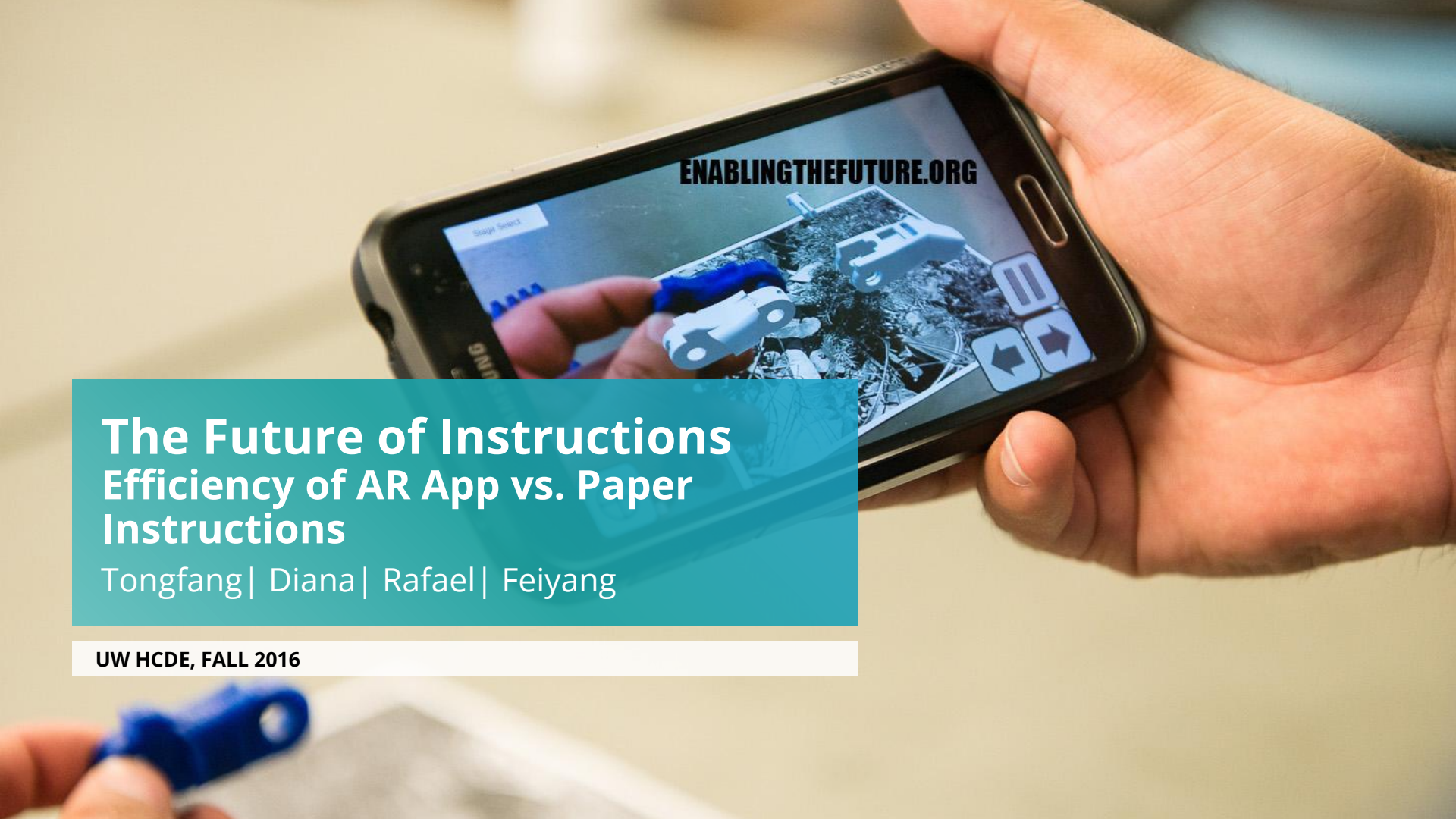



# The Future of Instructions

## Efficiency of AR App vs. Paper Instructions

Tongfang| Diana| Rafael| Feiyang

**UW HCDE, FALL 2016**

# Introduction
## Problem Statement

What are the effects of **AR App Instructions** compared to **paper instructions** in regard of **time consumption** while assembling a **3D object**?

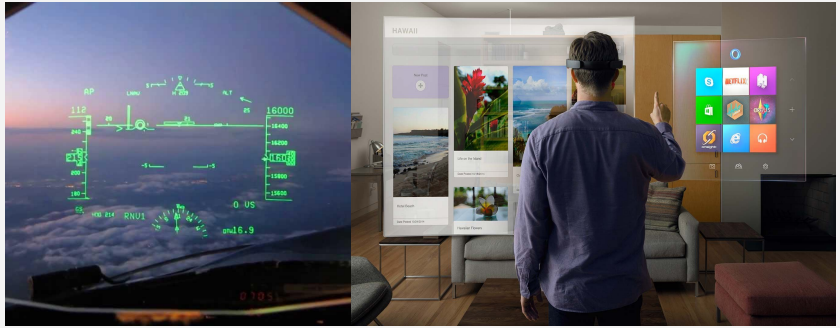
**IV:** Instruction Media
**2 Levels:** AR App, Paper Instructions

**DV:** Time consumption

**CV:** 3D object

# Introduction
## What is our Team's Research?

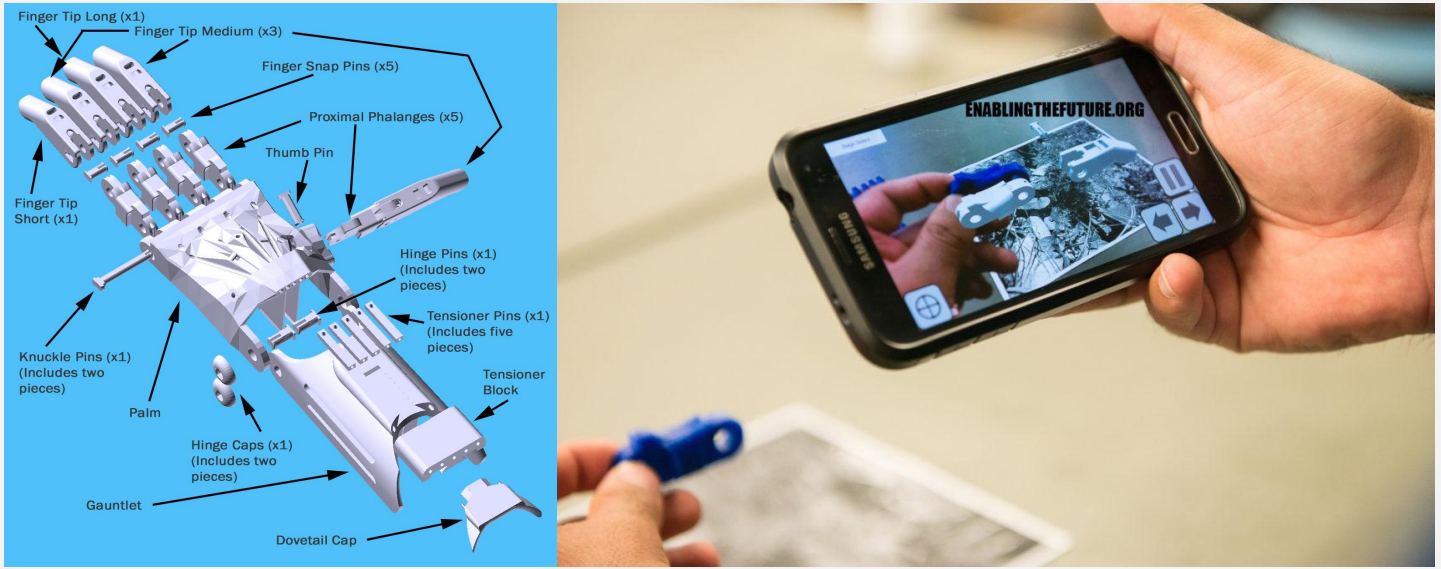
- Augmented Reality (**AR**): **Technology that blends virtual assets into the real world environment**
- **Motivation:** The Raptor Reloaded Arm is an Open Source Prosthetic Hand Design used by people all over the world.



Airplane AR system and Hololens

Raptor Reloaded OpenSource Hand Design

# Introduction
What is our Team's Research?




Raptor Reloaded OpenSource Hand Assembly

# **Motivation**
## Is the **AR Assembly Manual** for Enabling Prosthetic Design Efficient?

Pre-Research Evaluation:

- There are lots of papers that talk about AR **design**, **implementation** and its influence for the **future**

Problem:

- There are few **experimental research papers** to show the contemporary **real benefits** compared with traditional media
- Most articles ignore the **human factors** *(gender, background, familiarity with AR etc.)* influence in AR real cases and are focused in specific fields, **not suitable for public**

First AR experiment research conducted by Stefan Wiedenmaier, 1998 - 2001

# Hypothesis
Research focus

## Hypothesis 1

**H1:** Time using paper instructions is greater than time using AR instructions while assembling 3D objects

**H0:** Time using paper instructions is equal to time using AR instructions while assembling 3D objects

**IV:** Instructions' Media Platform (paper vs AR app)

**DV:** Time Consumption to assemble a 3D object

## Hypothesis 2

**H1:** Assembly time for participants with no experience with AR is greater than assembly time for participants with previous experience with AR

**H0:** Assembly time for participants with no experience with AR is equal to Assembly time for participants with previous experience with AR.

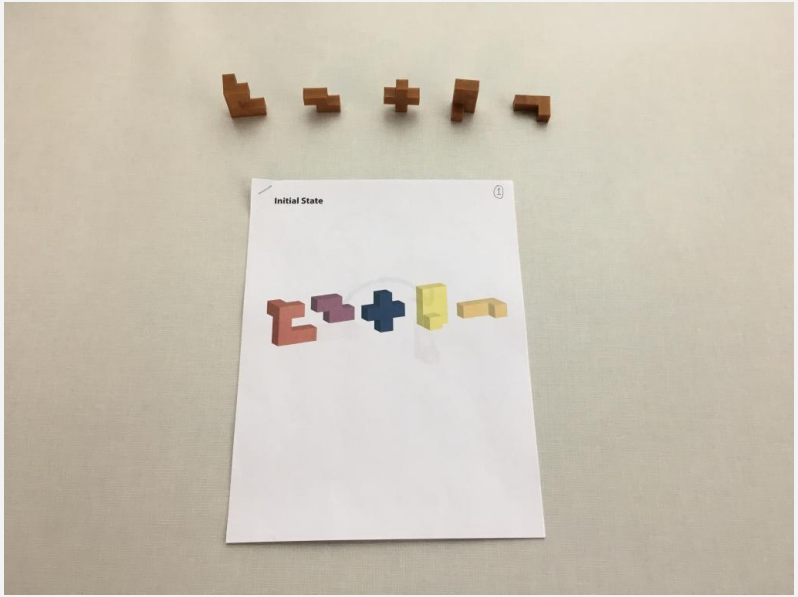
**IV :** Previous exposure to AR (Categorical)

**DV:** Time Consumption to assemble a 3D object

# Method
## Preparation Tasks Before Research Test

**AR**


**Paper**



# Method
## Experiment Station at UW Bothell Makerspace

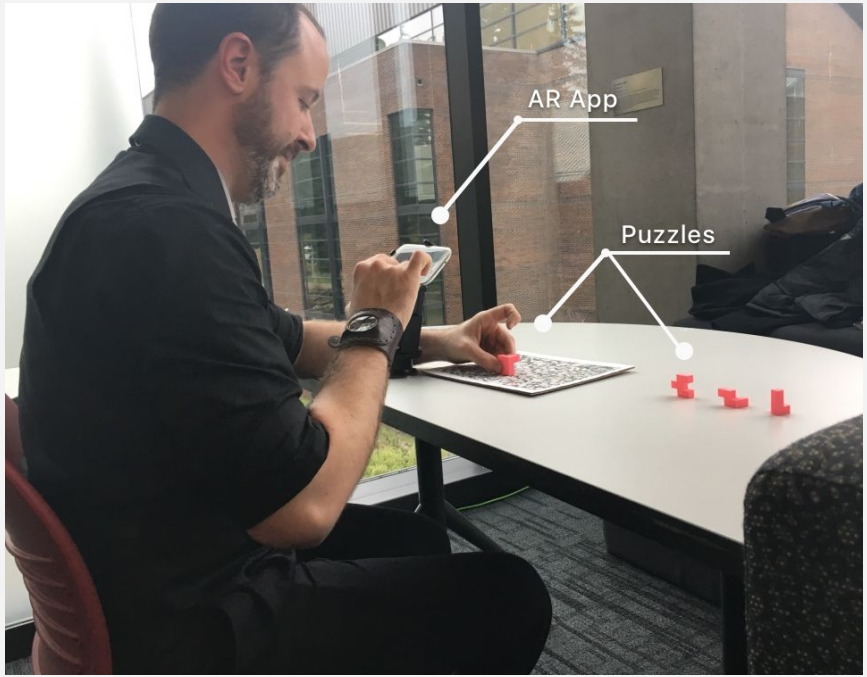
| Participant | Paper #1 | AR #1 | Paper #2 | AR #2 |
|---|---|---|---|---|
| 1 | NA | ✔ | ✔ | NA |
| 2 | ✔ | NA | NA | ✔ |
| 3 | NA | ✔ | ✔ | NA |
| ... | ... | ... | ... | ... |
| 36 | ✔ | NA | NA | ✔ |

Randomly Assigned

# **Method**
## Participants (Convenience Sampling)

- Recruited 36 people in total from UW Seattle and UW Bothell
- One outlier (one participant didn’t finish AR task2)
- Removing the outlier, 35 participants, age range 18-35, 18 males and 17 females
- 22 of the participants had previous experience with AR/VR while 13 participants did not have any previous experience with AR/VR

**mean = 23 years old, SD = 5.3**



# Method
## Research Workflow and Protocol

**User Testing**

Within Subject

Record time and tasks

**Survey**

Google Form

Record participants' background

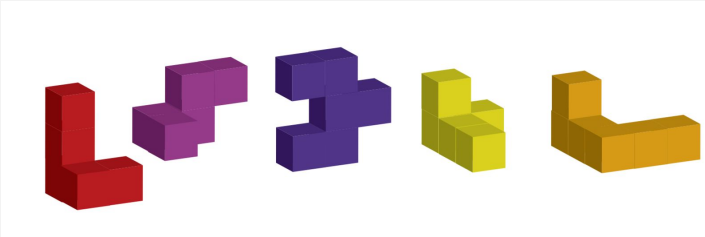
**Data Analysis**

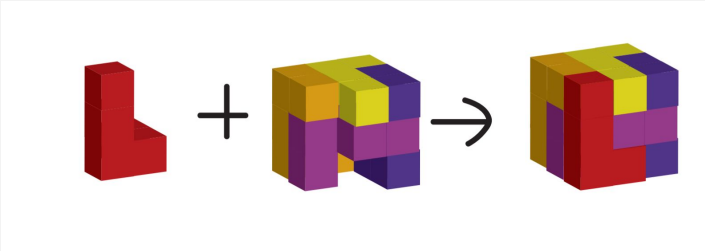
Kruskal Wallis Test

Two Way ANOVA

# **Method**
## Challenges

- Experience Bias
    - Having two different puzzles eliminate the experience effects. (one easy, one difficult)
- Instrument Bias
    - Making paper instruction and AR instructions as similar as possible
- External Validity Threats
    - Novelty Effects:  AR app is such a new tech, we gave participants some guidelines before testing
    - Researcher Bias: Record start time should be same (flip or click Step 1)





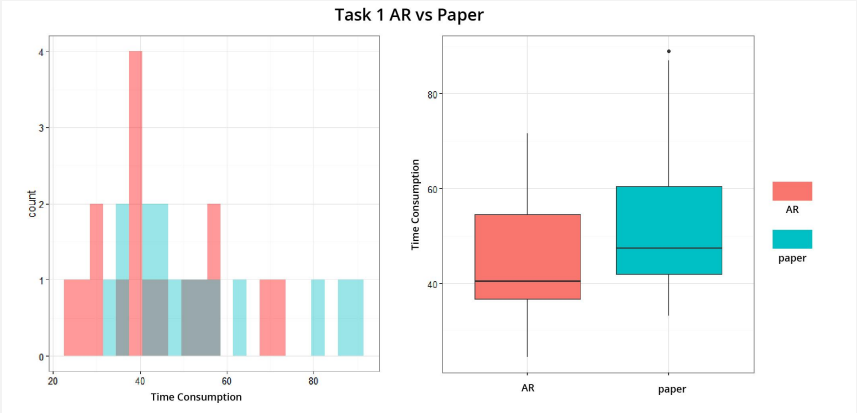
# **Data Analysis**
## Formatting Data

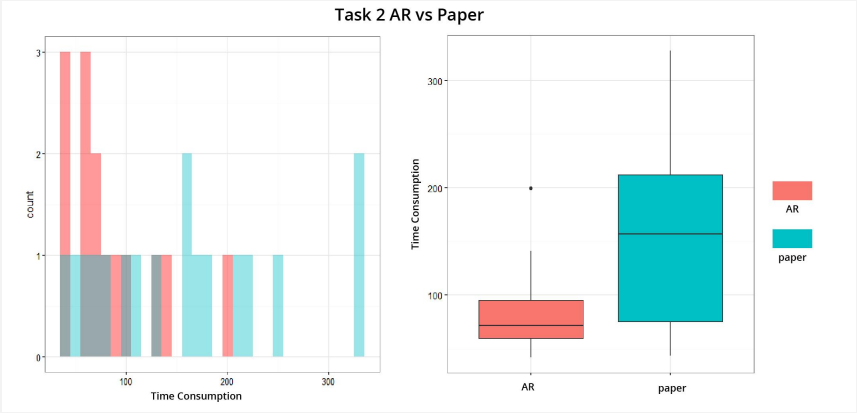
Formatting:

- Plot Task 1, Task 2 histogram and boxplot
- 2 statistical outliers removed in total
- Not normally distributed

Method:

- In each task, use *Kruskal–Wallis T-Test*
- To find out media influence,  use *Two-Way ANOVA* (IV: **Task** 1/2, **media** AR/paper and their **interaction**)
- To find out human factor influence, use *Two-Way ANOVA*



# Data Analysis
## Hypothesis 1: AR vs. Paper in Each Task and Task Difficulty Influence

In General:

- AR is better than paper instructions
- For difficult task (#2), AR performance is better
- **AR variance is more robust** and consistent than paper

The Details:

- Task 1:
  AR mean = 44.48, sd = 13.66
  Paper mean = 54.19467, sd = 18.34, ***p-value = 0.12*** *(0.09)*

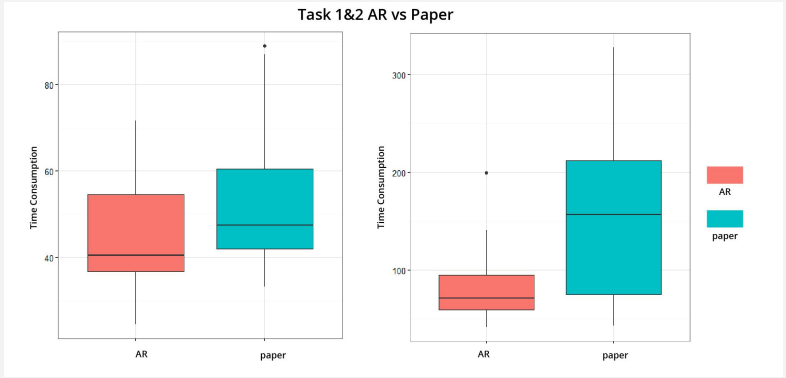
- Task 2:
  AR mean = 84.90, sd = 44.32
  Paper mean = 155.96, sd = 89.39, ***p-value = 0.015*** *(0.011)*

- General: media (paper/AR) effect ***p-value = 0.001***

```
        Kruskal-Wallis rank sum test

data:  time.task1 by media.task1
Kruskal-Wallis chi-squared = 2.339, df = 1, p-value = 0.1262
```

```
        Kruskal-Wallis rank sum test

data:  time.task2 by media.task2
Kruskal-Wallis chi-squared = 5.8629, df = 1, p-value = 0.01546
```

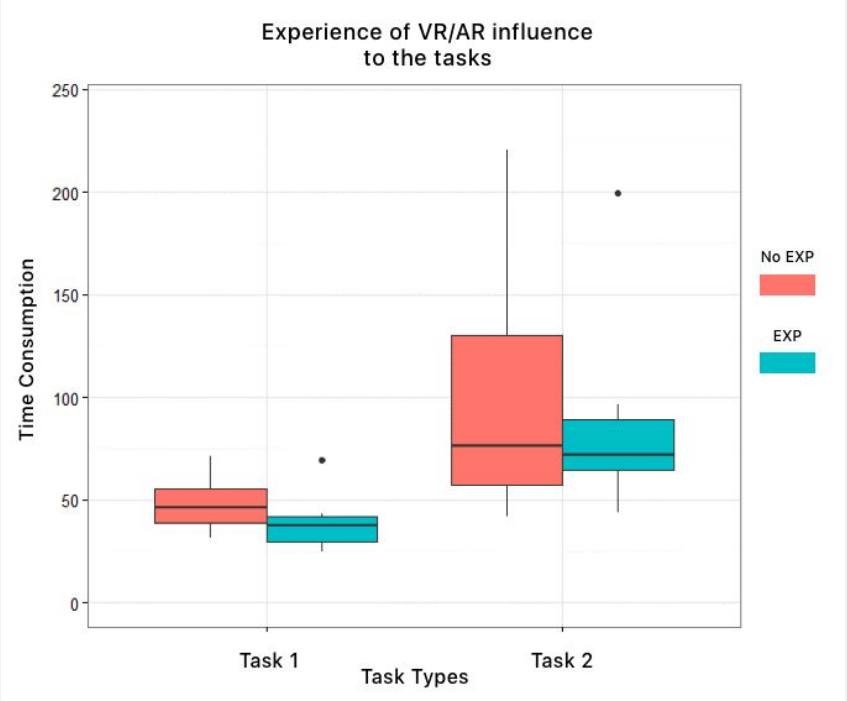
```
Analysis of Variance Table

Response: time
           Df Sum Sq Mean Sq F value   Pr(>F)
media       1  32605   32605 11.9427 0.001023 **
task        1  80324   80324 29.4210 1.14e-06 ***
media:task  1  14704   14704  5.3857 0.023778 *
Residuals  59 161079    2730
---
```



# Data Analysis
## Hypothesis 2: Human Factors Findings (Experience with AR/VR)

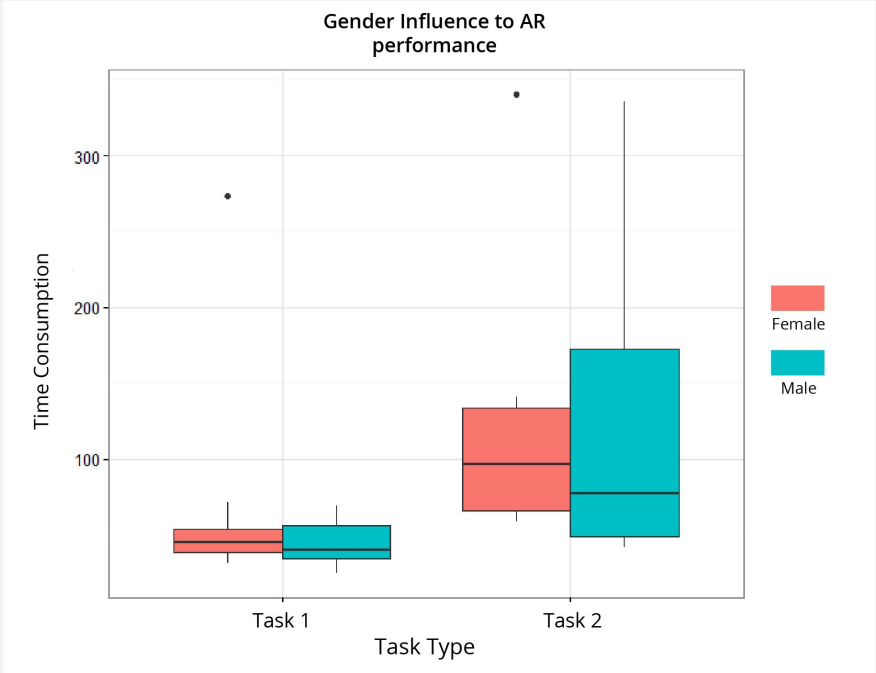
- Experience with VR/AR **does not have a significant influence** on the time consumption in each task ***(p-value = 0.59)***

- Although, people who have used VR/AR (Oculus, Hololens,etc.) performed better than people who haven't had experience, the difference is still not significant



# **Data Analysis**
## Hypothesis 2: Human Factors Findings (Gender)

- There is no difference between male/female in time consumption for either task ***(p-value = 0.54)***
- We noticed that females tended to followed the instructions step by step, while some males tried to skip steps



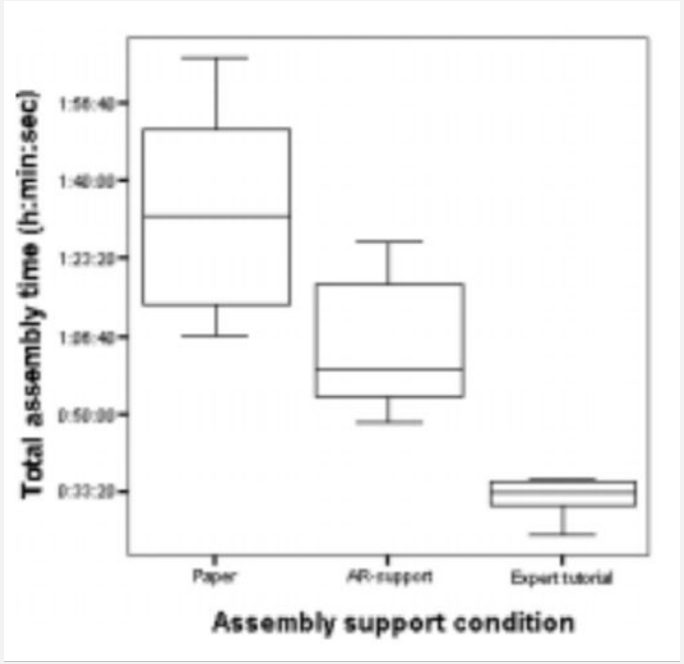
# **Discussion**
## Contribution and What's Interesting

- We found that AR App instructions can help us be more efficient in completing more complex tasks
    - AR shows the transition between steps and enables users to view a puzzle from different perspectives, this **helps with spatial comprehension**

- Modality of AR  (video see-through mobile technology) is more affordable and accessible in contrast with immersive optical see through technology

- We looked at **human factors influence**: background, gender

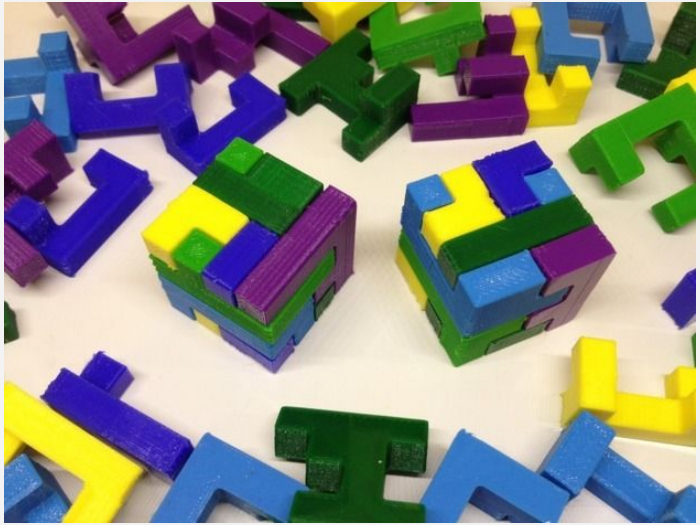
- Confirmation of similar experimental research around AR efficiency (Wiedenmaier's paper 2001)




Wiedenmaier, S., Oehme, O., Schmidt, L., & Luczak, H. (2003). Augmented reality (AR) for assembly processes design and experimental evaluation. *International journal of Human-Computer interaction*, *16*(3), 497-514.

# **Discussion**
## What We Learned

- Beware of researcher bias: think of unplanned situations to prevent bias
- Pilot research is very important: decided to use phone stand, placing pieces in a particular order
- Stick to the scope of the experiment



# **Discussion**
## Impact - Who Can Use This Work

- Anyone that is looking for efficiency in communicating complex tasks should consider adapting this technology

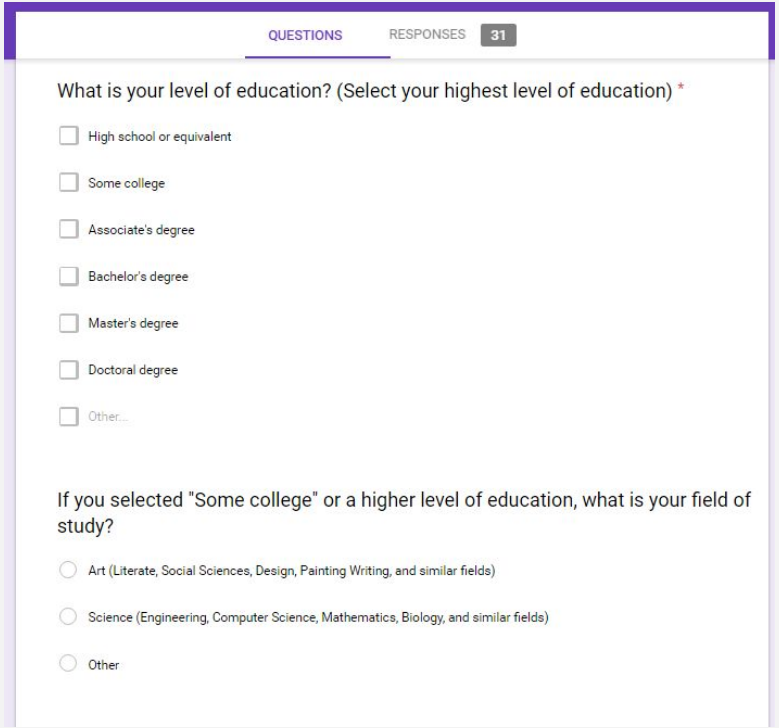
  *Example: manufacturers (IKEA), business,  medical, technology, developers*

- Experience improvement: Reduce frustration in dealing with complex tasks, improve user experience

- Enable Prosthetic Arm: this experiment provides empirical data to support the adoption of AR App instruction

# **Discussion**
## Limitations

- Increase our sample and widen to include more diverse population - wider age range and background
- Due to time constraints chose not to introduce a third medium - i.e. video
- Experimental design: decision to put phone on a stand limits the technology, decision to place puzzle pieces in order but not call it out
- Although this technology is more affordable is still depends on the use of a visual target and does not yet recognize other generic physical objects (i.e. hands)



# **Discussion**
## Significance

- We thought experience with VR/AR would result in better performance but we found this wasn't significant
- We thought participants' background would have an effect but our sample turned out to be engineering/science heavy therefore we were not able to find a significant effect

# Q&A