hci+d lab.

Week 12

Conducting A User Study

HCI 이론 및 실습 2020 Spring

Human-Computer Interaction+Design Lab _ Joonhwan Lee

Experimental User Study

Usability Testing vs Experiments

Usability testing

- Improve products
- Few participants
- Results inform design
- Usually not completely replicable
- Conditions controlled as much as possible
- Procedure planned
- Results reported to developers

Experiments for research

- Discover knowledge
- Many participants
- Results validated statistically
- Must be replicable
- Strongly controlled conditions
- Experimental design
- Scientific report to scientific community

Experimental User Study

- 실험은 왜 하는가?
  - 과학적 진실이 무엇인지 확인하기 위해서
  - Research Statement 가 ‘참’인지 평가하기 위해서
- 실험의 예: 뚱뚱한 사람은 혈압이 높다 (명제)
  - 다양한 연구 방법이 있을 수 있다.
    - 의사의 임상 데이터를 분석 (기존에 존재하는 데이터)
    - 사람들을 모집한 후, 혈압을 측정
  - 가장 이상적인 방법은 전세계의 모든 사람들의 혈압을 수집하는 것 (가능?)
    - 샘플 모집하여 실험

Experimental User Study

- 인터랙션에서 특정 요소를 살펴보기 위한 콘트롤된 실험
- 실험자는 실험을 위한 hypothesis 를 만든다
- 여러개의 실험 조건이 고려될 수 있는데, 그들 실험 조건은 조작된 변인에 의해 조금씩 차이가 만들어 짐 (eg., 20 menu items vs. 7 menu items)
- 서로 다른 조건에 반응하는 행동 방식 (eg., reaction time) 을 측정한다

Experimental Factors

- Subjects
  - 어떤 사람들을 실험 대상으로 선택할 것인지, 어느 정도의 사람을 대상으로 실험할 것인지
    (eg., dashboard re-design for elders)
- Variables
  - 조작하고 측정해야 하는 것들 (eg., grey on yellow vs. green on yellow or RT)
- Hypothesis
  - 실험을 통해 알고 싶은 것
- Experimental design
  - 실험을 어떻게 설계하고 진행할 것인지

Subjects

- How many subject 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

Testing Condition

- Usability lab or other controlled space.
- Emphasis on:
  - selecting representative users;
  - developing representative tasks.
- Tasks usually last no more than 30 minutes.
- The test conditions should be the same for every participant.
- Informed consent form explains procedures and deals with ethical issues.

Some Type of Data

- Time to complete a task.
- Time to complete a task after a specified time away from the product.
- Number and type of errors per task.
- Number of errors per unit of time.
- Number of navigations to online help or manuals.
- Number of users making a particular error.
- Number of users completing task successfully.

Variables & Hypothesis

- independent variable (IV) : 독립변수
  - 서로 다른 조건을 만들기 위한 것들
  - e.g. interface style, number of menu items
- dependent variable (DV) : 종속변수
  - 실험을 통해 측정가능한 것들
  - e.g. time taken, number of errors.
- 결과의 예측 (prediction of outcome)
  - IV 와 DV 의 관계를 예측
  - e.g.: error rate 은 폰트 사이즈가 줄어들면 증가할 것이다.

Experimental Design

- 실험 디자인 혹은 실험 설계
  - within groups design
    - 각각의 참여자들은 모든 condition 을 수행하여 실험한다
    - condition에 계속 노출됨에 따라 학습효과가 일어날 가능성 발생
    - 참여자 집단의 variation 에 따라 실험 결과가 영향을 미칠 가능성이 적다
  - between groups design
    - 각각의 참여자는 하나의 condition 만 수행
    - 학습효과 없음
    - 더 많은 참여자가 필요해서 비용이 많이 듬
    - 참여자 집단의 variation 이 결과를 왜곡되게 만들 수 있음.

Analysis of Data

- 다양한 통계 분석 기법이 필요
  - 데이터의 형태에 따라 통계 분석 기법이 달라짐
  - 변량의 비교: eg., t-test vs. anova
  - 예측모델: linear model analysis
- 분석의 결과로 찾는 것
  - condition 1 vs. condition 2
    - 차이가 있는지?
    - 차이는 통계적으로 유의미한 것인지?
    - 차이는 얼마나 큰지?
    - 가정은 얼마나 정확한지?
    - 차이를 만드는 이유는? → 추론, 상상력을 동원하여 데이터의 의미를 분석

Hypothesis Testing

- The use of **statistical procedures** to **answer research questions**
- Typical research question (generic):
  - Is the time to complete a task less using Method A than using Method B?
- For hypothesis testing, research questions are statements:
  - There is no difference in the mean time to complete a task using Method A vs. Method B.
    → *null hypothesis* (assumption of “no difference”)
- Statistical procedures seek to reject or accept the null hypothesis

Statistical Procedures

- Two types:
  - Parametric
    - Data are assumed to come from a distribution, such as the normal distribution, *t*-distribution, etc.
  - Non-parametric
    - Data are not assumed to come from a distribution
- A reasonable basis for deciding on the most appropriate test is to match the type of test with the measurement scale of the data

Measurement Scales vs. Statistical Tests

- Parametric tests most appropriate for…
  - Ratio data, interval data
- Non-parametric tests most appropriate for…
  - Ordinal data, nominal data (although limited use for ratio and interval data)

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	

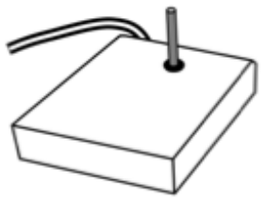
Statistical Analysis

- Parametric
  - Analysis of variance (ANOVA)
    - Used for ratio data and interval data
    - Most common statistical procedure in HCI research
- Non-parametric
  - Chi-square test
    - Used for nominal data
  - Mann-Whitney U, Wilcoxon Signed-Rank, Kruskal-Wallis, and Friedman tests
    - Used for ordinal data

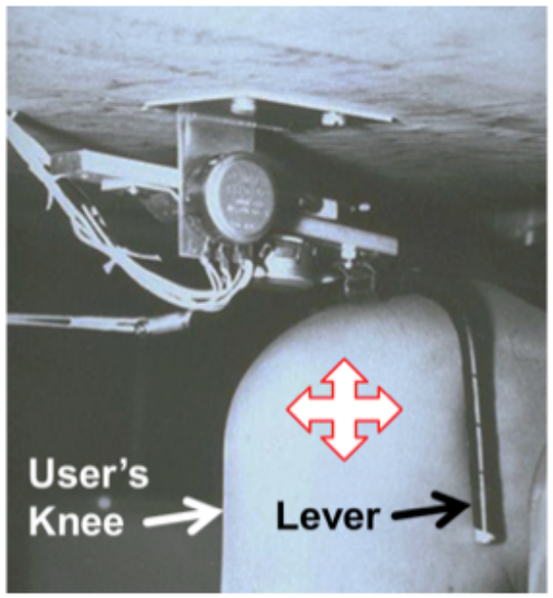
HCI's First User Study

- A comparative evaluation of…

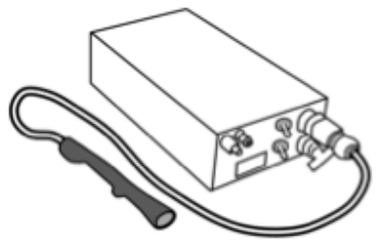
Mouse



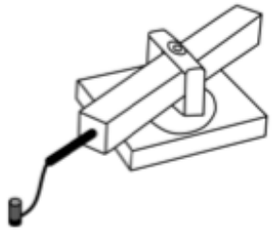
Joystick



Knee-controlled lever



Lightpen



Grafacon

English, W. K., Engelbart, D. C., & Berman, M. L. (1967). Display selection techniques for text manipulation. IEEE Transactions on Human Factors in Electronics, HFE-8(1), 5-15.

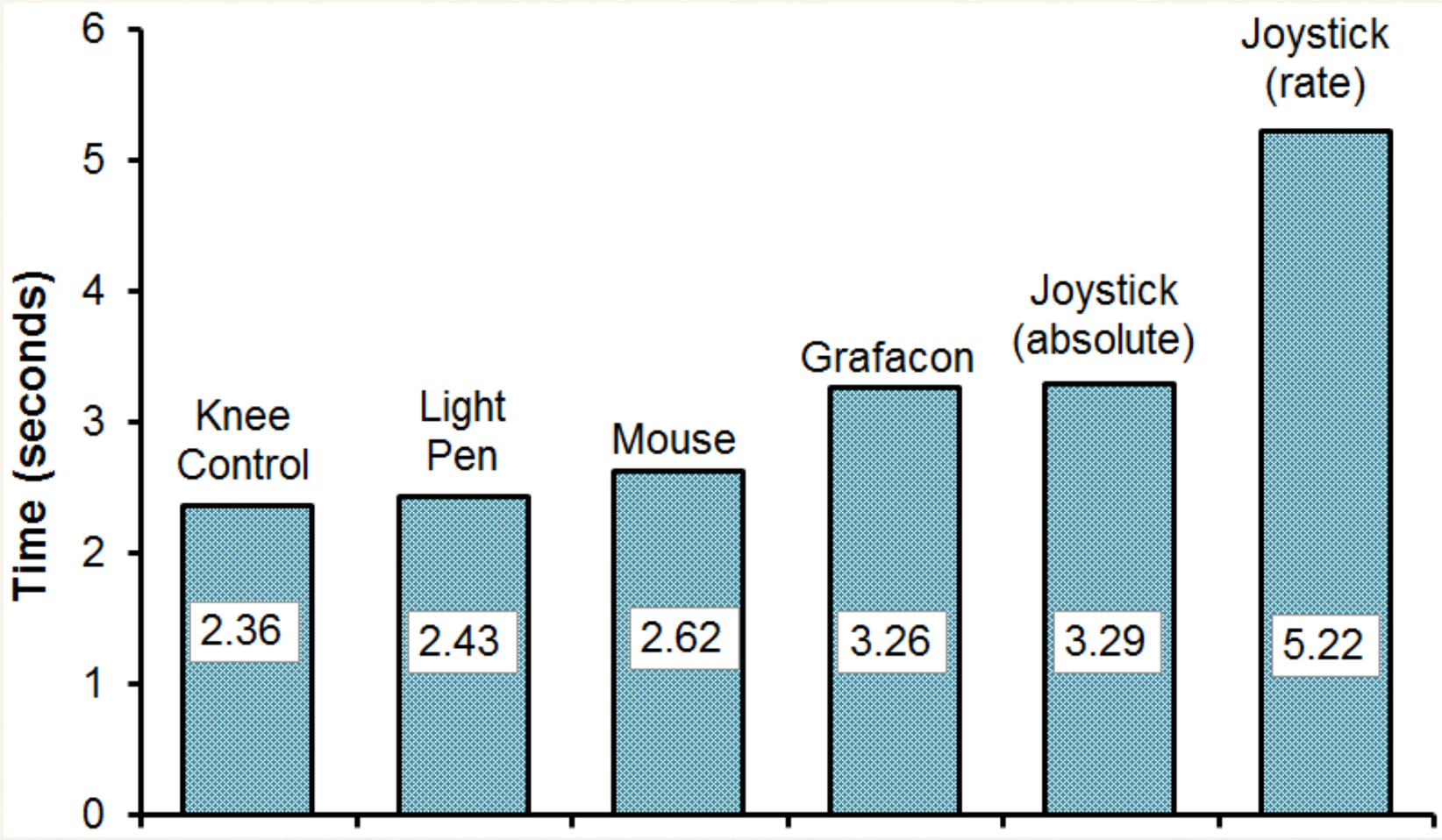
HCI's First User Study

- Experiment Design
  - Participants: 13
  - Independent variable
    - "Input method" with six levels: mouse, light pen, Grafacon, joystick (position-control), joystick (rate-control), knee-controlled lever
  - Dependent variables
    - Task completion time, error rate

      Note: task completion time = access time + motion time
  - Within-subjects, counterbalanced
  - Task:
    - Press spacebar, acquire device, position cursor on target, select target

HCI's First User Study

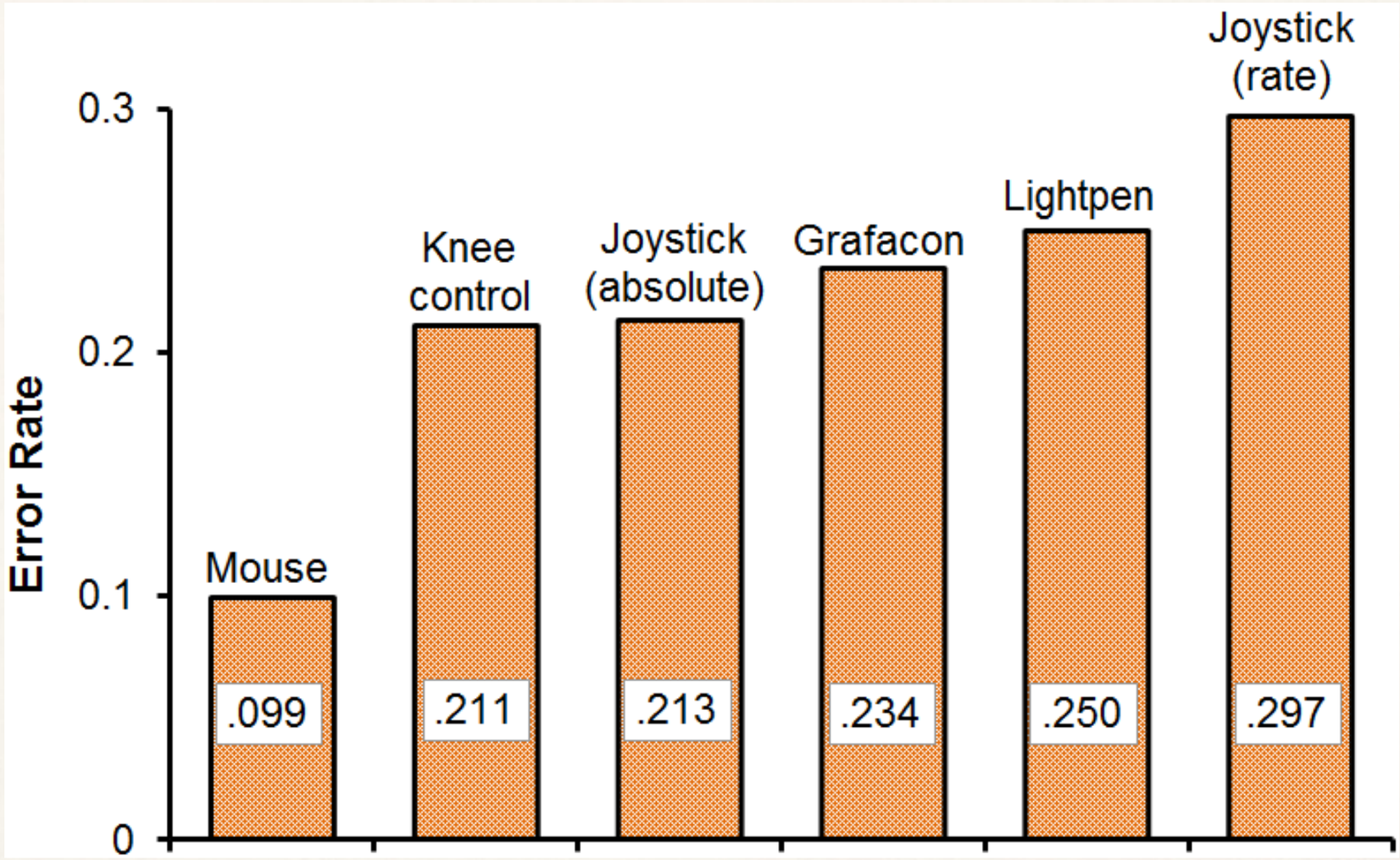
- Results (1)



Notes:
1 Access time with the knee-controlled lever was zero (since the device is always "acquired").
2 Light pen use is fatiguing, since the user's arm is held in the air in front of the display.

HCI's First User Study

- Results (2)



Study 2:

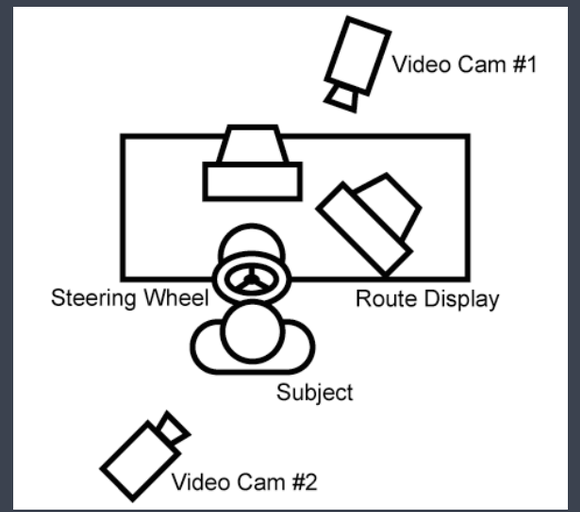
Evaluating MOVE Design

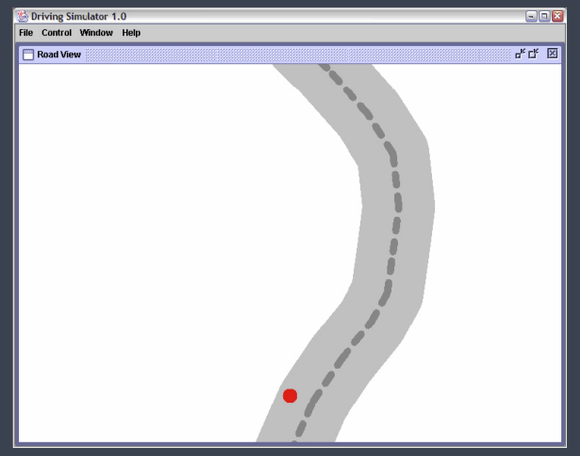
- Purpose: to evaluate feasibility and effectiveness of prototype design
- Map reading performance study
  - compare MOVE with the most optimized current static map (LineDrive)
- Hypothesis:
  MOVE presentation methods can reduce the number of glances and fixation times to comprehend information
  →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

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

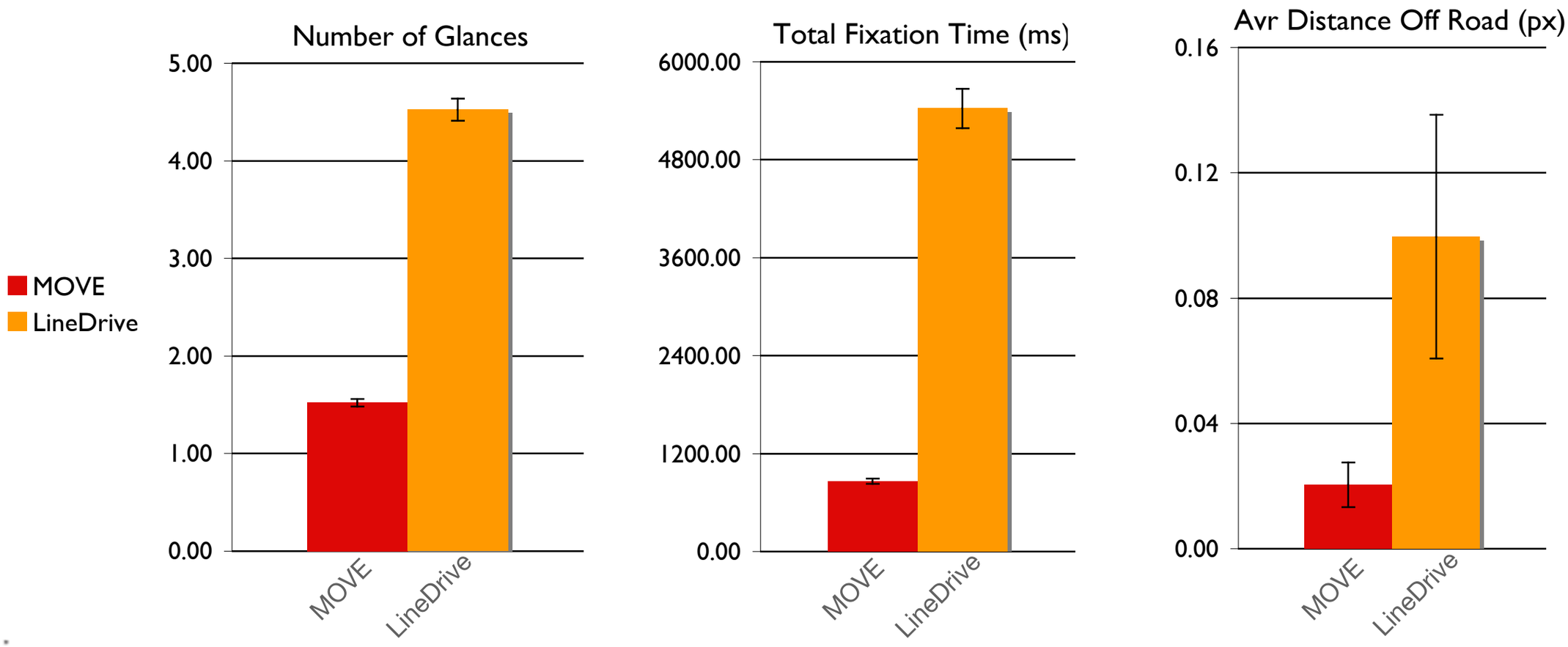
- 20 participants (12M, 8F; aged 19-56)
- Conditions (counter balanced)
  - Baseline - check primary task performance without map display
  - Static Route Map: LineDrive
  - 4 MOVE presentation styles (ZC, ZC+R, R, ZC+O)
  - ZC w/o car location cursor - to compare with static map
- Measures
  - Total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

Study 2: Evaluating MOVE Design

Results & Discussion

MOVE vs. LineDrive (lower is better)

All significant at 5% significance level

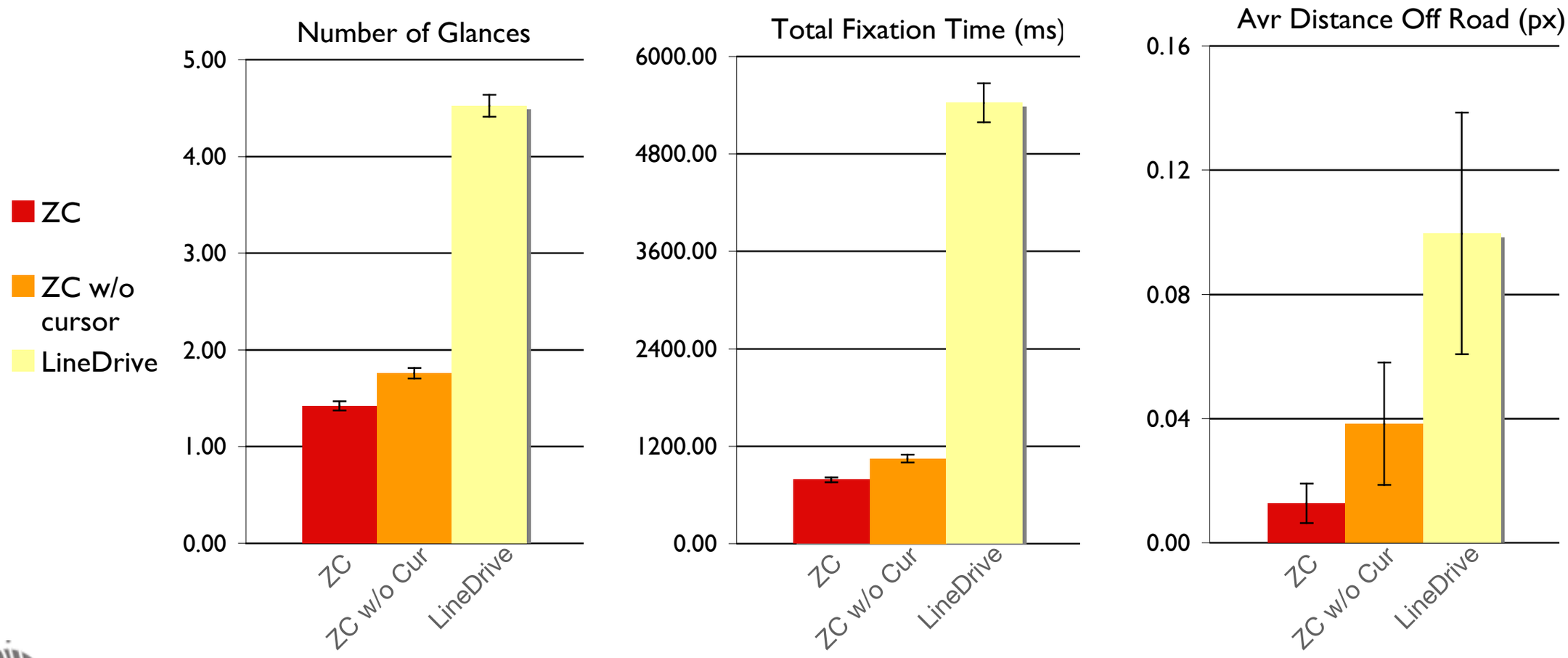


Study 2: Evaluating MOVE Design

Results & Discussion

Merit of Cursor (lower is better)

All significant at 5% significance level



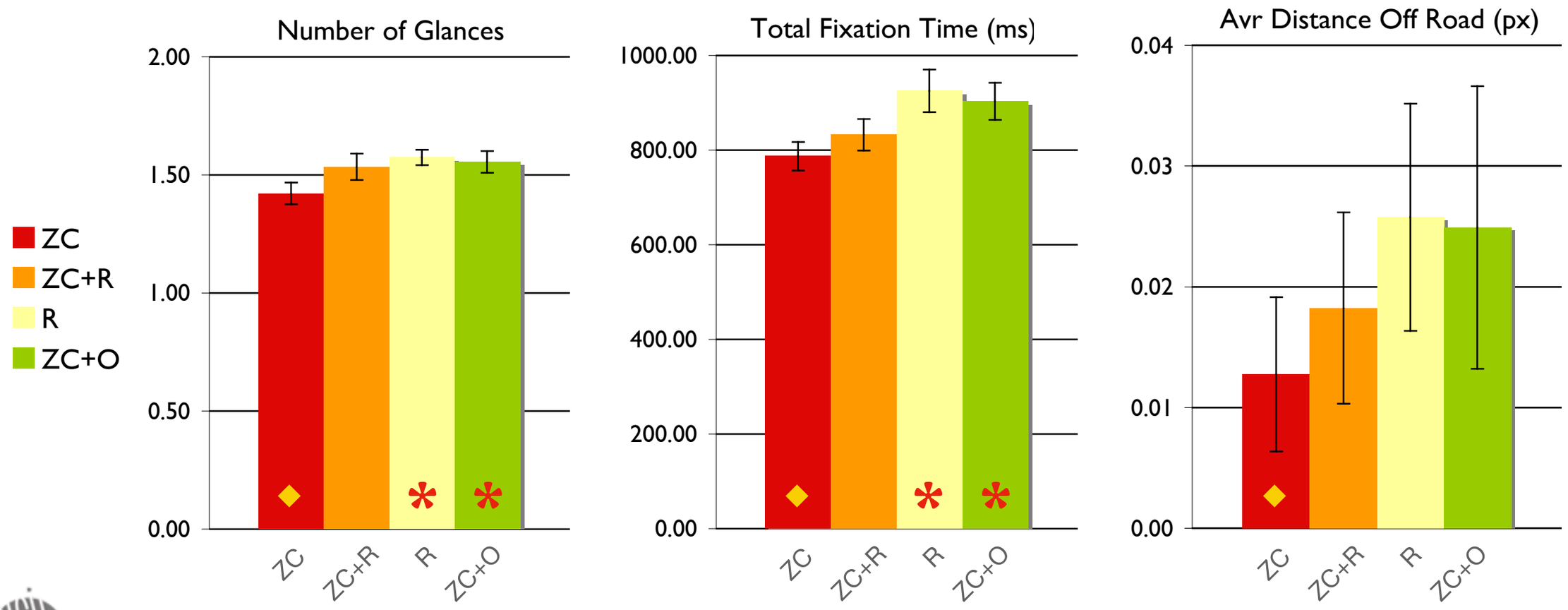
Study 2: Evaluating MOVE Design

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?

Experimental Studies on Groups

- 그룹을 대상으로 하는 실험은 단일 유저를 대상으로 하는 것 보다 훨씬 어려움.
- 여러 문제점들이 발생
  - 피험자 그룹의 선정
  - 실험을 할 태스크의 선택
  - 데이터 수집
  - 분석

Subject Groups

- 많은 수의 피험자는 실험의 비용이 올라가고, variation이 커지며, 안정화된 데이터를 얻기 까지의 시간이 많이 걸림.
- 많은 사람들의 시간을 맞추는 것도 어려움.
- 보통, 3-4개의 그룹을 대상으로 실험 → 그 이상은 실험을 운용하기가 어려워짐.

Data Gathering

- 그룹 실험의 데이터는 다양한 방법으로 수집 가능
- 몇대의 비디오 카메라를 설치해서 피험자들의 협업과정을 녹화, 분석
- 실험용 어플리케이션을 만들어 피험자들의 행위의 log를 기록
- 그룹으로 모아진 데이터에는 개개인의 개별적인 데이터가 포함되어 있으므로 synchronization 의 이슈가 발생할 수 있다. → time code 등의 사용으로 문제를 해결해야
- 그룹 프로젝트라 할지라도 개개인의 perspective 가 중요.

Physiological Methods

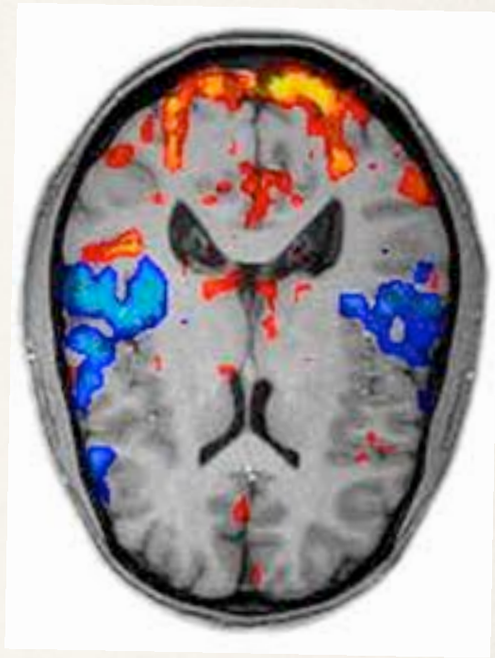
- Eye tracking
- Physiological measurement

Eye Tracking

- 머리에 부착하거나 책상위에 올려놓고 화면에서의 눈의 위치를 추적하는 장치
- 눈의 움직임은 디스플레이가 요구하는 cognitive process 의 양을 반영한다
  → 눈이 계속 머무르는 곳은 무엇인가 하기 위해 cognitive process 가 이루어지는 곳
- 측정하는 것
  - fixation: 눈이 머무르는 위치. 시간과 횟수는 디스플레이를 바라볼 때의 어려움의 수준을 반영
  - scan path: 눈이 정보를 찾기 위해 움직이는 경로

Physiological Measurements

- 신체의 변화와 관련된 정서적 반응을 측정
- 사용자가 인터페이스를 쓸 때의 반응 (reaction)을 알고, 그 때의 감정 상태 (예: 불편하다, 어렵다 등) 을 파악하는데 도움이 될지도 모른다



- measurements
  - heart activity, including blood pressure, volume and pulse.
  - electrical activity in muscle: electromyogram (EMG)
  - electrical activity in brain: electroencephalogram (EEG)
  - flow of oxygenated blood in brain: functional magnetic resonance imaging (fMRI)

Questions…?