Do academic background and travel styles influence a person's map aligning ability: An eye tracking approach

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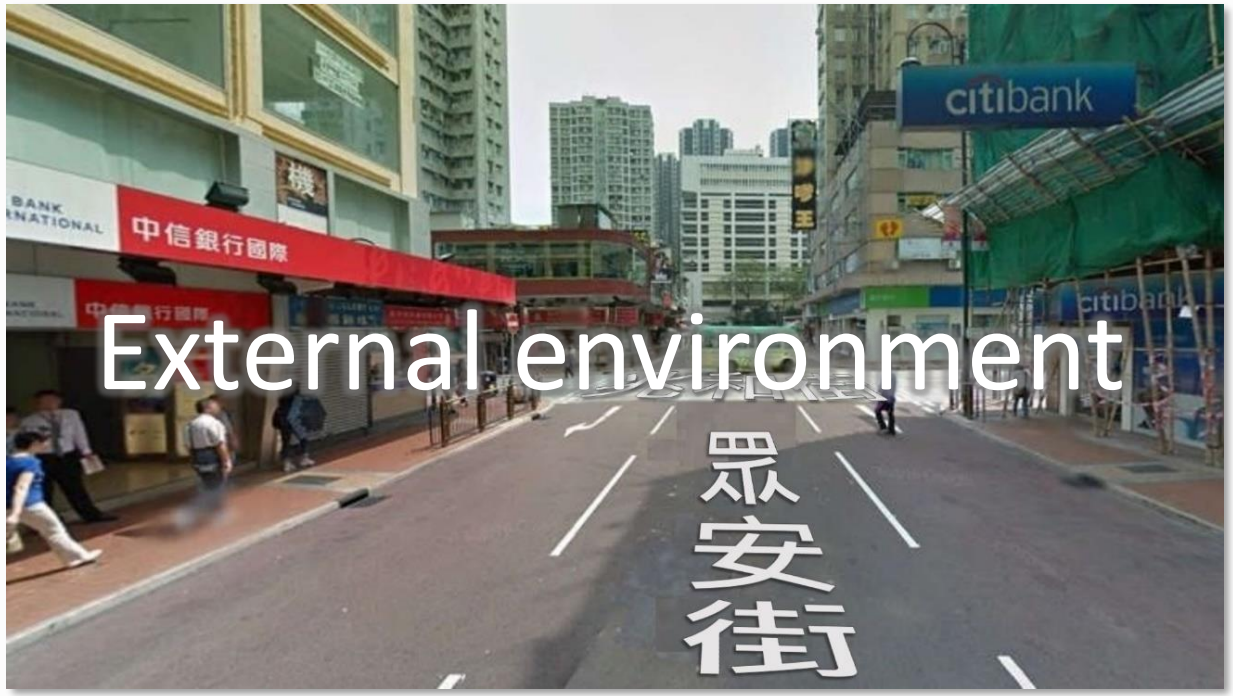
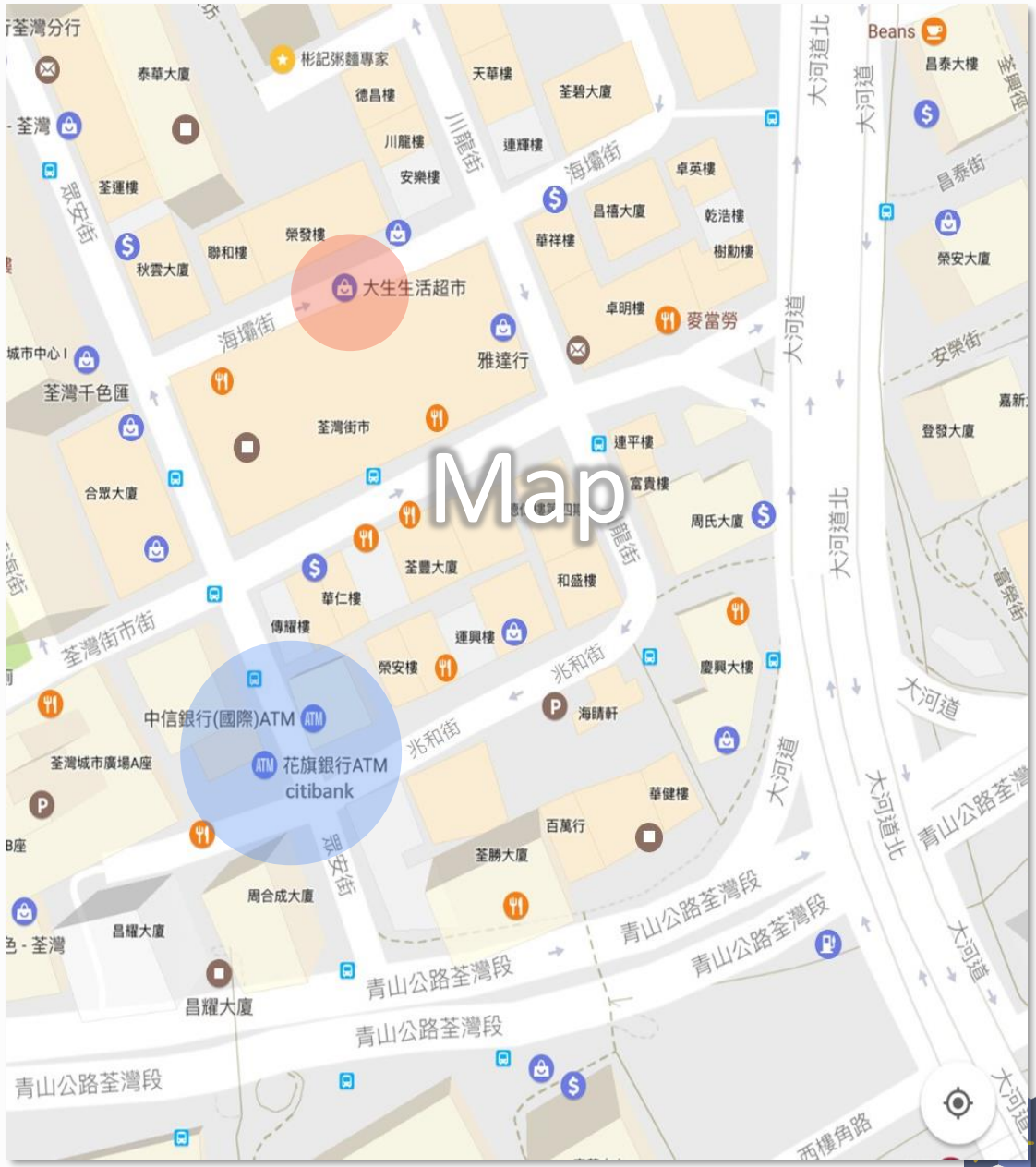
Imagine a scenario…



1. Find our location and destination
2. Which direction am I facing?

- → Integrate the two coordinate systems



Alignment Effect

- Alignment effect
  - People maintain the perspective adopted during first learning (Levine et al 1982)
  - Alignment effects are **the extra time and effort** required to **rotate** the mental representation of physical maps. (Shephard & Hurvitz 1984; Finke 1990; Lloyd 1989 1997; Golledge 1999; Shephard & Metzler 1971)

- Map alignment
  - Aligned map
  - Misaligned map
  - Counter-aligned map

Factors in alignment effect

- Spatial configuration (Presson et al 1989; Thorndyke-Roth 1982; Féry and Magnac 2000)
- Cognitive styles (Nori & Giusberti 2002)
  - visual/ route/ survey representations (Siegel and White 1975; Pazzaglia et al 2000)
- Mental rotation

Factors in alignment effect

- Mental rotation (Nori & Giusberti 2002)
  - People with higher **mental rotation ability** are more likely to get free from alignment effect (Pazzaglia & De Beni 2004)
  - Mental rotation also affects a person's cognitive styles (Pazzaglia & De Beni 2001)

- What shapes a person's mental rotation ability?
- Is mental rotation a **NATURE** or **NURTURE** thing?

Nature vs. nurture

- Nature
  - Biological factors such as hormonal factors or hemispheric specialization and brain organization
  - Evolutionary theories (Buss 1999; Geary 1998)
- Nurture: spatial experiences

Spatial tasks
(eg. Cherney & Neff 2004)

Spatial activities
(Ginn and Pickens 2005)

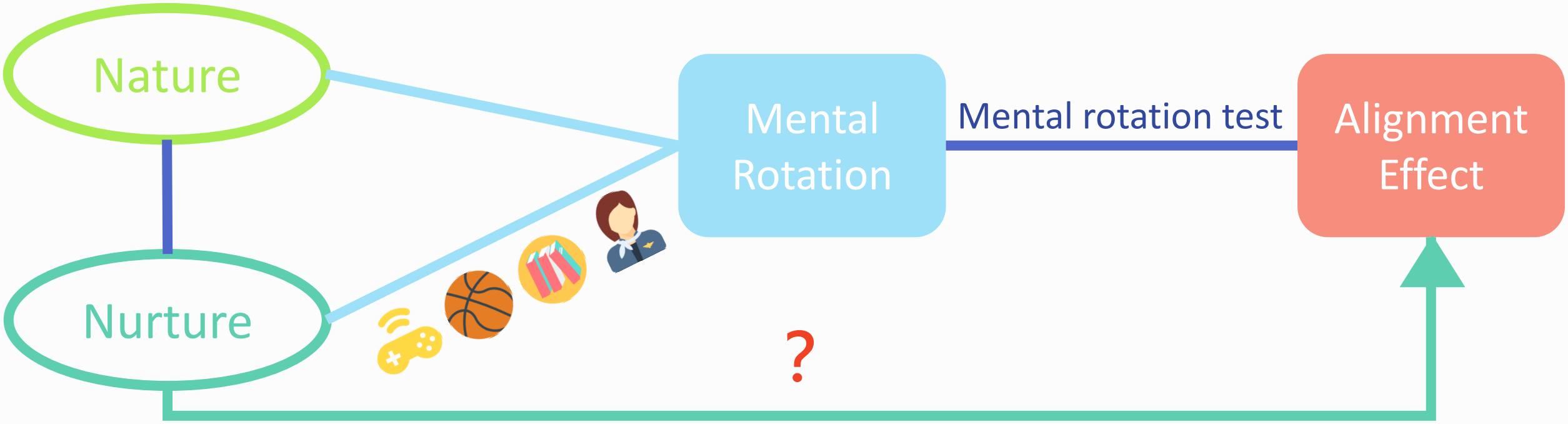
Educational experience
(Burnett & Lane 1980;
Casey, Colon & Goris 1992;
Quaiser-Pohl & Lehmann 2002)

Social gender role
(eg. Eagly & Wood 2002;
Lippa et al. 2010)

- The interaction of nature and nurture (Casey 1996; Casey et al. 1992; Casey, Nutall & Pezaris 1999; Quaiser-Pohl, Geiser & Lehmann 2006)

Nature vs. nurture

- Biology and experience are intertwined in a manner that is difficult to separate (Halpern and Tan 2001).



The influence of nurture / experiences

Academic background

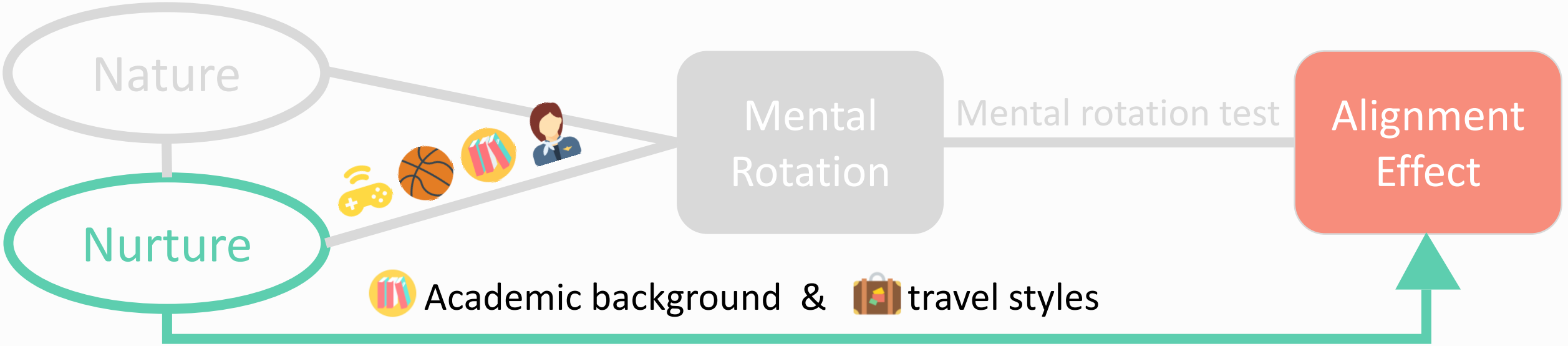
(Burnett & Lane 1980; Casey, Colon & Goris 1992; Quaiser-Pohl & Lehmann 2002)

- Previous studies have proofed its relationship with mental rotation

Travel styles

- **Practice** with misaligned maps improves performance with them (MacEachren 1992).
- **Spatial knowledge** are indeed varied with previous experience with **transport modes** (Mondschein et al. 2010).
  - Cognitive travel styles (active / passive / mixed)

THE RESEARCH PURPOSES

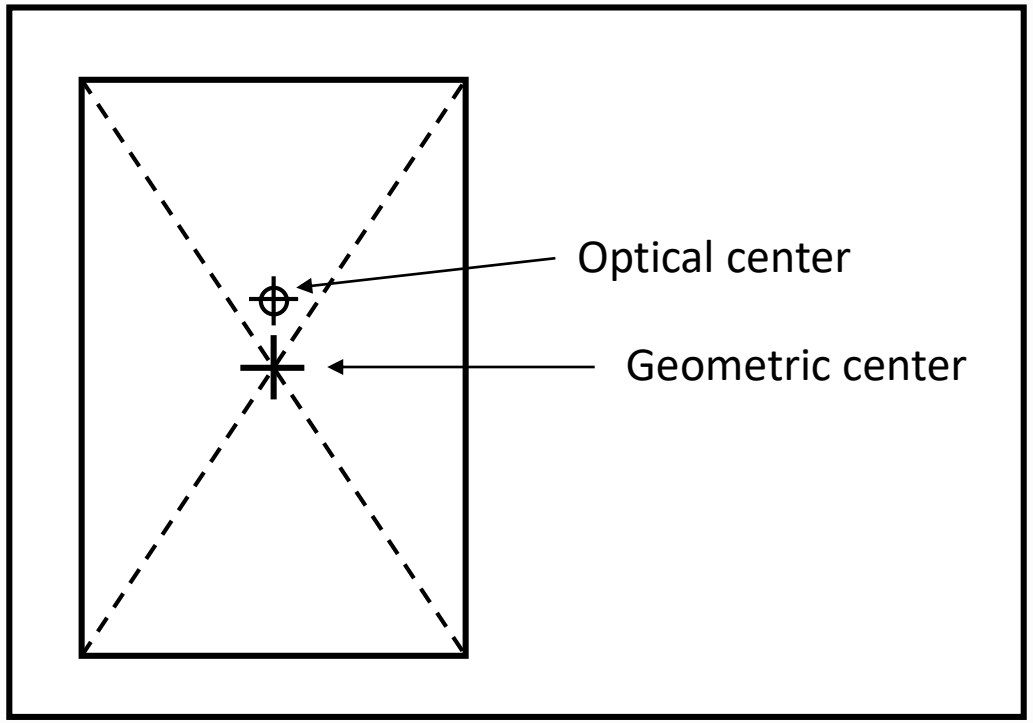


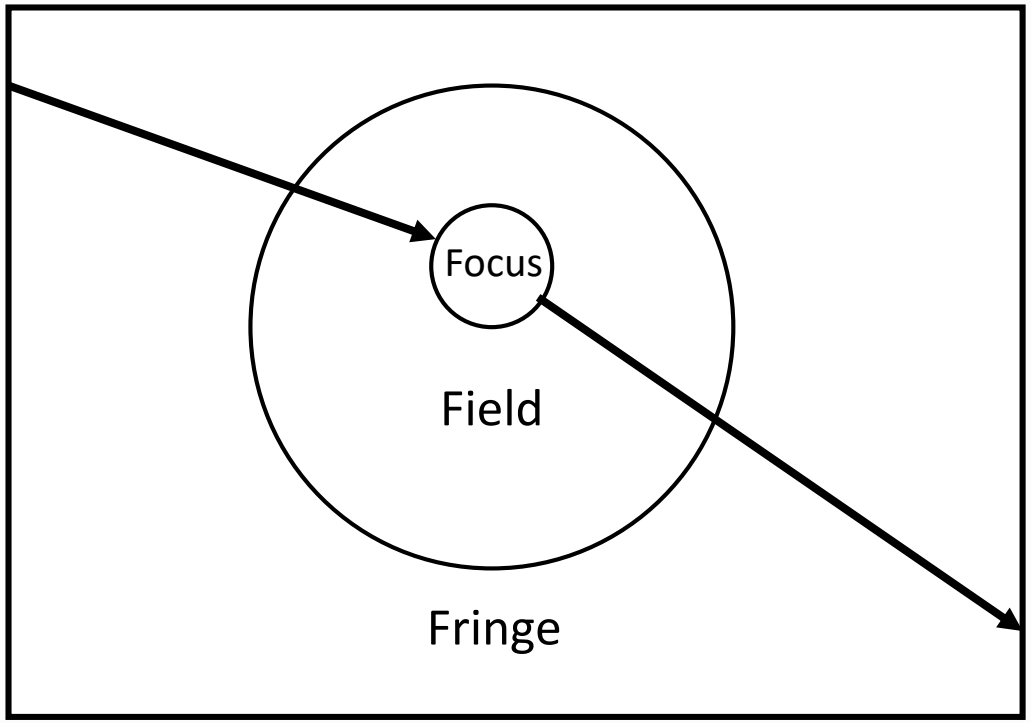
- Are students from **math and science background** more free from map alignment effect?
- Do **travel experience** influence the performance on map aligning?
- What's the difference between people who had higher and lower score on map aligning?

METHOD – Cartographic design theory

Dent, B. D. 1999. Cartography – *Thematic Map Design*. Fifth Edition. WCB McGraw – Hill.

- The two centers of an image space
- The eye movement through an image





METHOD – Eye tracking

- The process of **measuring and recording gaze positions and eye movements**
- Most of the eye trackers are mounted to a monitor and record a stream of pixel coordinates that the user has looked at.
- Applications
  - Psychological science
  - Visualization and human-computer interaction sciences

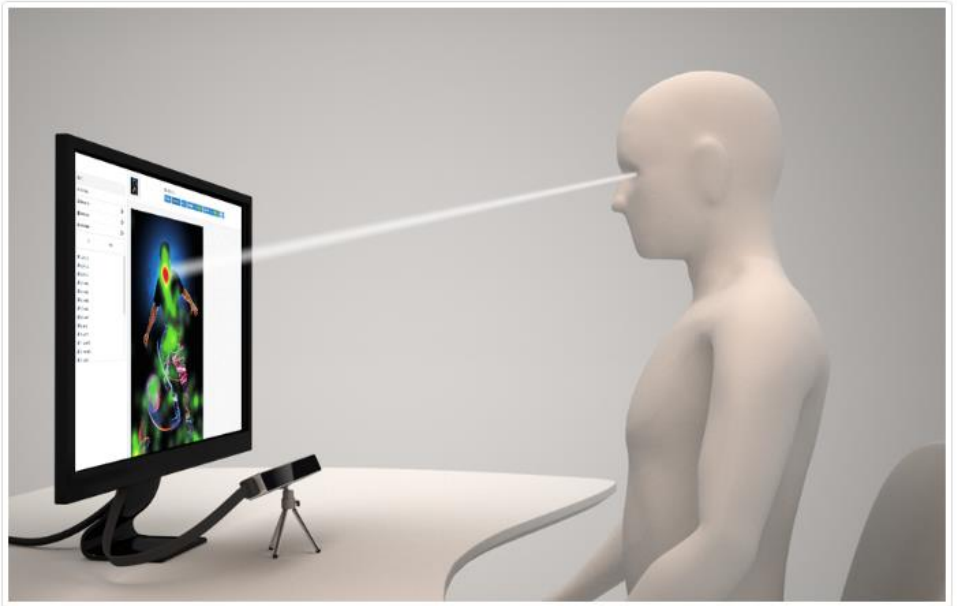
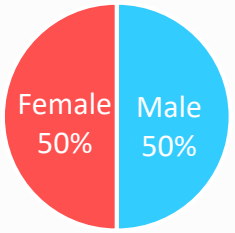


Figure and snapshot from: https://s3.eu-central-1.amazonaws.com/theeyetribe.com/theeyetribe.com/dev/general/index.html

Eye tracking helps understand **how** people see or read things, and provide insights into users' ways of reasoning and problem solving.

EXPERIMENT

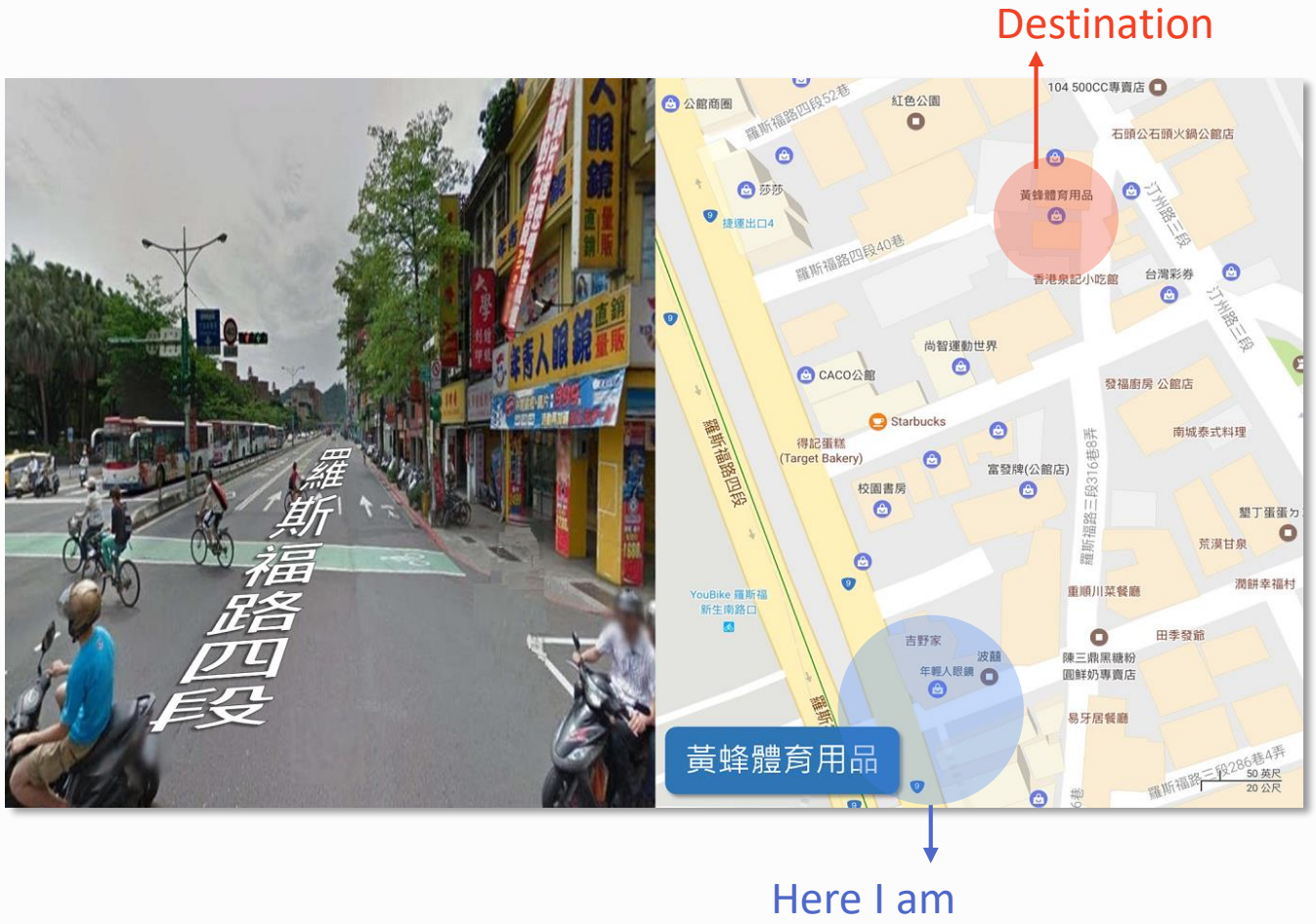
- Apparatus: **The Eye Tribe** (eye tracker)
- Software: **Ogama** for experiment designing, recording and analyzing
- Time: Feb. 21 – Mar. 3, 2017 (about 2 weeks)
- Participants
  - 12 subjects: 6 males and 6 females
  - Age: 18 – 30
  - Students from National Taiwan University



Figures and snapshots from: http://www.techstrat.in/eyetribetracker.html;
https://s3.eu-central-1.amazonaws.com/theeyetribe.com/theeyetribe.com/dev/start/index.html#setup

EXPERIMENT – tasks design

- 6 map aligning tasks
- In each task:
  - Be informed of their location and destination by words
  - Align the map to the environment (15 secs)
  - Answer “**from their standpoint**, which direction is the destination? ”



* ”Here I am” and destination are **NOT** on the map in the experiment.

RESULTS

PART 1

Do **academic background** and **travel experience** affect alignment performance?

- Math courses
- Travel styles
- Interaction

PART 2

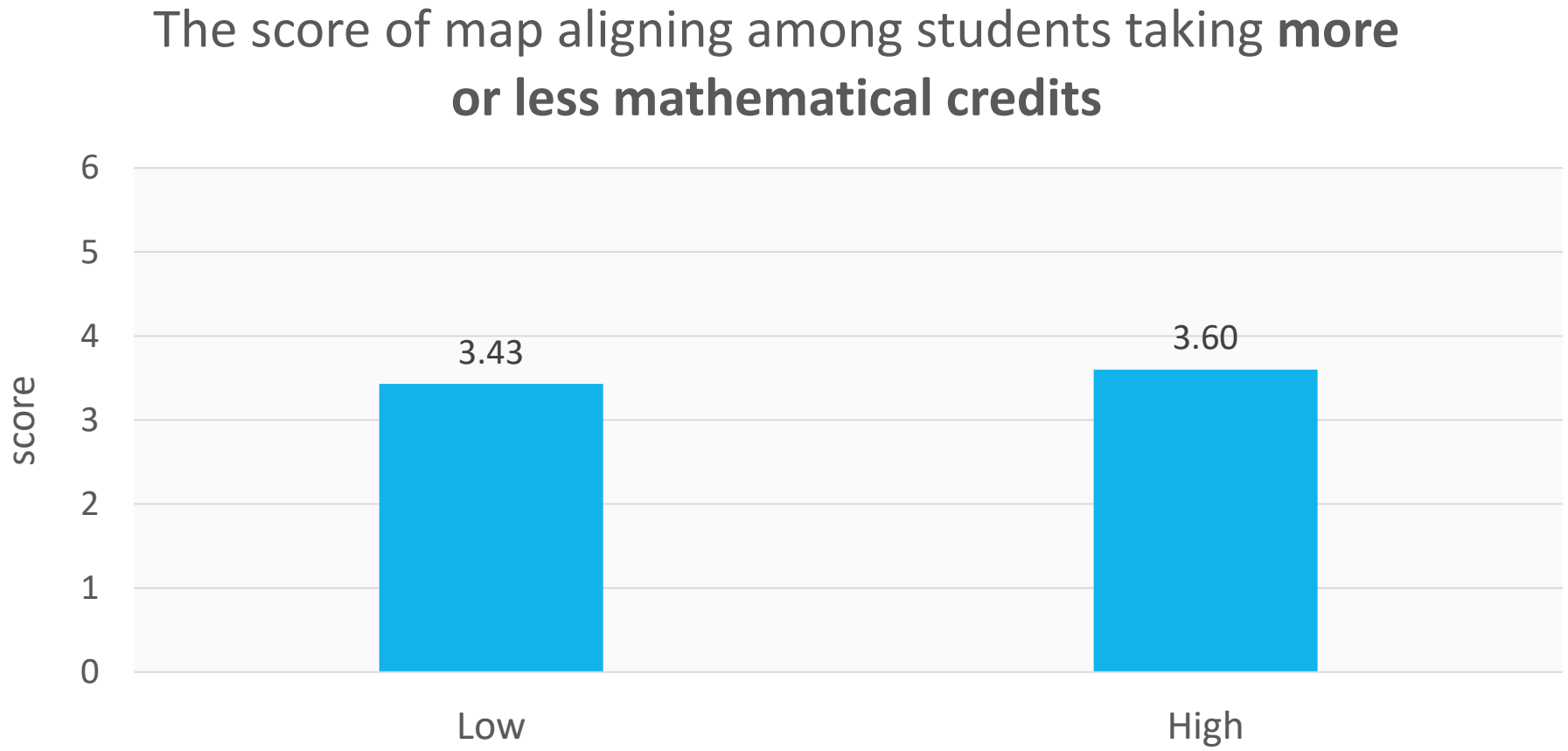
How can people **improve** their map aligning performance?

- Fixations
- AOI transitions
  - Map
  - Street-view

- Through eye tracking, where's **the difference** between the two groups with **high and low score on map aligning?**

RESULTS

PART 1 → Math courses



Math_LOW	
Mean	0.105
Median	0.124
Standard deviation	0.088

< median

Math_HIGH	
Mean	0.259
Median	0.244
Standard deviation	0.064

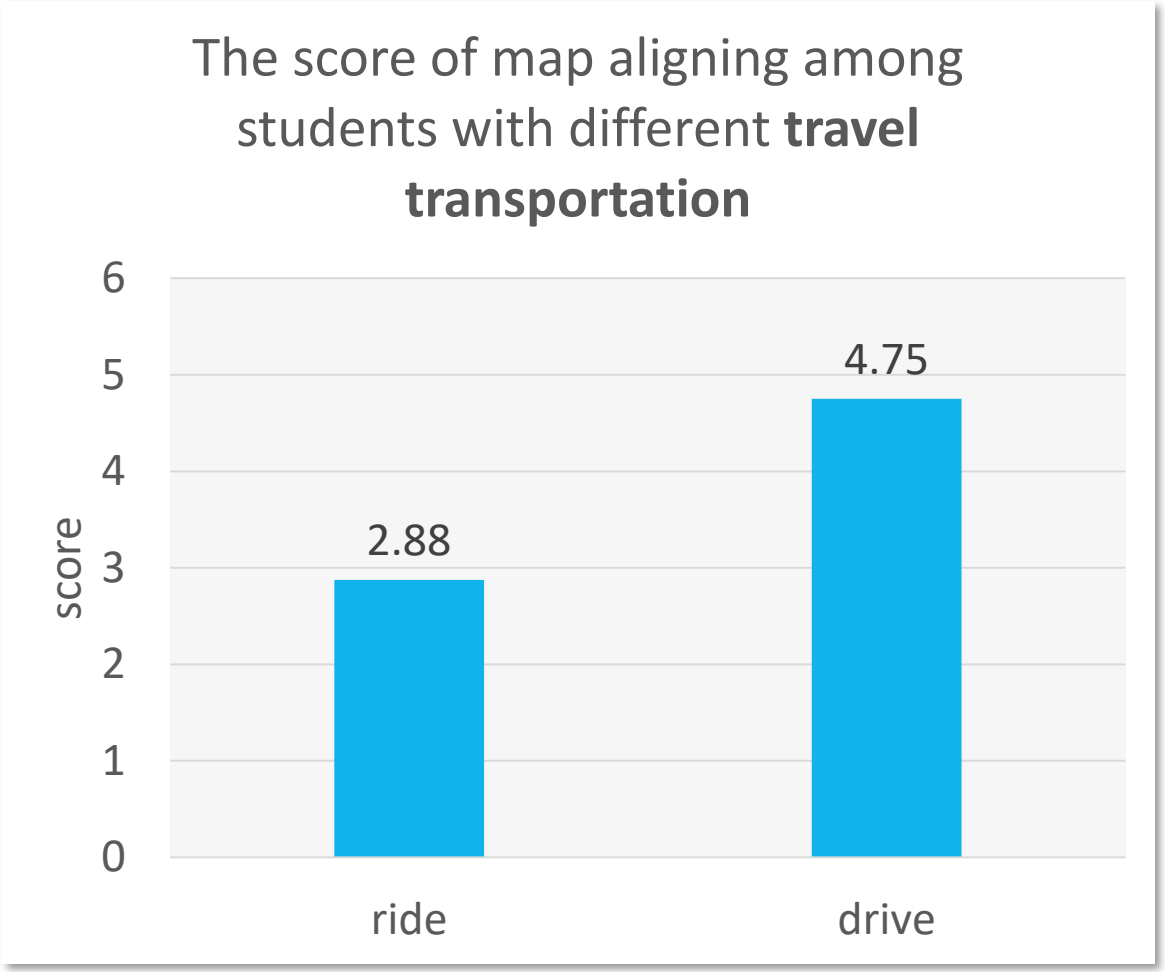
>= median

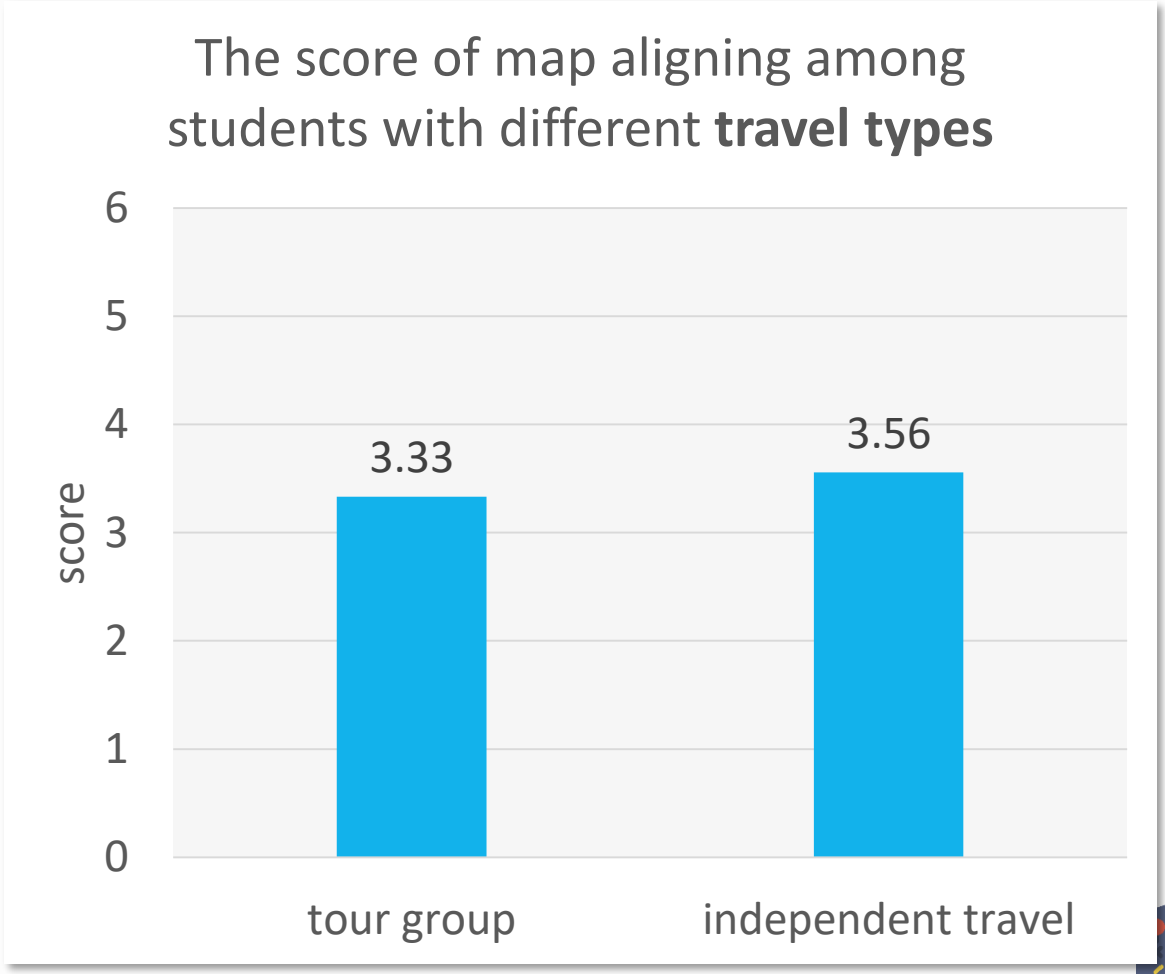
RESULTS

PART 1

Travel styles

- Travel transportation
- Travel types



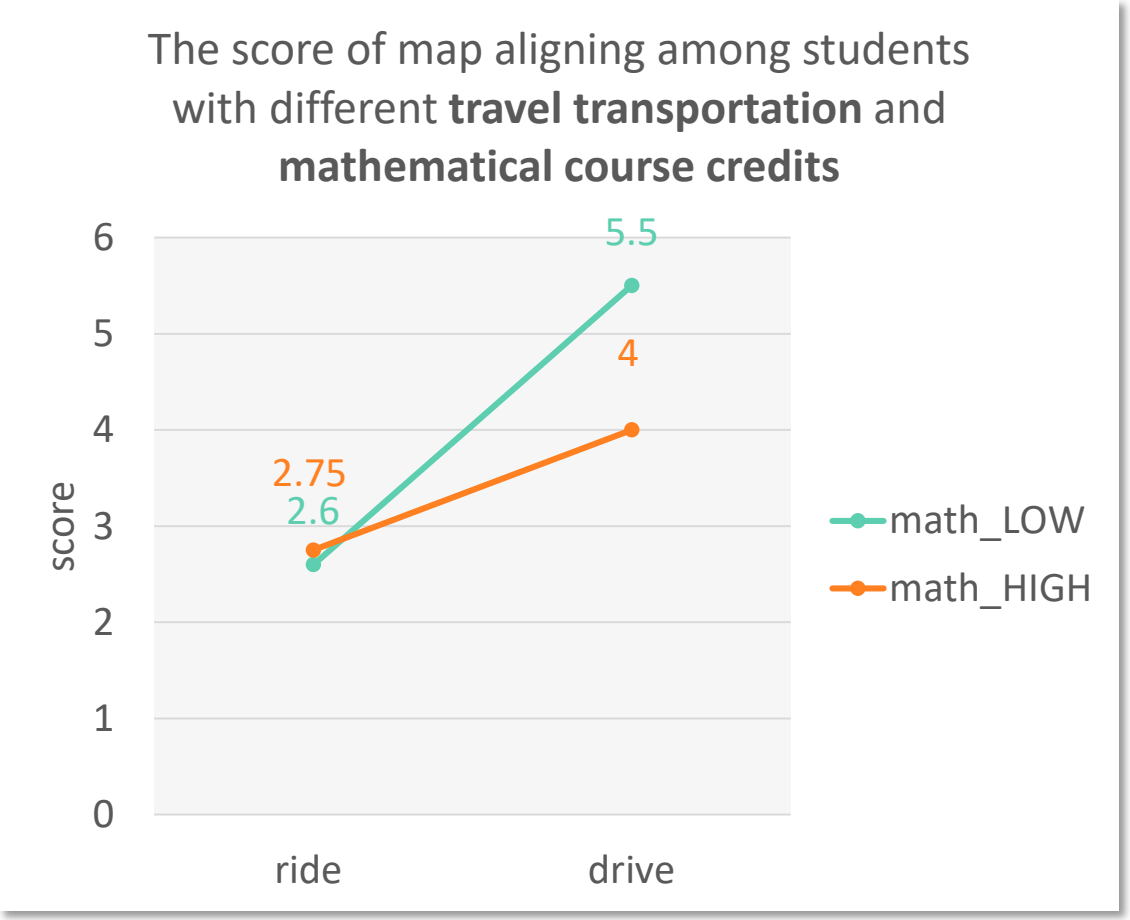


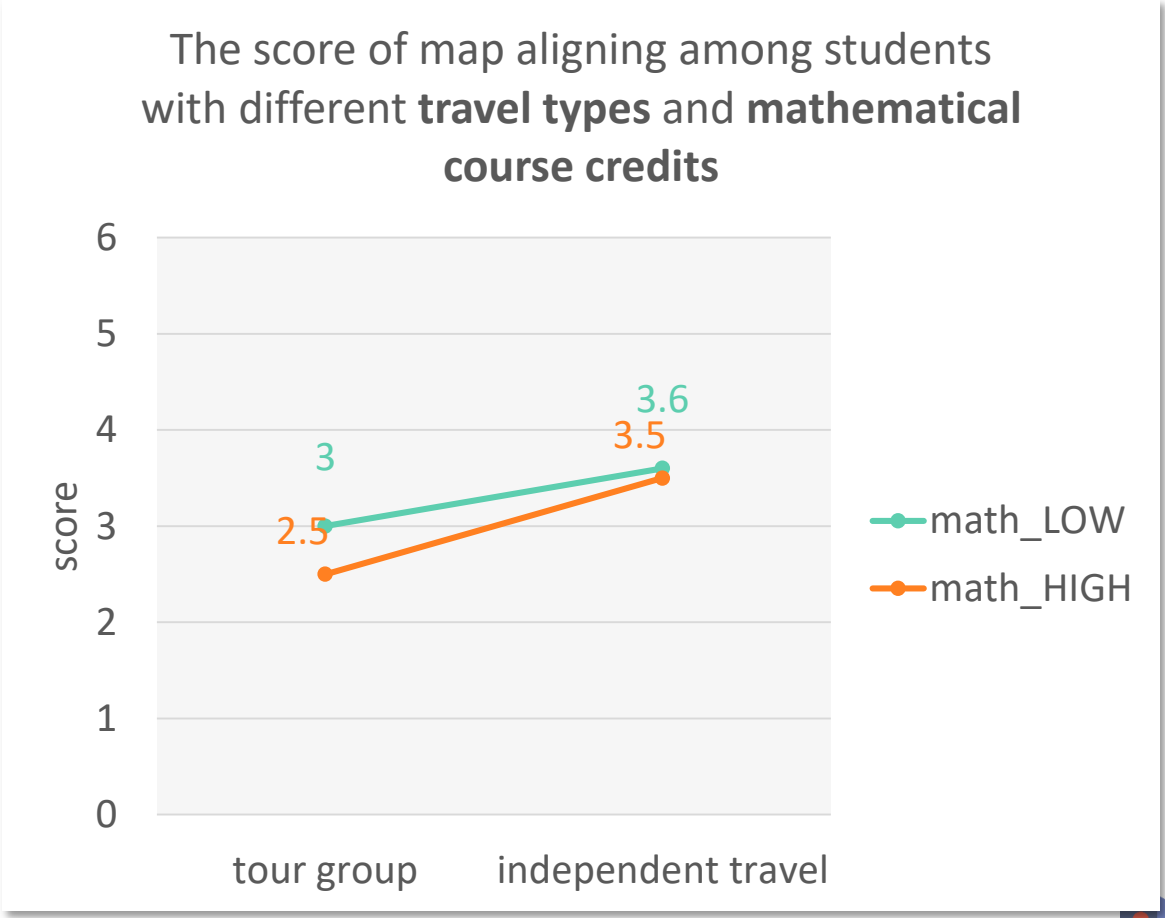
RESULTS

PART 1

Interactions

- Math courses
- travel styles





* ”Here I am” and destination are **NOT** on the map in the experiment.

RESULTS

PART 2

case 1: high score on map aligning

* ”Here I am” and destination are **NOT** on the map in the experiment.

RESULTS

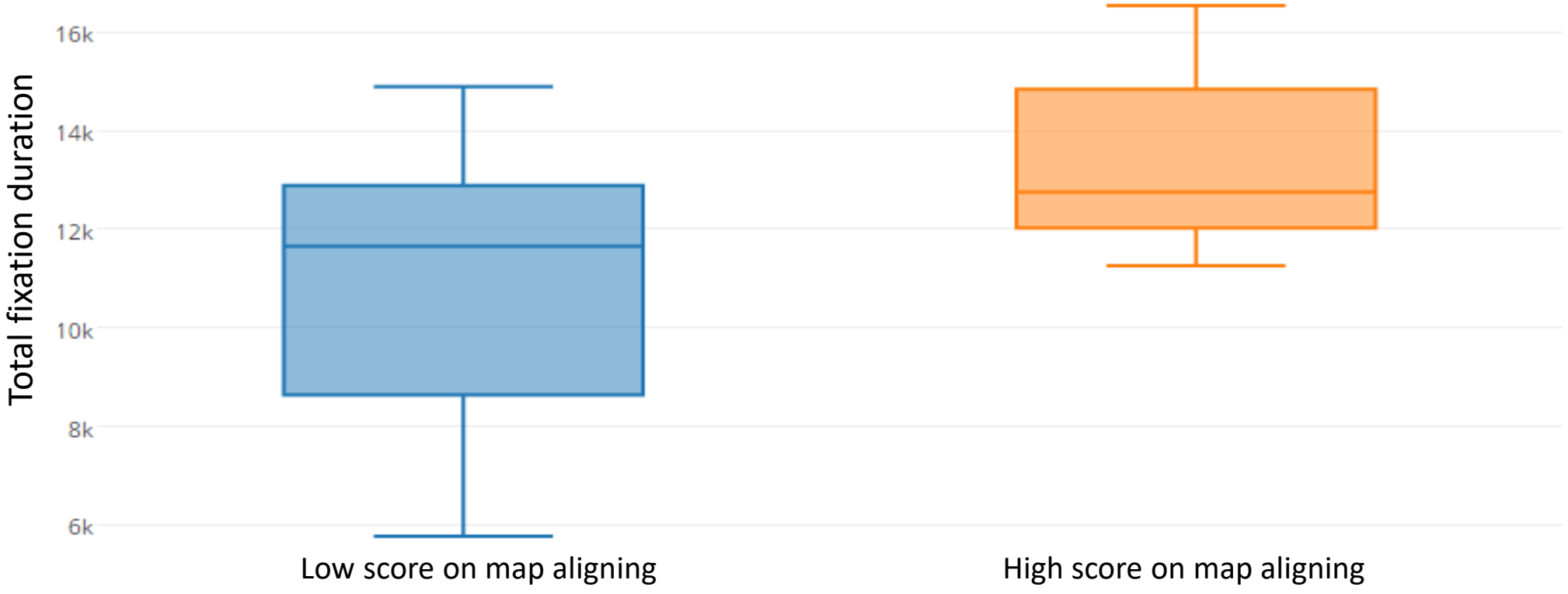
PART 2

case 2: low score on map aligning

RESULTS

PART 2 → Fixations

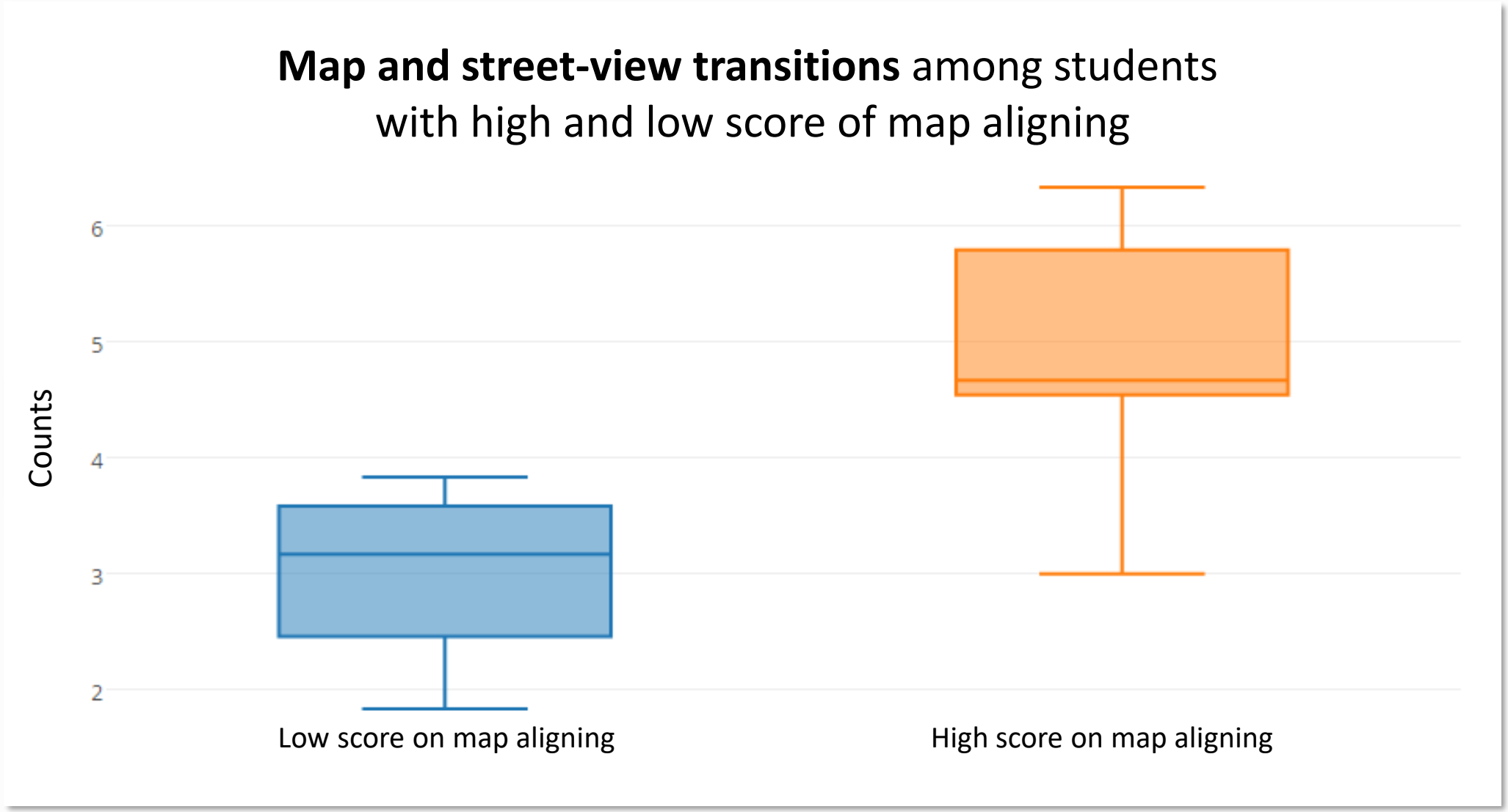
Fixation duration among students with high and low score on map aligning



RESULTS

PART 2 → AOI transitions

- Map
- Street-view



SUMMARY

- Due to the small number of sample size, it would be too sloppy to assert that the percentage of gained **mathematical credits** determines a person's **map aligning performance**.
- However, it seems to have **a tendency** that different **travel styles** could affect a person's map aligning ability.
  - Transportation used
  - Travel types
- Through eye tracking, the **process** and **behavior** of map aligning could be revealed.
  - The engagement in the process
  - The number of times of transitions between map and street-view

FUTURE WORK

- **Collect more samples** to do statistical analysis
- **Define critical AOIs** to **analyze the AOI transitions or sequences** and generalize the reading process or strategies
- **Apply GIS trajectory similarity analysis** to systematically group different patterns of eye movement, and observe strategies of map aligning

- The results from eye trajectory analysis could provide more pragmatic implications and work in **broader fields** such as **spatial cognition, spatial ability or wayfinding**.

Thank you!

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