

# WAY-FINDING IN LARGE SCALE VIRTUAL ENVIRONMENTS

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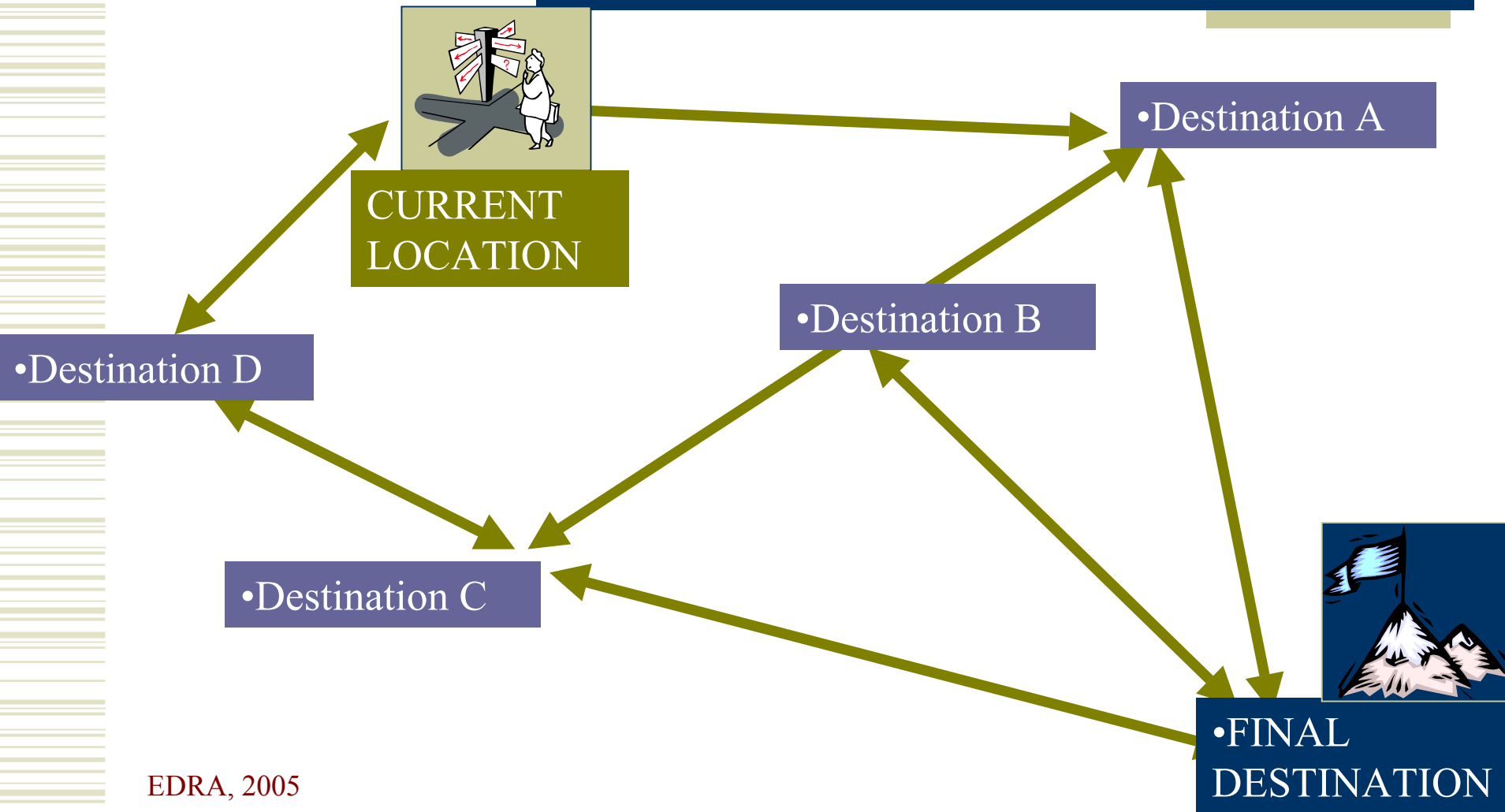
Ohio State University, OH

**36<sup>th</sup> EDRA CONFERENCE - 2005**

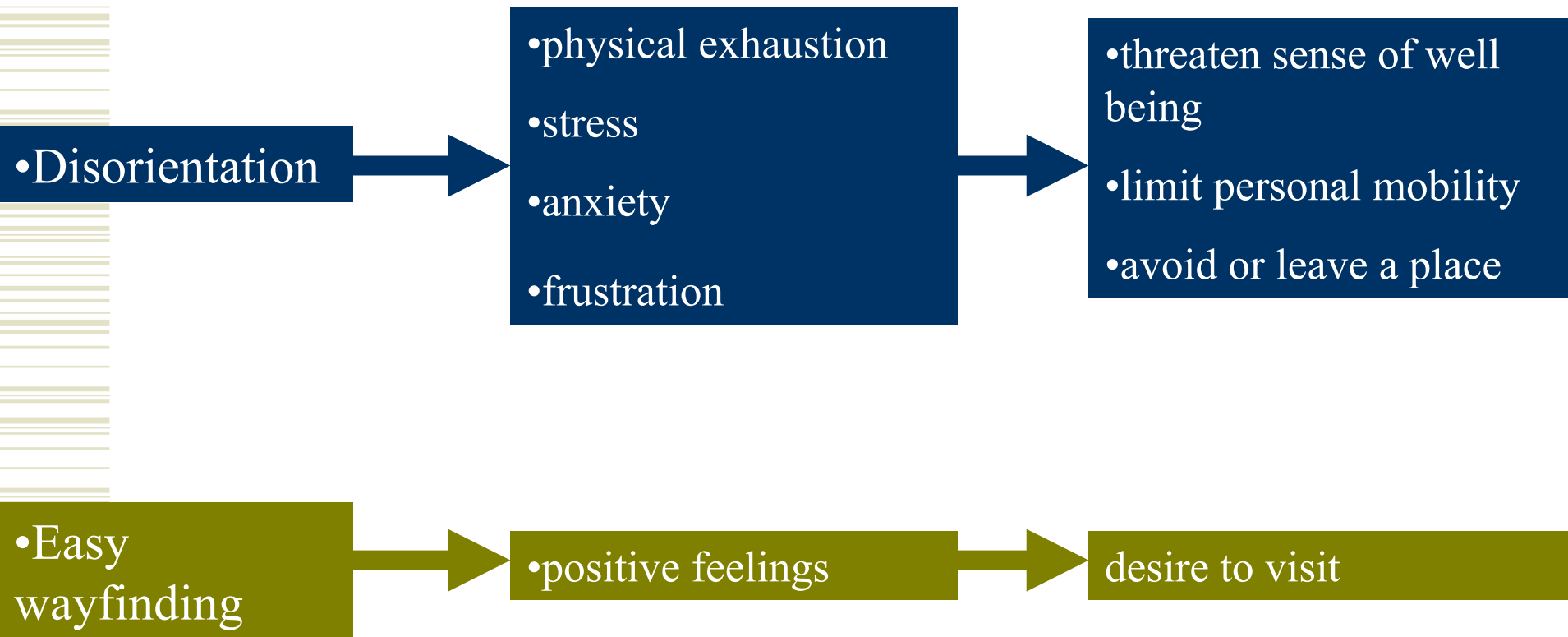
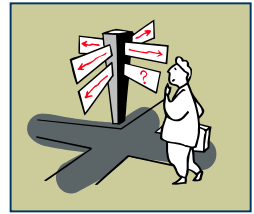
April 27 - May 01, 2005

OLD THEORIES, NEW TECHNIQUES:  
MOVEMENT STUDIES IN  
ENVIRONMENT AND BEHAVIOR

# What is wayfinding?



# Significance of Research



# The Aim

- Develop a comprehensive approach
- Focus more on the physical environmental factors



## Physical Environment

- Plan Layout Complexity
- Physical Differentiation

## Personal Characteristics

- Gender
- Age

## Way-finding Behavior

# The Method

## Software (Virtual Environments)

### Previous Studies

- 3D Construction Kit (Incentive Software, Donmark Ltd)
- RenderWare Software
- Superscape VRT 4.00 etc.

#### Bad:

- Not available
- Not affordable
- Not realistic



### Present Study

- Quake III Arena
- GTK Radiant

#### Good:

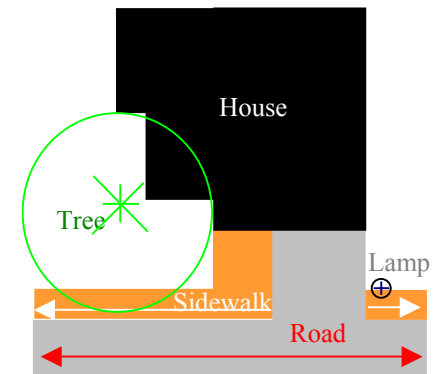
- Available
- Affordable
- High realism



# The Method – Physical environmental characteristics

## 18 Residential Neighborhood:

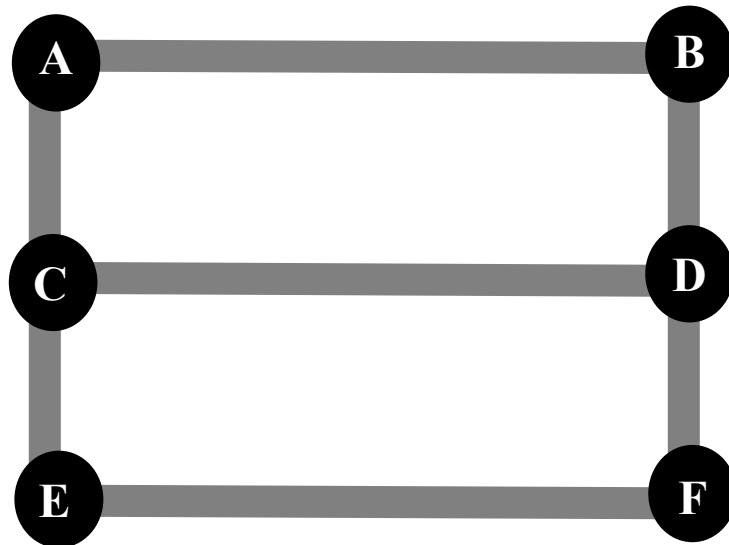
- Same house plan
- Different
  - Plan layout  
(simple X complex)
  - Vertical differentiation  
(absent X object landmark X building landmark)
  - Horizontal differentiation  
(absent X road width variation X road pavement variation)
- Level of Physical Differentiation:
  - Low --- No vertical or horizontal differentiation
  - Moderate --- Either vertical or horizontal differentiation
  - High --- Both vertical or horizontal differentiation



# The Method – Plan Layout

- How to measure complexity?

With ICD (Interconnection density measure (O'Neill, 1991))



$$A=2$$

$$B=2$$

$$C=3$$

$$D=3$$

$$E=2$$

$$F=2$$

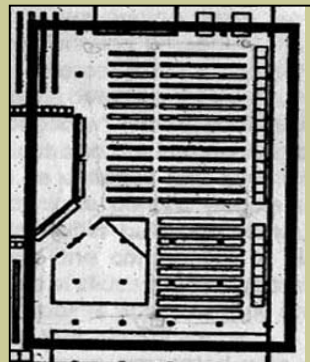
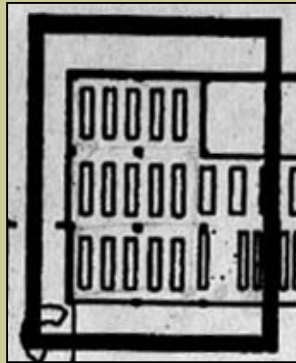
$$+ \underline{\hspace{1cm}}$$

$$14$$

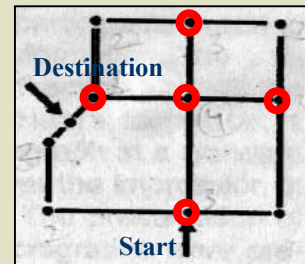
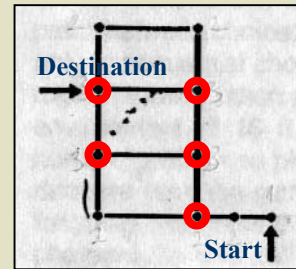
$$14/6 = 2.33 = \text{mean ICD}$$

# The Method – Plan Layout

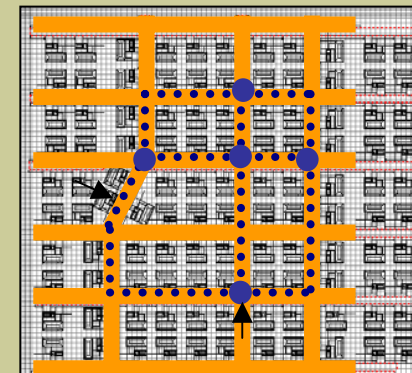
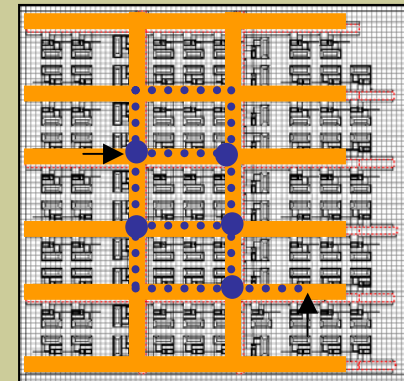
O'Neill's Library



Schematic Drawing



This study's  
Residential Setting



Simple  
ICD = 2.4

Complex  
ICD = 2.54



# The Method – Vertical Differentiation

- How to achieve vertical differentiation?

## Object Landmark

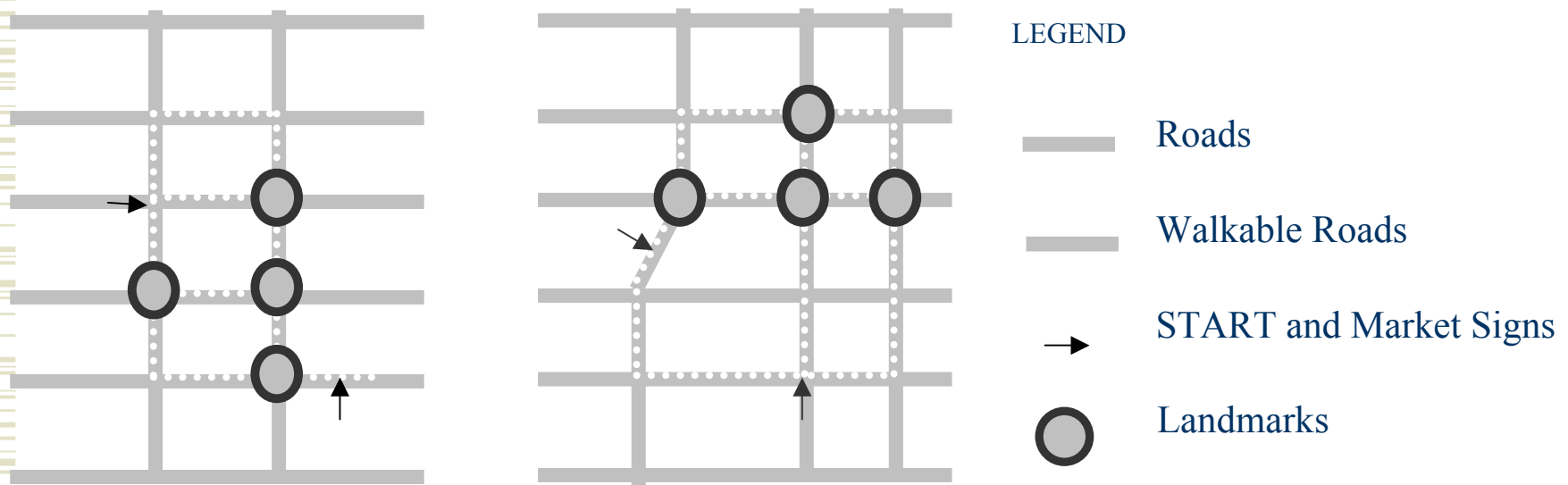


## Building Landmark



# The Method – Vertical Differentiation

- Where to locate landmarks? At decision points



# The Method – Horizontal Differentiation

- How to achieve horizontal differentiation?

## Road Width



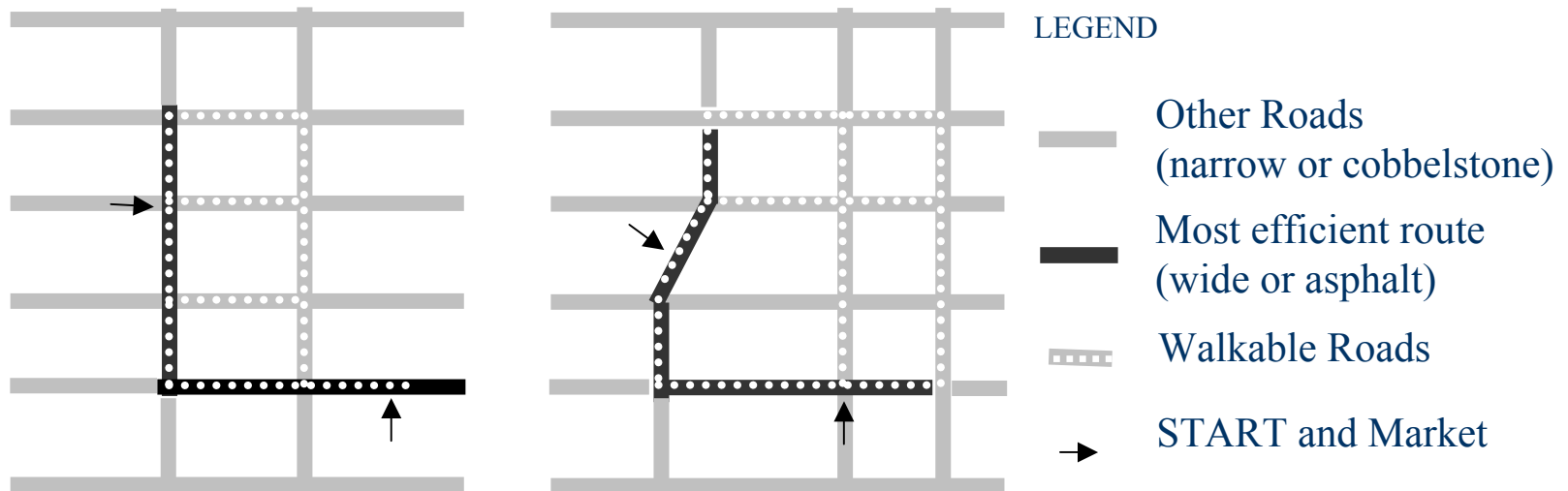
## Road Pavement



# The Method – Horizontal Differentiation

- How to differentiate road variation?

Most efficient route as one type all other roads are other type



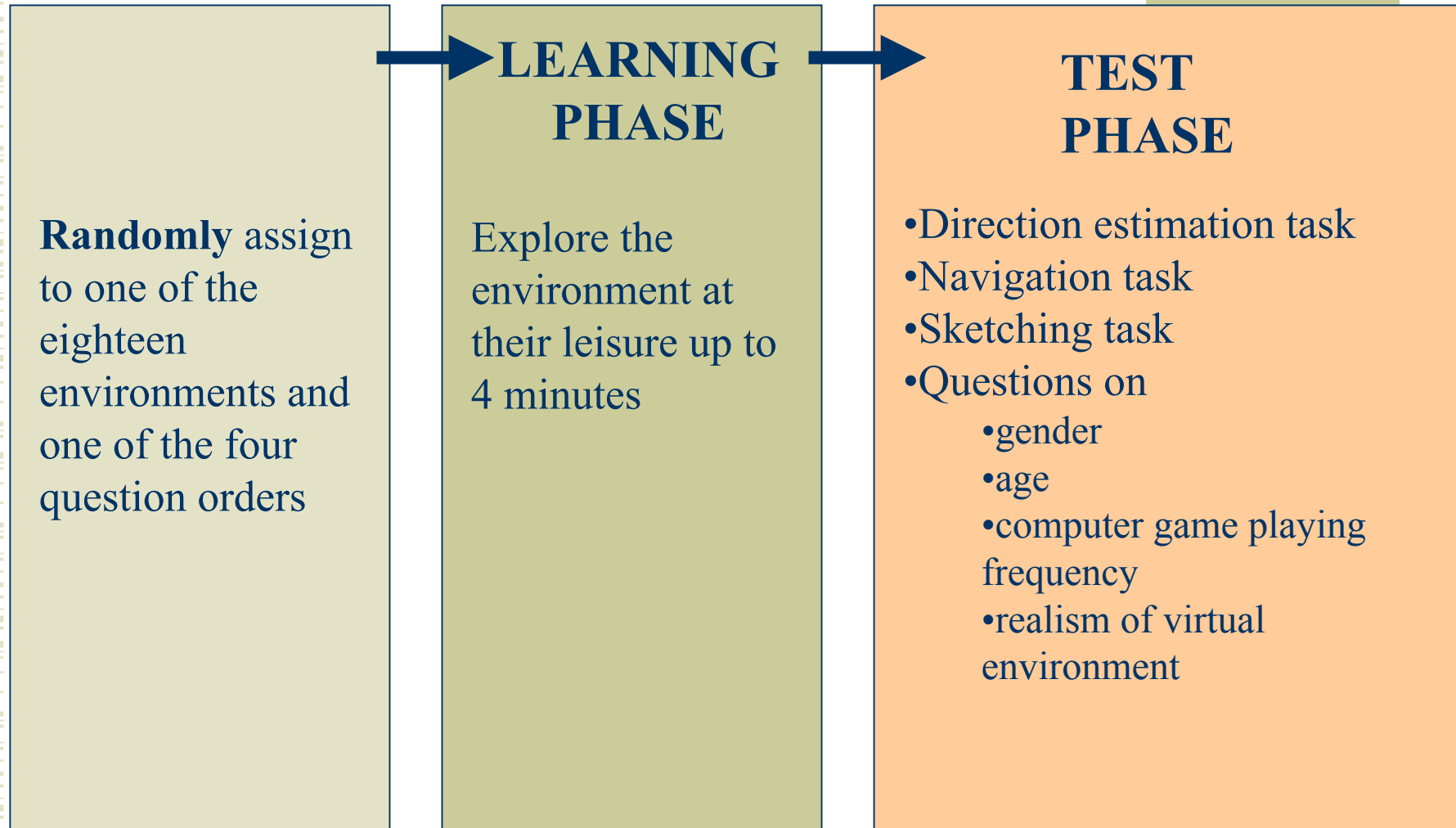
# The Method – Level of Physical Differentiation

<b>Level of Differentiation</b>	<b>With Vertical Differentiation (Landmark)</b>	<b>With Horizontal Differentiation (Road Hierarchy)</b>
Low Differentiation	No	No
Moderate Differentiation	Yes (one of two kinds)	No
	No	Yes (one of two kinds)
High Differentiation	Yes (one of two kinds)	Yes (one of two kinds)

# The Method – Participant & Group Demographics

- 166 volunteers (98 males, 68 females)
- 6 volunteer dropped – did not complete the survey
- 160 people randomly assigned to one of the eighteen environments and one of the four question orders.
  - 85% students & 15% staff
  - 95 male & 65 female
  - Ages ranged 18-48
  - Computer game playing frequency ranged from 1 (not at all) to 7 (all the time) with a mean of 3.64 (between rarely and sometimes)

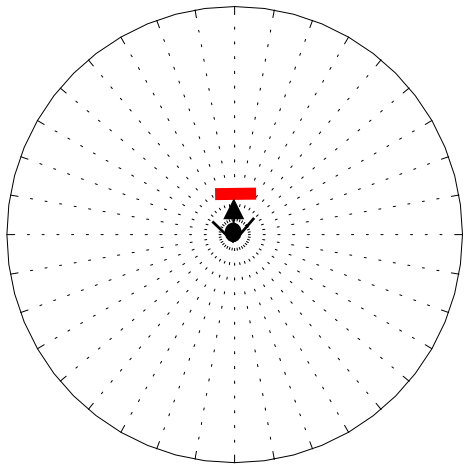
# The Method – Procedure



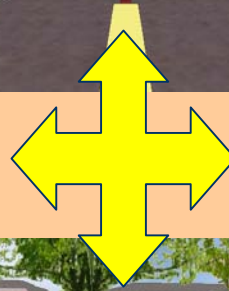


# The Method – Spatial Knowledge Tasks

## Direction Estimation

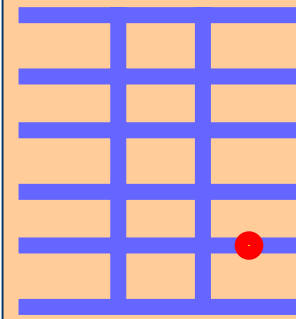


## Navigation

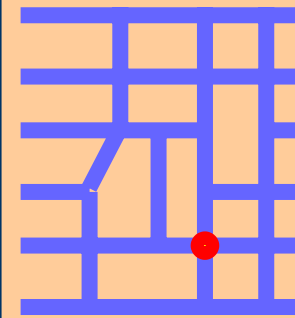
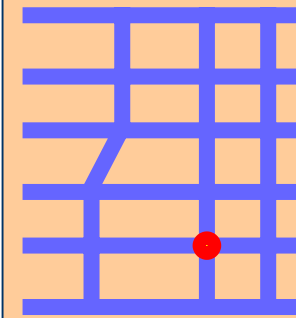
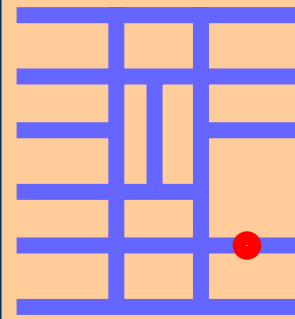


## Sketching

Correct



Distracter





# The Method – Measures

- Learning Phase:
  - Exploration distance
  - Exploration time
  - Exploration speed (distance covered / time)

# The Method – Measures

- Test Phase:

- **Direction Estimation Error**

- estimated angle of direction – true direction

- **Navigation Error**

- speed = 1 - standardized (distance / time)

- extra distance walked = (distance walked – minimum distance) / minimum distance)

- extra turns taken = sum of turns that lead away from MARKET sign.

- **Sketching Error**

- map selection : 0 = correct, 0.5 = distracter, 1 = wrong

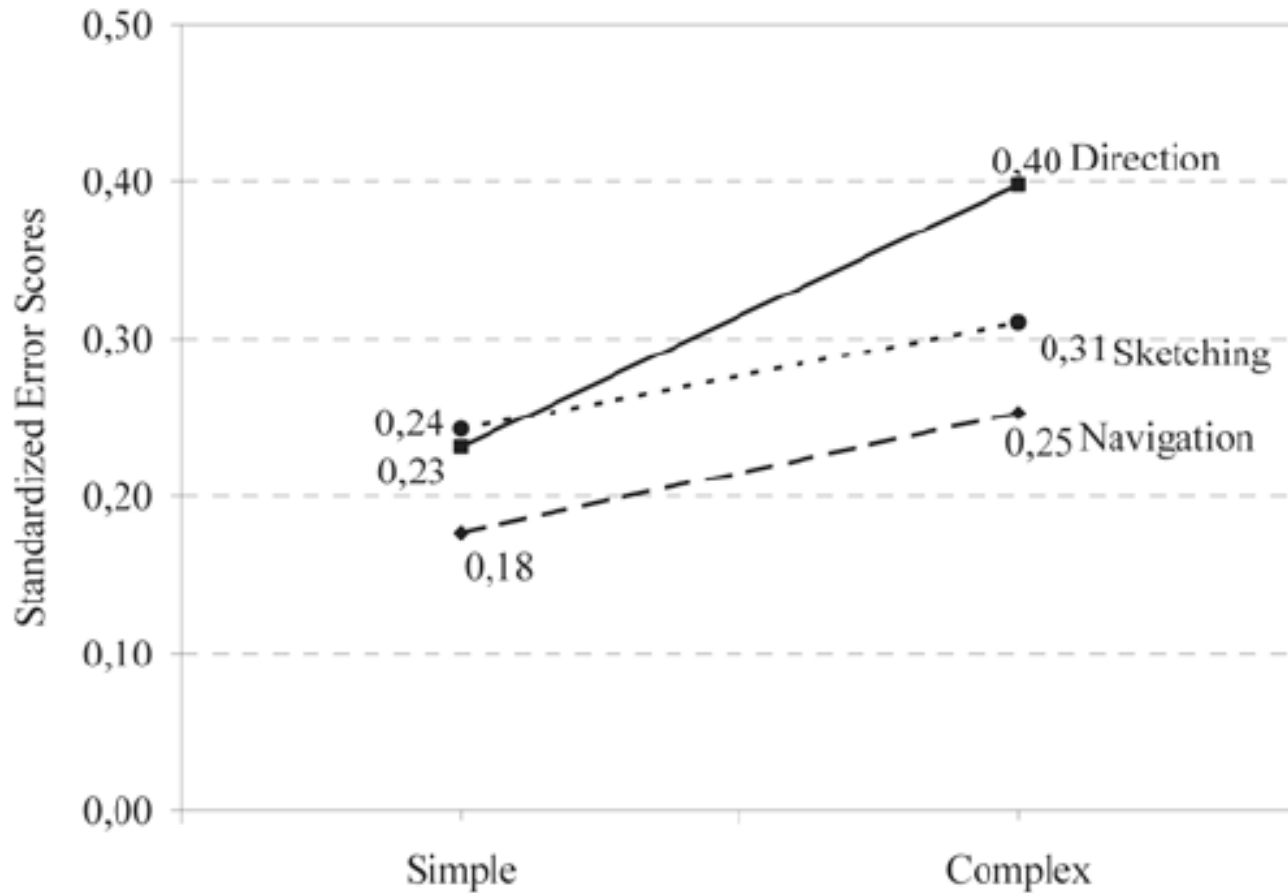
- position of market sign : 0 = correct at an intersection or on road, 1 = wrong

- market sign distance = estimated distance (crow flies) – true distance / true distance

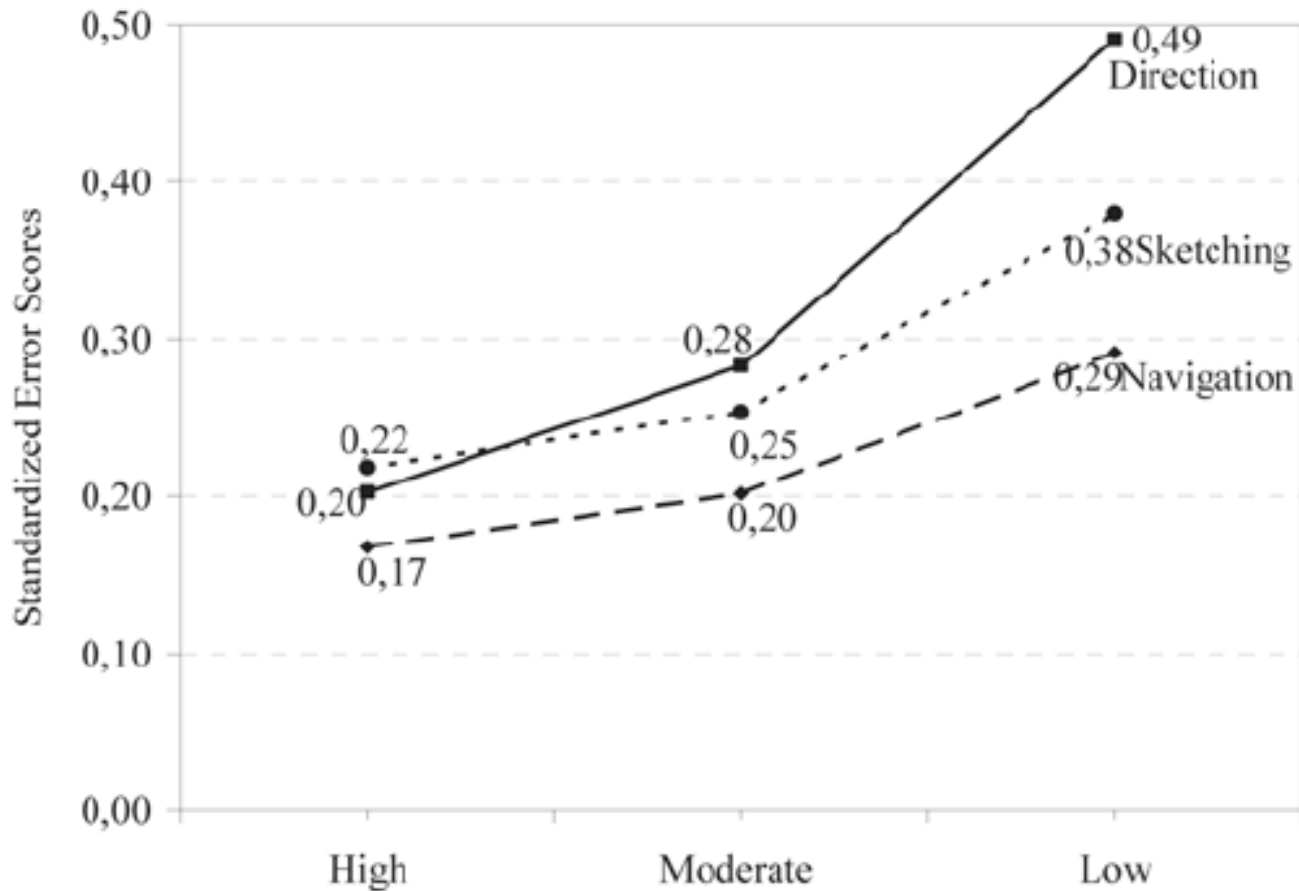
- Route turn = turns made but not drawn + turns drawn but not made

- Route segment = segment walked but not drawn + segments drawn but not walked

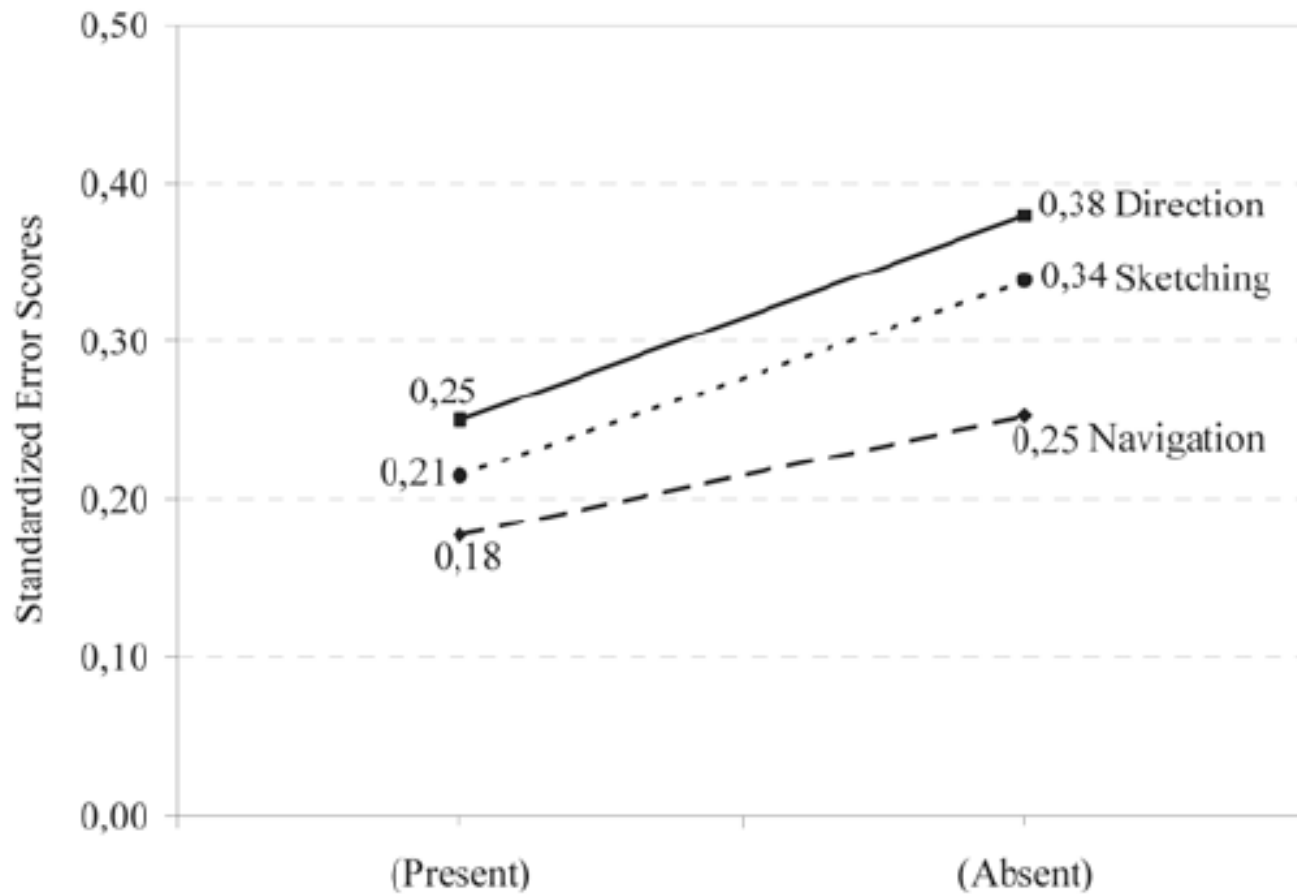
# The Results – Plan Layout



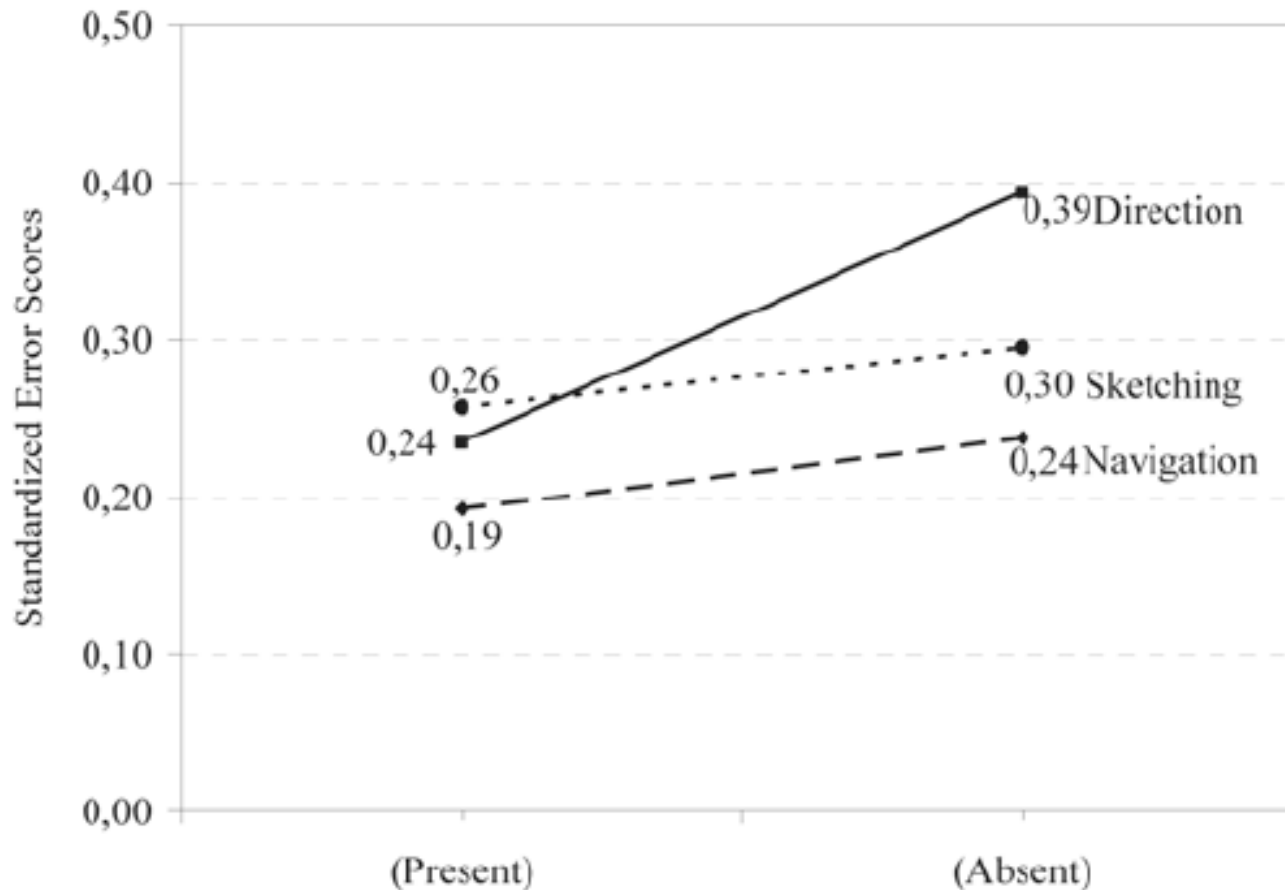
# The Results – Physical Differentiation



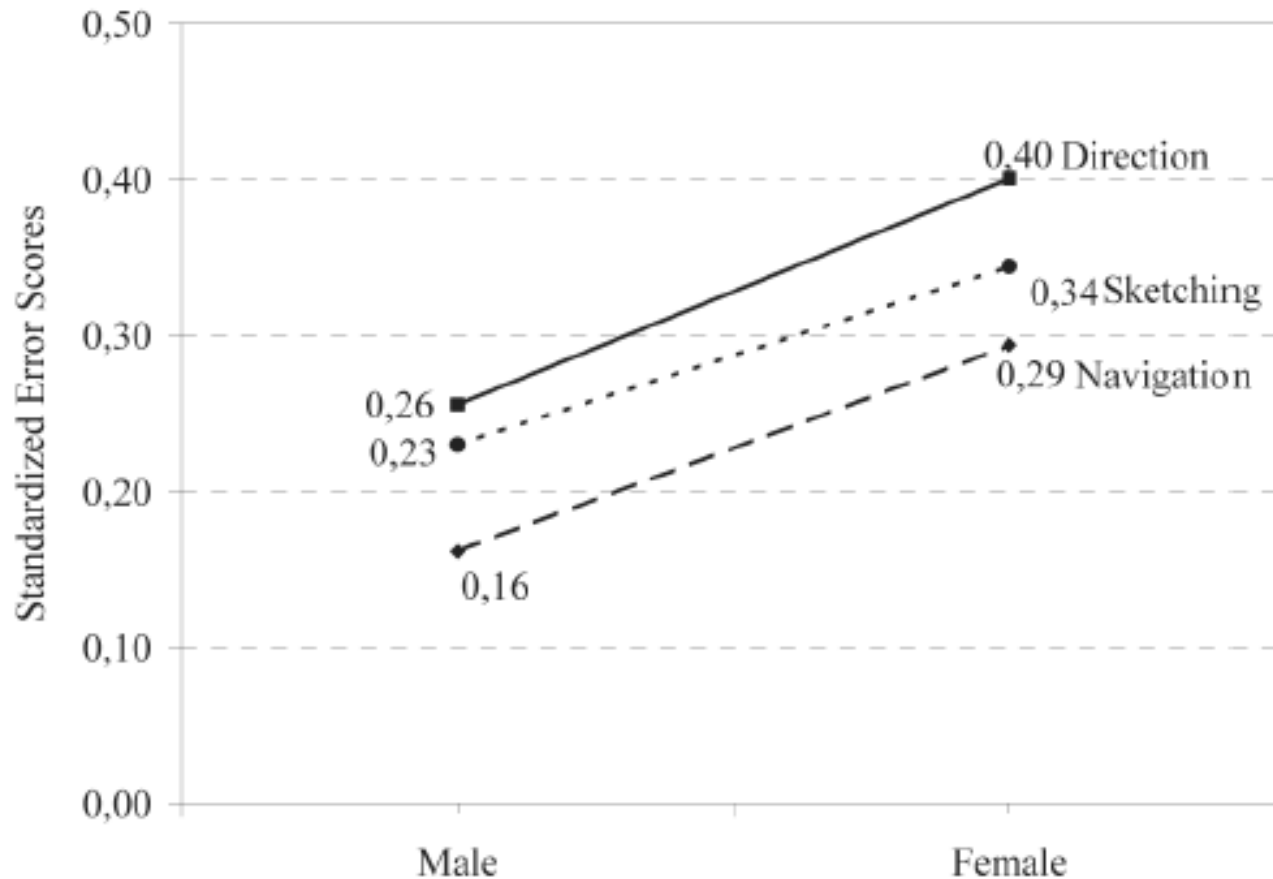
# The Results – Vertical Differentiation (Landmark)



# The Results – Horizontal Differentiation (Road Hierarchy)



# The Results – Gender



# The Results – General Linear Models Direction Error Scores

Source (n = 160)	df	MS	F
Analysis 1			
Gender	1	8,288.20	2.60
Age (year born)	1	1,393.85	0.44
Game playing	1	180.06	0.06
Exploration speed	1	58.93	0.02
Plan layout	1	34,498.25	10.81*
Physical differentiation	2	18,803.84	5.89*
Analysis 2			
Gender	1	9,620.64	3.00 <i>MS</i>
Age (year born)	1	1,593.48	0.50
Game playing	1	177.14	0.06
Exploration speed	1	74.14	0.02
Plan layout	1	34,614.20	10.79*
Landmark differentiation	1	11,728.01	3.66 <i>MS</i>
Road differentiation	1	24,932.91	7.77*

NOTE: *MS* = .05 < *p* < .10.

\**p* < .01.



# The Results – General Linear Models Sketching Error Scores

Source (n = 160)	df	MS	F
Analysis 1			
Gender	1	0.08	0.41
Age (year born)	1	0.02	0.10
Game playing	1	1.03	5.10*
Exploration speed	1	0.69	3.44 <i>MS</i>
Plan layout	1	1.41	7.02**
Physical differentiation	2	0.69	3.45*
Analysis 2			
Gender	1	0.08	0.38
Age (year born)	1	0.04	0.18
Game playing	1	1.04	5.24*
Exploration speed	1	0.63	3.18 <i>MS</i>
Plan layout	1	1.39	6.99**
Landmark differentiation	1	1.66	8.34**
Road differentiation	1	0.07	0.35

NOTE: *MS* = .05 < *p* < .10.

\**p* < .05. \*\**p* < .01.

# The Results – General Linear Models Navigation Error Scores

Source (n = 157)	df	MS	F
Analysis 1			
Gender	1	0.42	2.78 <i>MS</i>
Age (year born)	1	0.75	4.93*
Game playing	1	0.32	2.13
Exploration speed	1	1.82	11.97**
Plan layout	1	2.10	13.83**
Physical differentiation	2	0.16	1.04
Analysis 2			
Gender	1	0.43	2.85 <i>MS</i>
Age (year born)	1	0.76	5.01*
Game playing	1	0.32	2.13
Exploration speed	1	1.80	11.81**
Plan layout	1	2.09	13.75**
Landmark differentiation	1	0.21	1.37
Road differentiation	1	0.07	0.49

NOTE: *MS* = .05 < *p* < .10

\**p* < .05. \*\**p* < .01.

# Conclusion & Future Research

- Conclusions
  - Physical differentiation and Simple layouts enhance people's survey spatial knowledge.
  - The effect sizes for personal factors were small compared to physical environmental factors
- Future Research
  - Different population (children, elderly, Alzheimer patients)
  - Different settings (airport, hospitals, colleges)



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Thank you !

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