enough
  - http://www.useit.com/alertbox/20000319.html
  - http://www.useit.com/alertbox/20040719.html
  - http://www.useit.com/alertbox/quantitative_testing.html
  - http://www.measuringusability.com/blog/five-history.php

How Many Participants?

- How many participants do we need?



history.php

Questionnaires

- Questionnaires are used in most HCI experiments
- Two purposes
  - Collect information about the participants
    - Demographics (gender, age, first language, handedness, visual acuity, etc.)
    - Prior experience with interfaces or interaction techniques related to the research
  - Solicit feedback, comments, impressions, suggestions, etc., about participants' use of the experimental apparatus
- Questionnaires, as an adjunct to experimental research, are usually brief

Information Questions

- Questions constructed according to how the information will be used

Please indicate your age:_____

Ratio-scale data

Please indicate your age?

☐ < 20 ☐ 20-29 ☐ 30-39

☐ 40-49 ☐ 50-59 ☐ 60+

Ordinal-scale data

Which browser do you use? _____

Open-ended

Which browser do you use?

☐ Mozilla *Firefox* ☐ Google *Chrome*

☐ Microsoft *IE* ☐ Other (_____)

Closed

Participant Feedback

- Using NASA Task Load Index (TLX):

Frustration: I felt a high level of insecurity, discouragement, irritation, stress, or annoyance.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

- ISO 9241-9:

Eye fatigue:

1	2	3	4	5	6	7
Very high						Very low

Within-subjects, Between-subjects

- Two ways to assign conditions to participants:
  - *Within-subjects* → each participant is tested on each condition
  - *Between-subjects* → each participant is tested on one condition only

- Example: An IV with three test conditions (A, B, C):

Within-subjects

Participant	Test Condition		
1	A	B	C
2	A	B	C

Between-subjects

Participant	Test Condition
1	A
2	A
3	B
4	B
5	C
6	C

Within-subjects, Between-subjects

- Within-subjects advantages
  - Fewer participants (easier to recruit, schedule, etc.)
  - Less “variation due to participants”
  - No need to balance groups (because there is only one group!)
- Within-subjects disadvantage
  - Order effects (i.e., interference between conditions)

Within-subjects, Between-subjects

- Between-subjects advantage
  - No order effects (i.e., no interference between conditions)
- Between-subjects disadvantage
  - More participants (harder to recruit, schedule, etc.)
  - More “variation due to participants”
  - Need to balance groups (to ensure they are more or less the same)

Within-subjects, Between-subjects

- Sometimes…
  - A factor must be assigned within-subjects
    - Examples: Block, session (if learning is the IV)
  - A factor must be assigned between-subjects
    - Examples: gender, handedness
  - There is a choice
    - In this case, the balance tips to within-subjects (see previous slide)
- With two factors, there are three possibilities:
  - both factors within-subjects
  - both factors between-subjects
  - one factor within-subjects + one factor between-subjects (this is a mixed design)

Order Effects, Counterbalancing

- Only relevant for within-subjects factors
- The issue: *order effects* (aka *learning effects, practice effects, fatigue effects, sequence effects*)
- Order effects offset by *counterbalancing*:
  - Participants divided into groups
  - Test conditions are administered in a different order to each group
  - Order of administering test conditions uses a Latin square
  - Distinguishing property of a Latin square each condition occurs precisely once in each row and column

Latin Squares

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

Balanced Latin Square

- With a balanced Latin square, each condition precedes and follows each other condition an equal number of times
- Only possible for even-orders
- Top row pattern: A, B, *n*, C, *n* – 1, D, *n* – 2, …

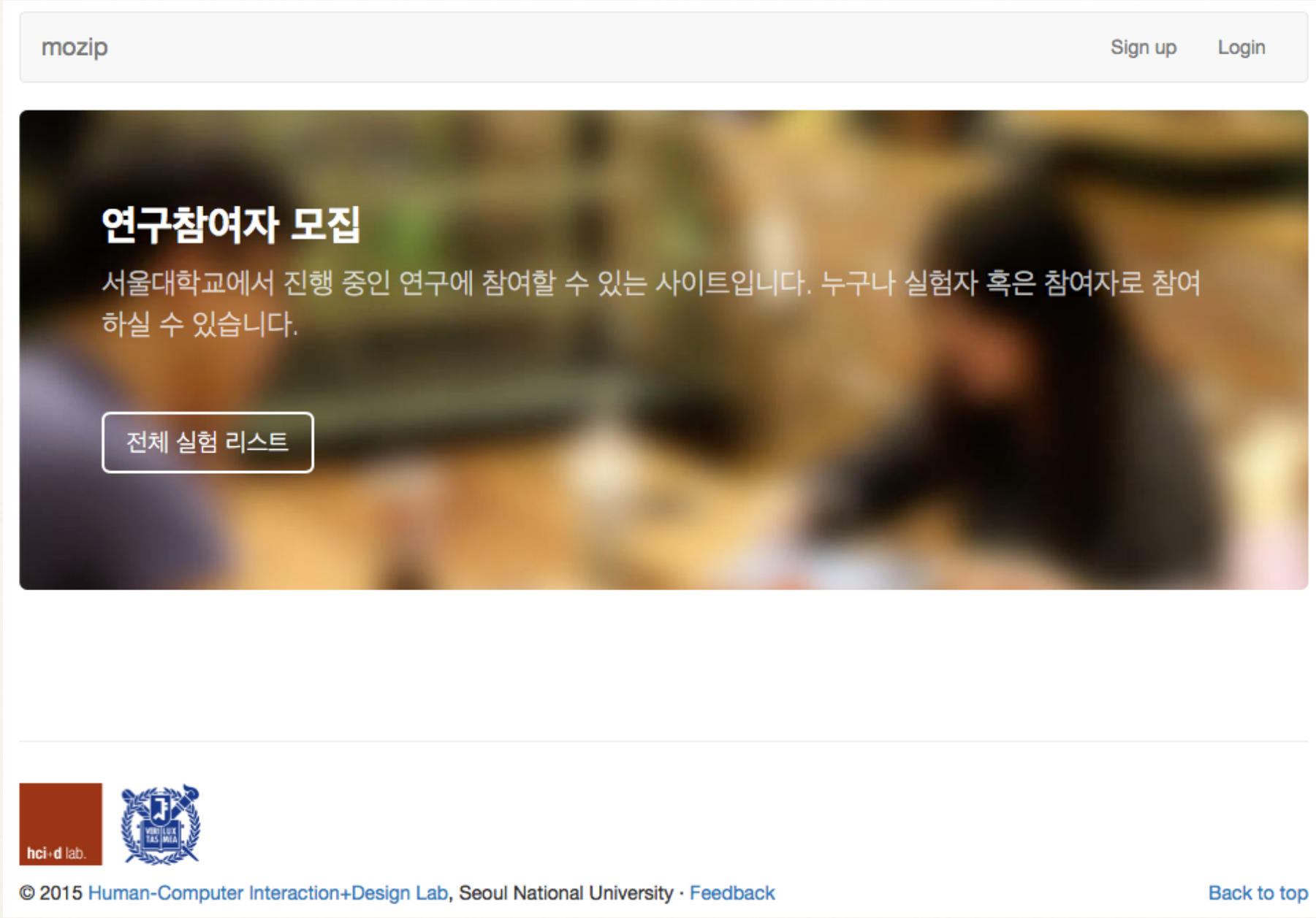
4 x 4

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

6 x 6

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

Recruit Participants



http://mozip.snu.ac.kr

Recruit Participants

새로운 실험 정보 입력

실험제목

실험 정보

실험의 목적, 내용, 진행과정 등을 구체적으로 입력해 주세요.

실험 시작일	2016 April 24
실험 종료일	2016 April 24
실험참여 사례비	숫자만 입력해주세요. 예: 5000
실험 언어	예: 한국어, 영어
제약사항	실험참여 제한이 필요한 경우 명시해 주세요.
IRB 승인여부	승인받지 않음 / 승인됨
실험 방법	실험실 / 웹
실험 장소	실험이 이루어질 장소를 구체적으로 명시해 주세요. 예: 64동 405호

연구자 정보

연구자	이준환
책임자	이름 / 이메일
소속기관	

Create Study

Recruit Participants

[교육학개론 온라인 학습 2차] 온라인 학습 중 센서데이터 분석 연구

실험 정보

2차 온라인 학습입니다.
원하는 시간을 선택해주세요.

월요일부터 금요일 중 10시, 12시, 2시 선택 가능합니다.

실험 시작일	2016년 4월 4일 (Monday)
실험 종료일	2016년 4월 8일 (Friday)
실험참여 사례비	25000
실험 언어	한국어
제약사항	교육학개론 수강생
IRB 승인여부	승인
실험 장소	롯데국제교육관(152-1동) 세미나실 603호, 604호, 605호

연구자 정보

연구자	최진한
책임자	서봉원
소속기관	서울대학교 융합과학기술대학원

전체 실험목록 보기

실험 일정

번호	날짜	진행시간	예약상황
1	2016년 4월 4일, 10:00 am	120 분	참여가능
2	2016년 4월 4일, 10:00 am	120 분	참여가능
3	2016년 4월 4일, 10:00 am	120 분	참여가능
4	2016년 4월 4일, 12:00 pm	120 분	참여가능
5	2016년 4월 4일, 12:00 pm	120 분	참여가능
6	2016년 4월 4일, 12:00 pm	120 분	참여가능
7	2016년 4월 4일, 2:00 pm	120 분	예약됨
8	2016년 4월 4일, 2:00 pm	120 분	참여가능

Study Example

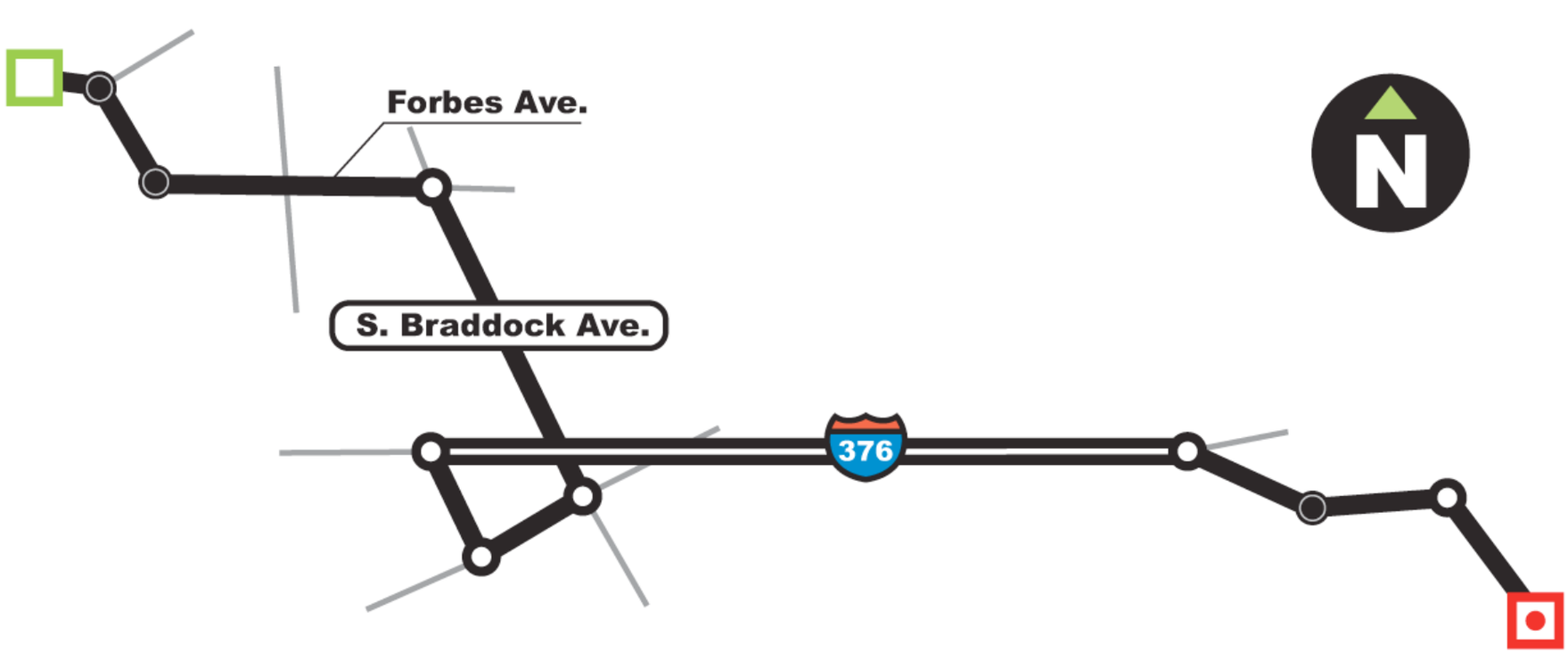
Study 2:

Evaluating MOVE Design

- Purpose: to evaluate feasibility and effectiveness of prototype design
- Map reading performance study
  - compare MOVE with the most optimized current static map (LineDrive)
- Hypothesis:
  MOVE presentation methods can reduce the number of glances and fixation times to comprehend information
  → *reduce perceptual load*

MOVE Design

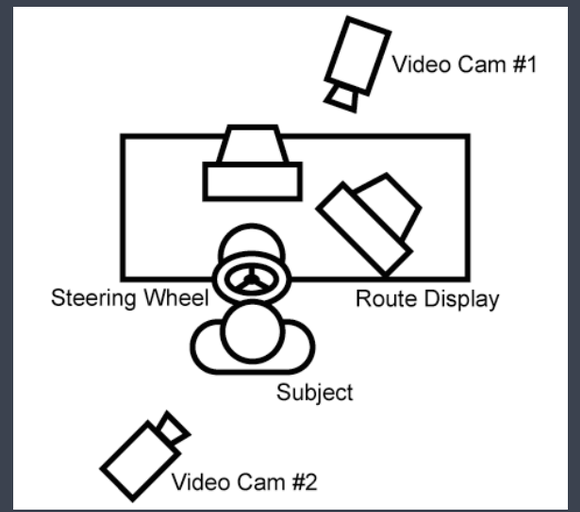
- replicated from previous hand-drawn map -

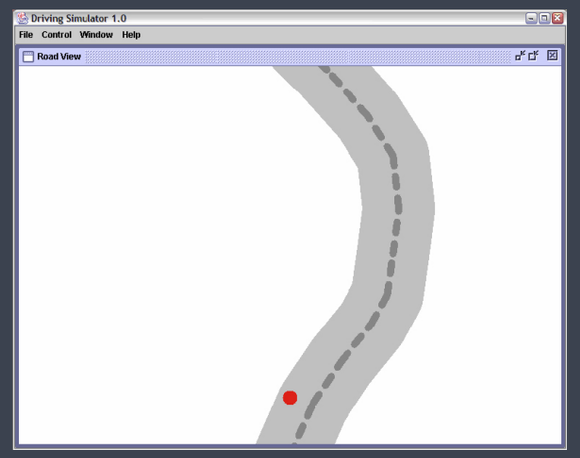


Study 2: Evaluating MOVE Design

Study Overview

- Dual task study
- Simple simulated driving task to saturate attention plus navigation display
- Subjects were told to maintain a central position on the road and prompted to glance at the navigation system and verbally report what was seen





Simulated driving task

Study 2: Evaluating MOVE Design

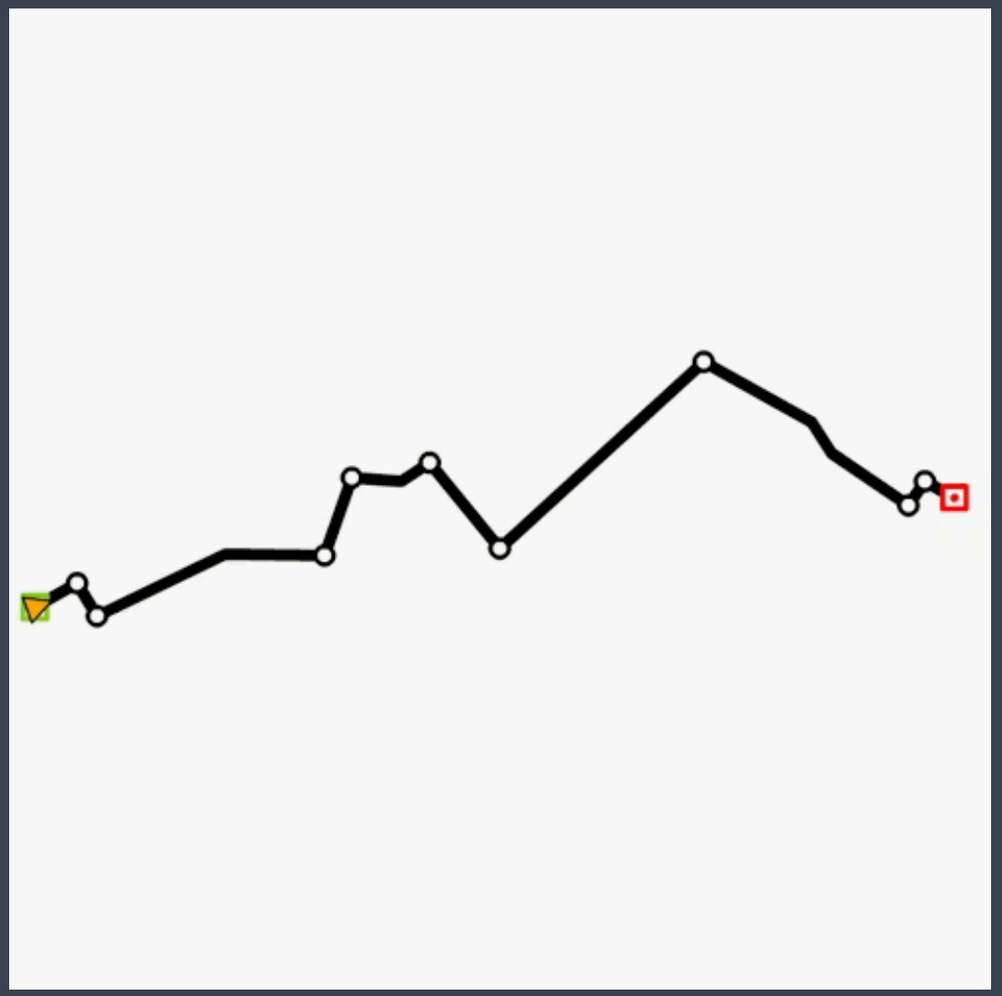
Procedure

- 20 participants (12M, 8F; aged 19-56)
- Conditions (counter balanced)
  - Baseline - check primary task performance without map display
  - Static Route Map: LineDrive
  - 4 MOVE presentation styles (ZC, ZC+R, R, ZC+O)
  - ZC w/o car location cursor - to compare with static map
- Measures
  - Total number of glances per task
  - Total fixation time
  - Average distance off from the road

MOVE Presentation Styles

- Zoom in Context (ZC)

  + Driver can see entire route
  – Target position move back and forth



MOVE Presentation Styles

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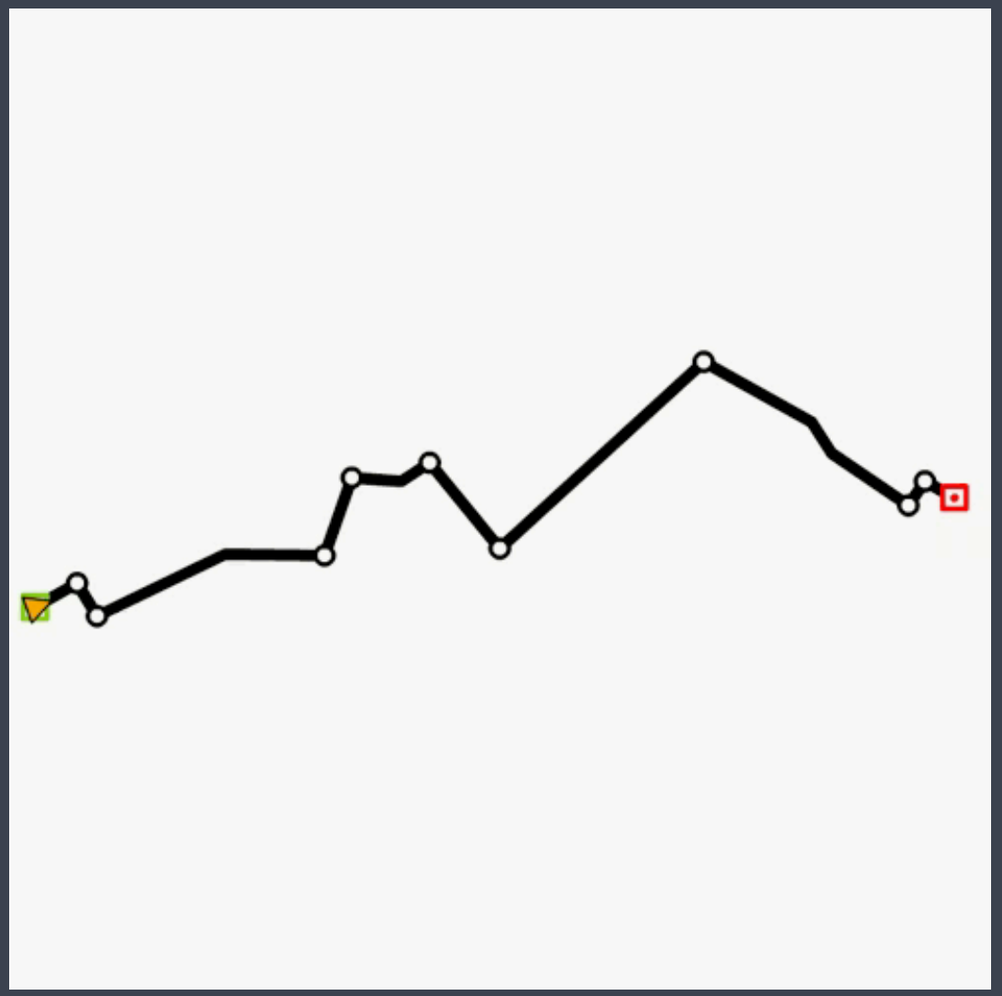
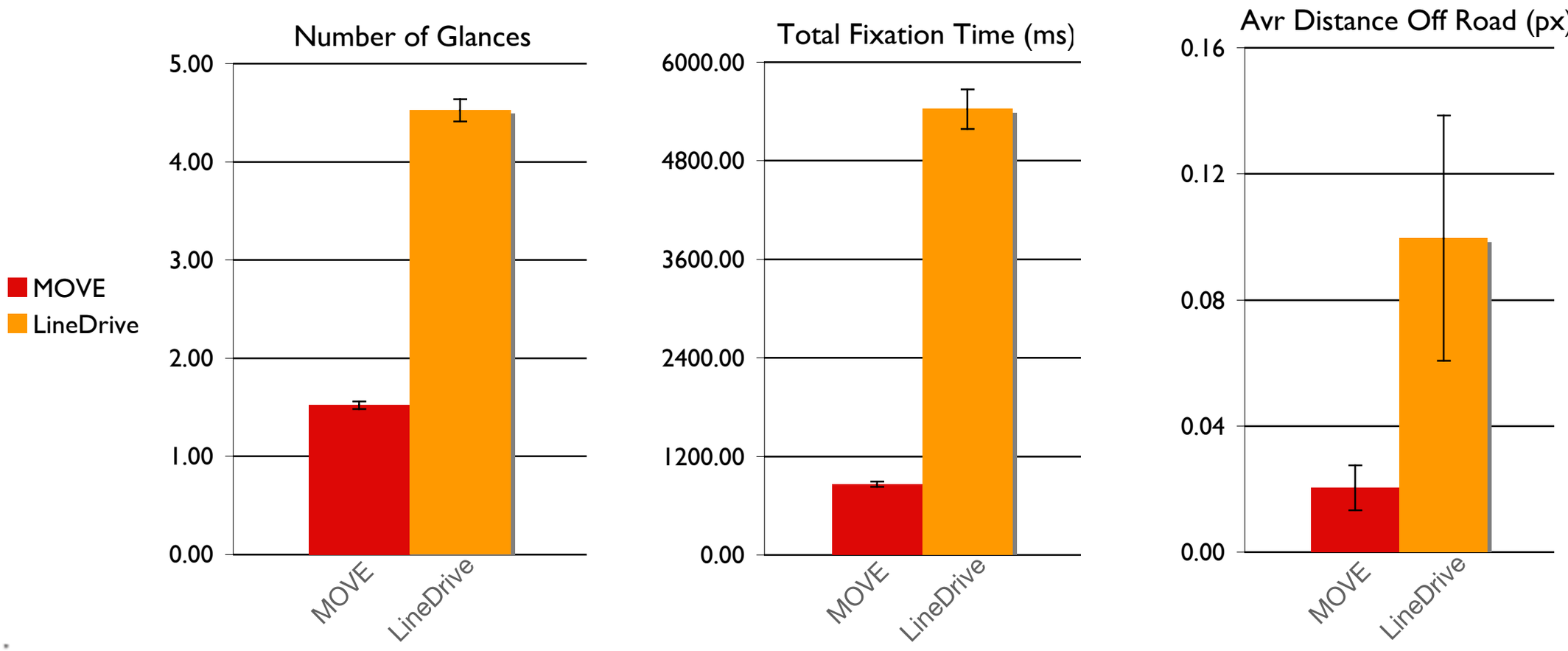


Study 2: Evaluating MOVE Design

Results & Discussion

MOVE vs. LineDrive (lower is better)

All significant at 5% significance level

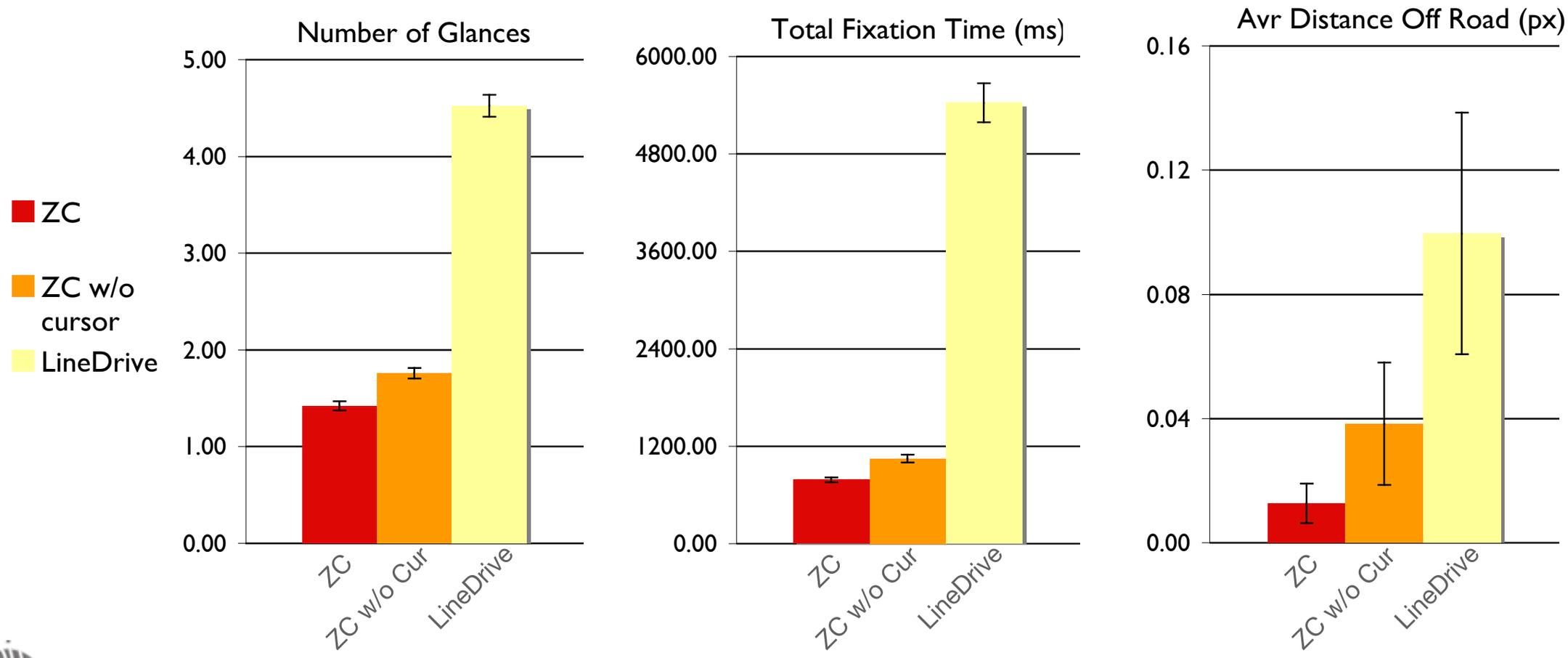


Study 2: Evaluating MOVE Design

Results & Discussion

Merit of Cursor (lower is better)

All significant at 5% significance level



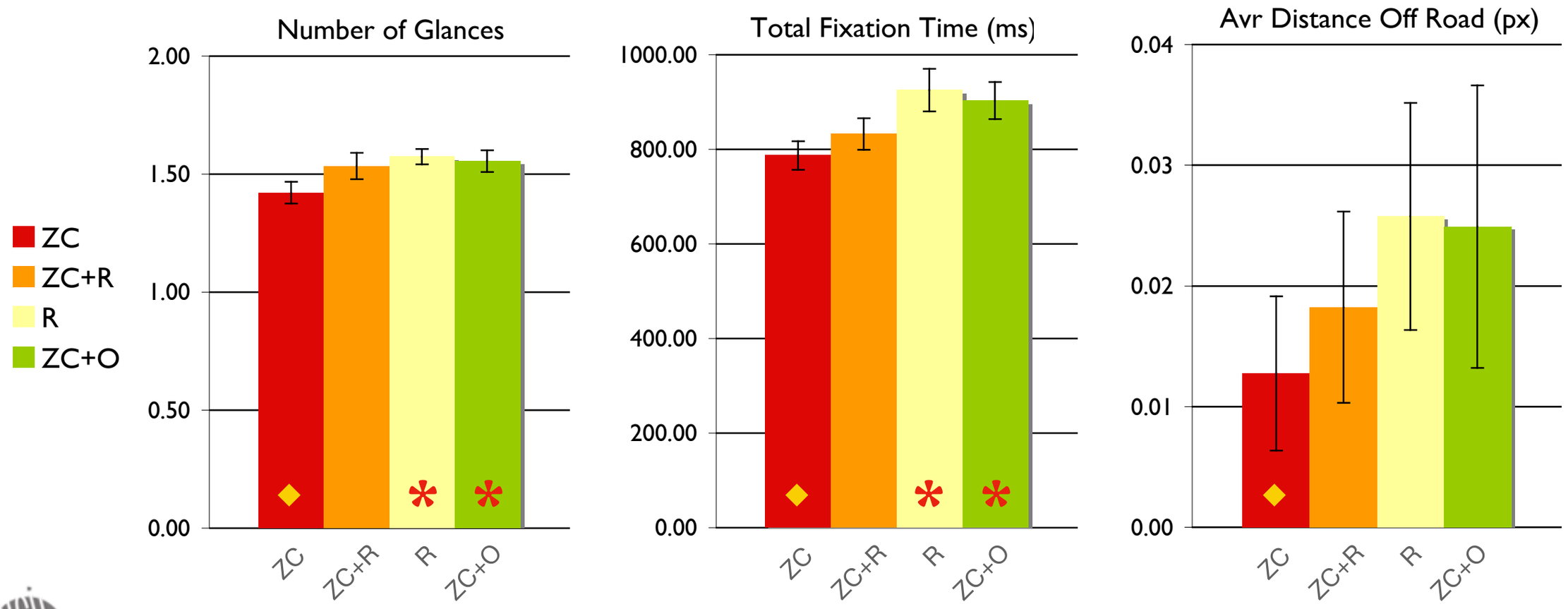
Study 2: Evaluating MOVE Design

Results & Discussion

MOVE 4 Presentation Styles (lower is better)

◆ used for baseline comparison

✱ All significant at 5% significance level

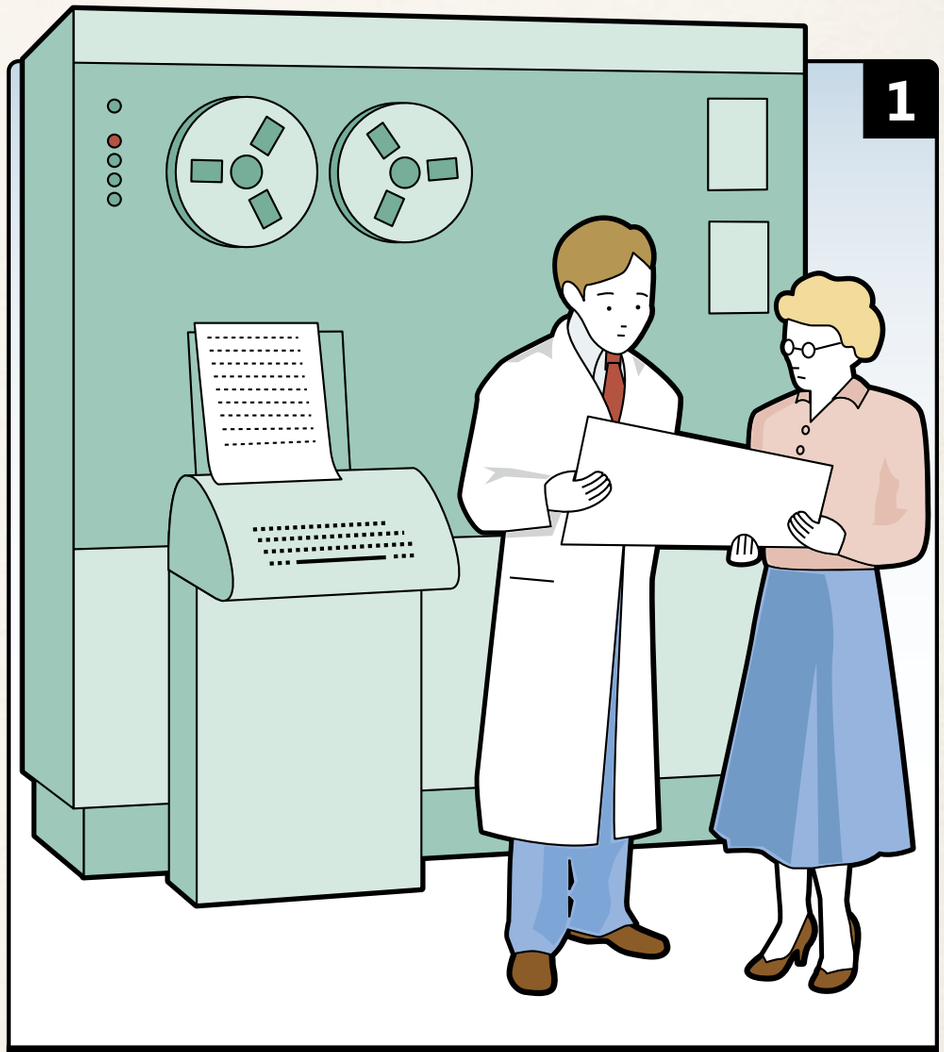


Brainstorming: User Study

- People who use a mouse and keyboard together will be faster to fill out a form than keyboard alone.
- 스터디 디자인을 해보자
  - Hypothesis?
  - Population?
  - Procedure?
  - Two types?
    - Between vs Within
  - Data Analysis?

Ubiquitous Computing / HRI Overview

Four Computing Eras



1960s: Mainframe Era
One computer per many users.

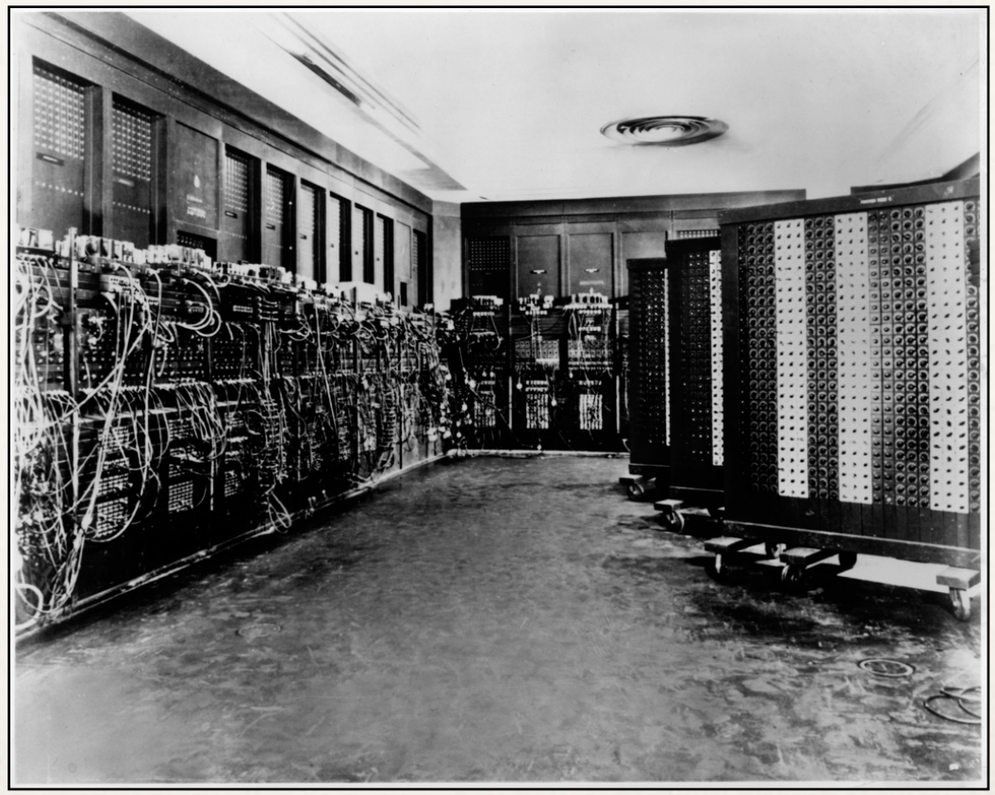
Mainframe 시대

- 컴퓨터의 고도의 계산을 목적으로 개발 됨
- 1930년대: 튜링머신 제안
  - 군사 목적의 디지털 컴퓨터 개발
  - 2차 세계 대전 당시 독일의 암호문 해독에 사용
- 1940년대
  - 미사일 탄도 계산을 위한 컴퓨터의 제작 ➔ ENIAC

    (L 30m X H 3m, 30t, 18,800 개의 진공관)

Mainframe 시대

- ENIAC
  - 세계 최초 범용 컴퓨터
  - 거대한 사이즈, 고가 → 기관만 사용 가능
  - 온도, 습도 등의 조절을 위해 컴퓨터 센터 및 전문 운영팀 필요



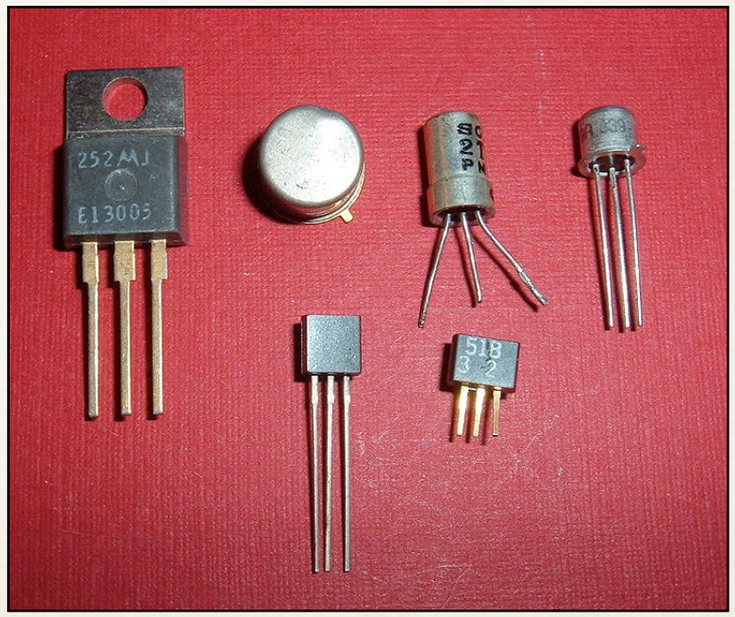
Mainframe 시대

- 트랜지스터의 발명
  - 가격, 크기, 제조 공정 면에서 진공관보다 우월

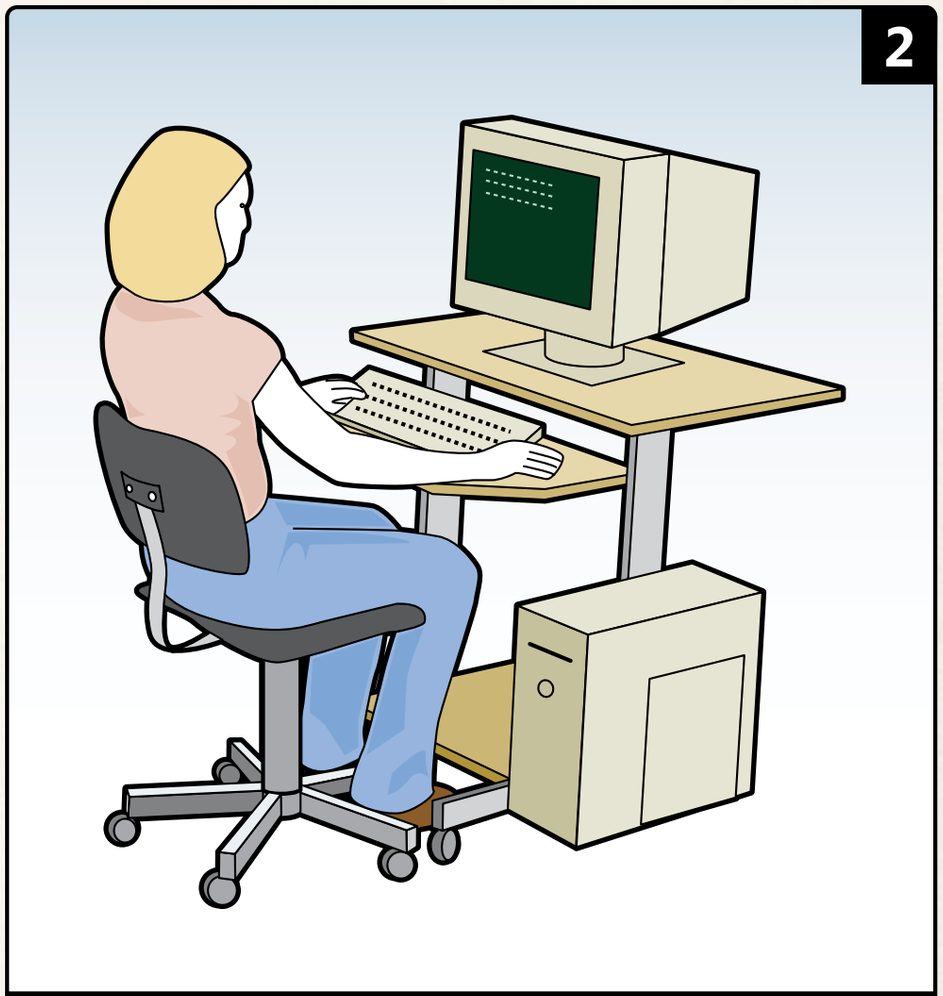
    → 진공관을 대체 (1/100 크기)
- 1950년대부터 컴퓨터에 사용 → IC 로 발전
  - 컴퓨터 크기 축소
  - 전력소모, 발열량 감소
  - 빠른 계산, 안전성 향상
  - 저렴한 가격 → 운영비 감소

    → 컴퓨터 활용분야 확대

    (비지니스, 항공사, 대학교)



Four Computing Eras



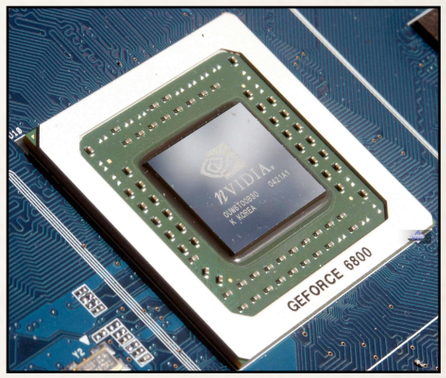
1980s: Personal Computer Era
One computer per user.

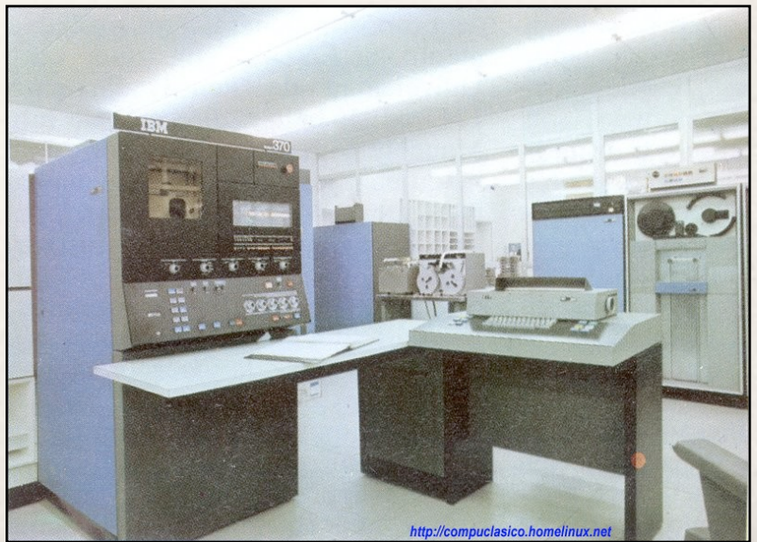
디지털 기술의 발전

- 반도체 집적도의 증가
  - LSI (Large Scale Integration) → VLSI (Very Large Scale Integration) → ULSI (Ultra Large Scale Integration)
  - 칩 하나에 담을 수 있는 전자회로 소자 증가

    → 컴퓨터 성능의 비약적 향상, 가격 하락, 크기 축소
- IBM 370, UNIVAC 1100, CDC 170 등과 같은 다양한 메인프레임과 미니컴퓨터 등장

VLSI





IBM 370

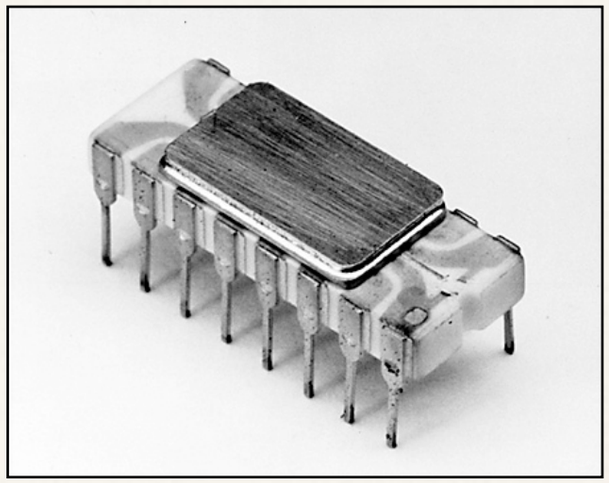
개인용 컴퓨터 시대

- CPU (Central Processing Unit) 등장

  → 마이크로컴퓨터와 퍼스널 컴퓨터의 등장

  - 하나의 실리콘 칩에 processing unit 을 비롯, 다양한 칩이 내장

4381 System Processor
(IBM 370)

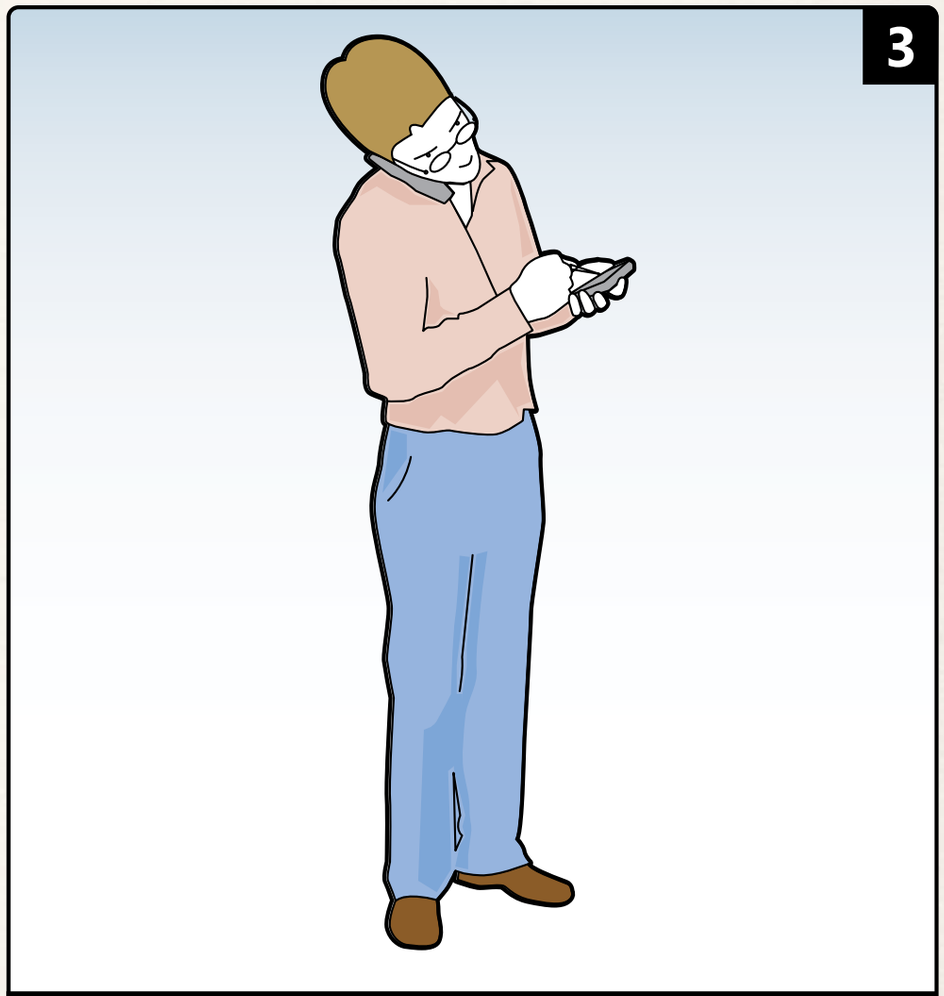


Intel 4004 - containing 2250 transistors
on a single chip.

개인용 컴퓨터 시대

- 1970년대 후반 부터 퍼스널 컴퓨터 등장
  - 컴퓨터의 대중화
  - 대량생산으로 가격이 저렴해 짐
  - Xerox ALTO (mid 1970)
  - Apple I (1977), Apple II (1978)
    - 가정용 컴퓨터의 등장
  - IBM PC (1981)
    - Intel 8088 칩 사용 → 비지니스 시장 공략

Four Computing Eras

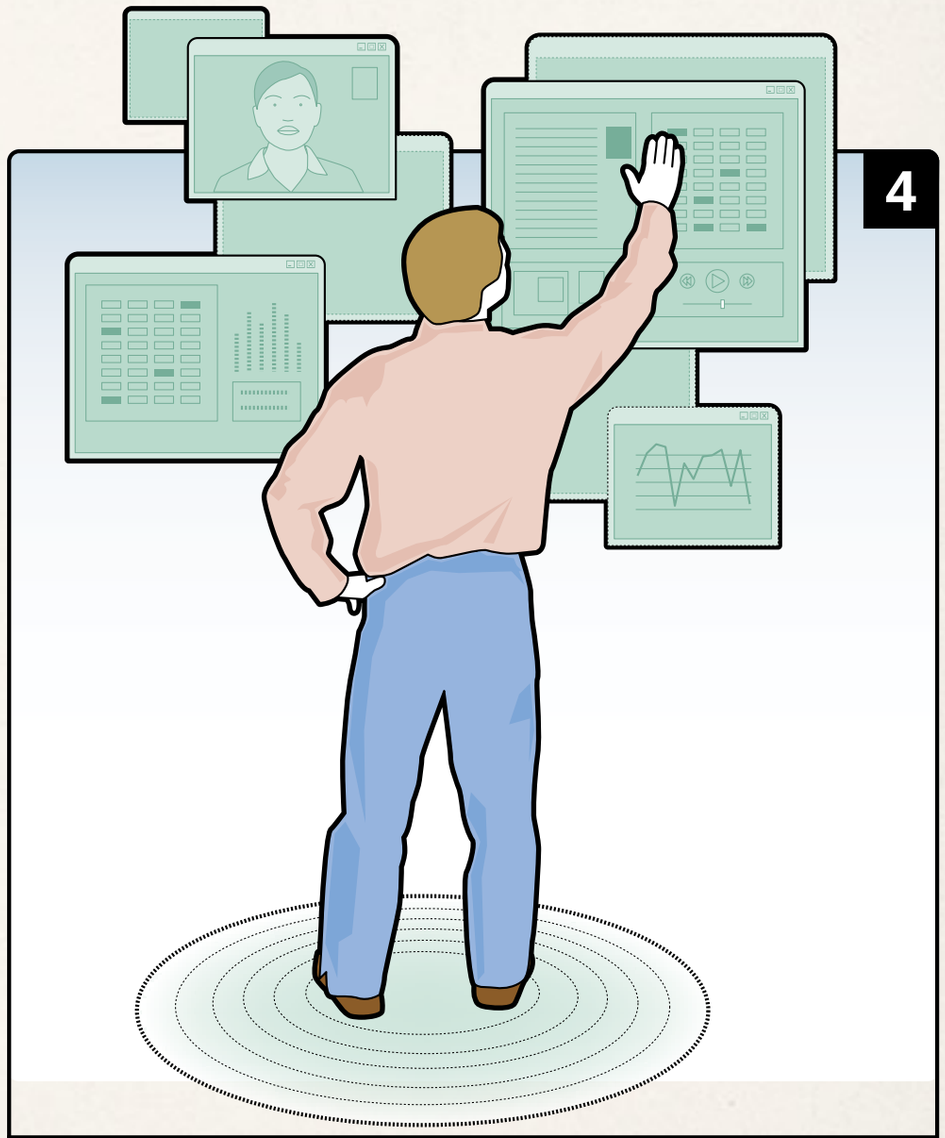


2000s: Mobility Era
Several computers per user.

모바일 컴퓨팅 시대

- 가전제품을 위한 특수 목적의 마이크로프로세서 칩과 메모리의 개발
- Digital TV, MP3 Player, 휴대폰, Digital Camera, 자동차 등 다양한 디바이스에 마이크로프로세서 내장 (embedded)
- Embedded microprocessor 를 위한 OS의 개발
  - MS Windows CE, Symbian, Blackberry OS, Palm, Embedded Linux
  - Apple iOS, Android, Bada, Windows 8 등
- Embedded microprocessor 와 embedded OS 의 성능 향상 → 모바일 컴퓨팅 가능

Four Computing Eras



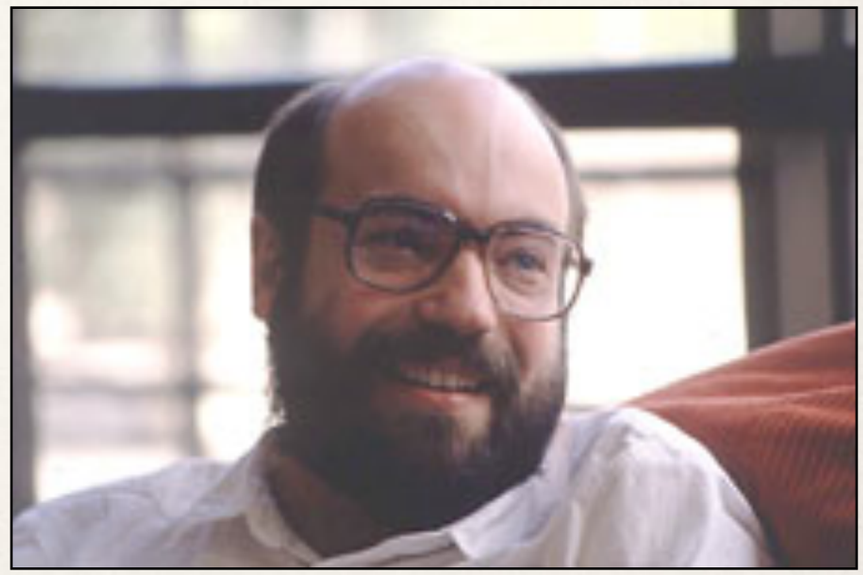
2020 and beyond: Ubiquity Era
Thousands of computers per user.

pervasive computing → disappearing computer

Ubiquitous Computing

- disappearing computing
- invisible computing
- calm computing

Mark Weiser, PARC 1998



Ubiquitous Computing

- 기술 자체가 강조되어서는 안된다.
- 기술은 사용자가 필요한 것이 무엇인지 알아야 한다.
- 사용자의 행위(human behavior)와 기술이 사용되는 맥락(context)의 이해가 무엇보다 중요하다.

Interaction 의 변화

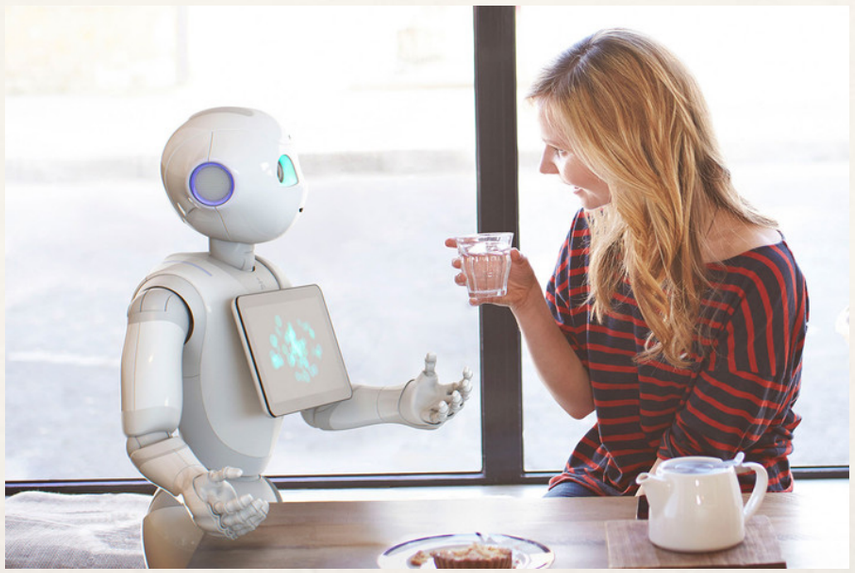
- 데스크탑이라는 한계에서 벗어 남.
- 다양한 환경에서 다양한 형태의 디바이스와 interact
- gesture, multi-touch, gaze, 펜컴퓨팅 등 다양한 형태의 인터랙션이 등장
  - Natural User Interface 의 등장


3
3

대화형 에이전트의 등장

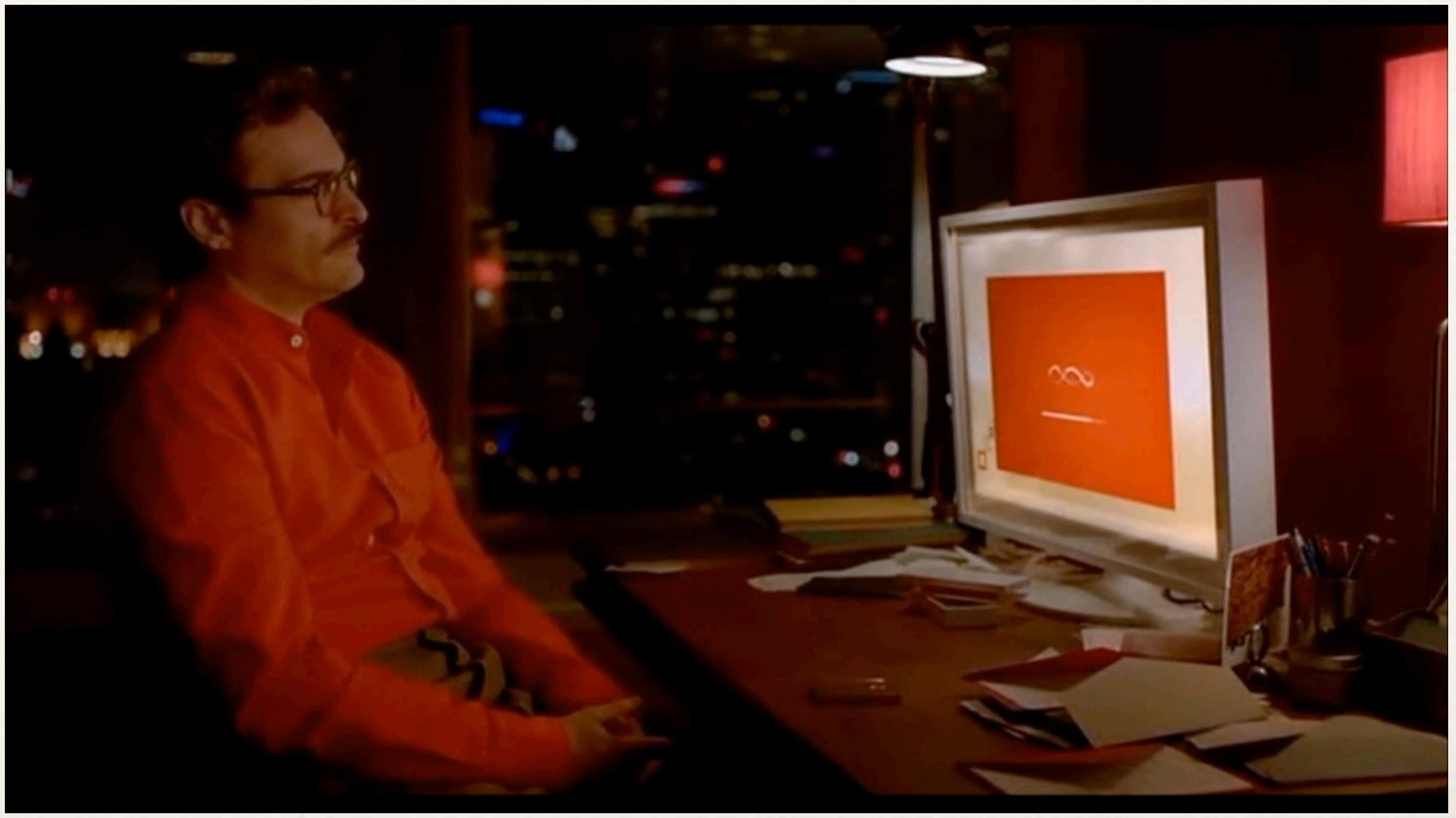
- 인공지능의 발전으로 대화형 에이전트(Conversational Agent, CA) 가 등장
- CA를 기반으로한 소셜 로봇 등도 활발하게 개발 중
- 최근 등장하는 소셜 로봇들은 귀엽고 친근한 모습을 통해

단지 숨어서 도와주는 개인비서의 모습이 아니라 사람들과 감정을 교류할 수 있는 **동반자의 모습**을 갖추기 시작



소셜 로봇

- 소셜로봇은 사물인터넷(IoT), 빅데이터, 클라우드 기술과 접목하여 보다 나은 사용자 경험을 제공
- 사용자와 보다 친밀한 관계를 형성하며 사용자의 어려 일상을 돕는 개인 비서의 역할 수행



인공지능과 함께 살아가기

"I'm looking for something on May 3rd."

HRI: 사회적 로봇 연구

- 주로 알고리즘 성능의 향상과 기능의 개발에서 사회적 관계를 만들어내는 방향으로 연구 관심사가 이동
  - 앞으로 인간이 일상에서 로봇을 마주할 가능성 증가됨에 따라 로봇과 사람간의 “관계”에 대한 연구가 필요. (Warta, 2015)
    - (사회적) 로봇을 사람에게 어떤 존재로 인식시켜야 할지는 학계와 산업계 등에서 가장 우선으로 연구하고 답을 제공해야 할 부분 (Kahn et al., 2007)
- 인공지능과 로봇의 연구에 사회과학적인 시각을 좀더 확대할 필요가 있음 → Human-Robot Interaction
  - 이를 통해 “로봇과의 관계”를 만들어 나가야 함.

Human-Robot Interaction

- Issues to consider in a human-robot coordination:
  - Mutual understanding, modeling on both sides
    - Can robot understand the human (e.g. emotion? Workload of human?)
    - Directed attention: Can robot get attention of human? And vice-versa
  - Function allocation in human-robot teams
    - How to learn states of agents (both human & robot)
  - Levels of autonomy, how to allocate for different tasks
  - Social aspects of mixed teams, expectations of partnership – grounding
- Spillover boundaries from engineering to social science

Computers Are Social Actors

- Media (computer) = real (actual person)
- CASA framework
- Computers are Social Actors (Reeves & Nass, 1996)
- 사람들은 별 생각없이 컴퓨터를 사람처럼 대하고 사람과 사람 사이의 인터랙션을 위해 사용하는 사회적 행위(의 경험)를 그대로 컴퓨터에게도 적용한다 (Nass et al.)
- Social response: 사람들이 미디어를 대하는 방식은 근본적으로 실제 사람을 대하는 방식과 같음

Computers Are Social Actors

- 심지어 Text-to-Speech(TTS)와 같이 기본적으로 시스템 자체의 non-humanness 성향이 부각되는 경우에도 사람들은 미디어에 social cue 적용 (Nass & Lee, 2000)
- 따라서 일반적으로 **인간-컴퓨터** 혹은 **인간-로봇** 등 **agent와의 상호작용 또한 대인커뮤니케이션에 기반해 설계**
  - 성격과 관계 (Nass, Moon, Fogg, Reeves & Dryer, 1995)
  - 유머와 사과 (Reeves & Nass,1996)

    → 의인화 연구

Linguistic Markers

- **Linguistic Markers** (Torrey, Fussell, Kiesler, 2013)
  - hedging: based on politeness to protect the other side
    - e.g., “I guess,” “maybe,” “probably,” “I think,” and “sort of,” “kind of” etc.
  - backchannel:
    - e.g., “Mmm,” Uh-huh” etc.
  - discourse markers: derived not exclusively from their literal definition but from their use in context
    - e.g., “like you know,” “I mean,” “well,” “just,” “like,” “yeah” etc.

Linguistic Markers

TABLE I. EXAMPLES OF HELP MESSAGES COMMUNICATED IN EACH COMMUNICATION CONDITION, USING THE STEP "CREAM BUTTER AND SUGAR."

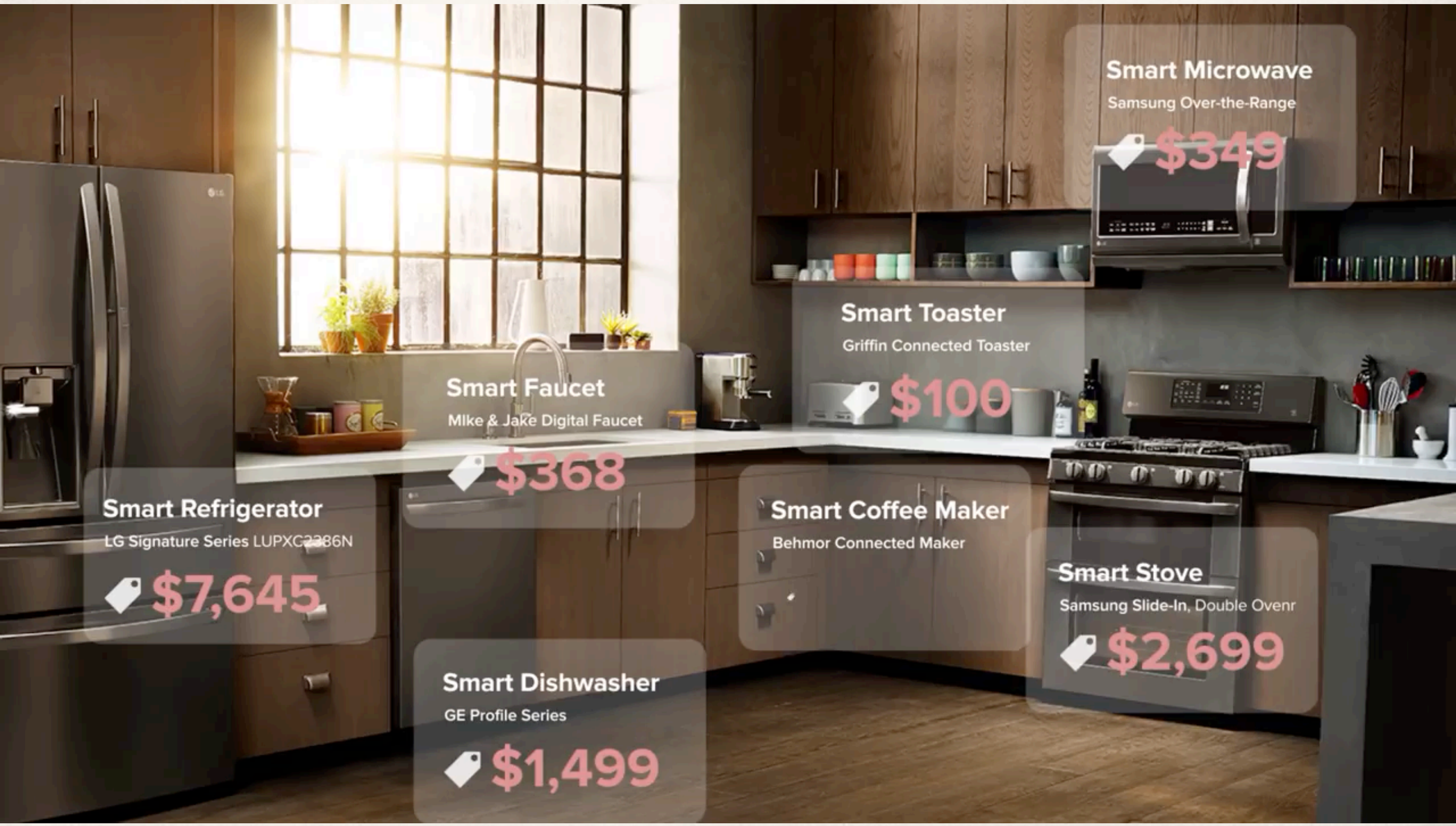
	No Discourse Markers	Discourse Markers
No hedge	"The mixture should be smooth and fluffy. The color will get lighter too."	"Basically just keep going until it's like a smooth mixture. Lighter color and fluffier."
Hedge	"Until the batter looks smooth. It'll get kind of fluffier and the color will lighten up."	"And kind of mix it, until it's just like fluffy. Basically, a nice smooth consistency, a little bit lighter color."

Torrey et al., 2013

Beyond CASA: Human-Robot Interaction

- 로봇을 의인화하거나 사람처럼 행동하게 하는 것만이 전부는 아님
- 사람, 로봇 양쪽에서 연구가 필요
  - 로봇과 같이 사는 우리의 인지능력과 행동은 어떻게 변화할 것인가? → 구글트랜슬레이터의 예
  - 사람과 다른 인지능력을 가진 로봇의 역할은 무엇일까?
- Synthetic Sensor (Carnegie Mellon)
  - 주변의 다양한 소리를 듣고 판단하는 센서
  - 발상의 전환: 로봇과의 인터랙션이 대화를 통해서만 이루어질까? 로봇이 인간과 다른 인지능력을 가졌다면 대화라는 형식 밖에서의 인터랙션은 어떻게 가능할까? → Beyond CASA

Synthetic Sensor



Next Week: Reading Assignments

- T2: Human-Computer Interaction
  - Chapter 6. Hypothesis Testing

Questions…?