Uncovering human behaviour in crisis situations and how to develop improved strategies to increase the efficiency of evacuation

Daniel Nilsson

Department of Fire Safety Engineering
and Systems Safety, Lund University

"Design of evacuation systems for underground transportation systems"

Daniel Nilsson,

Håkan Frantzich, Karl Fridolf,
Kristin Andrée and Enrico Ronchi
Department of Fire Safety Engineering
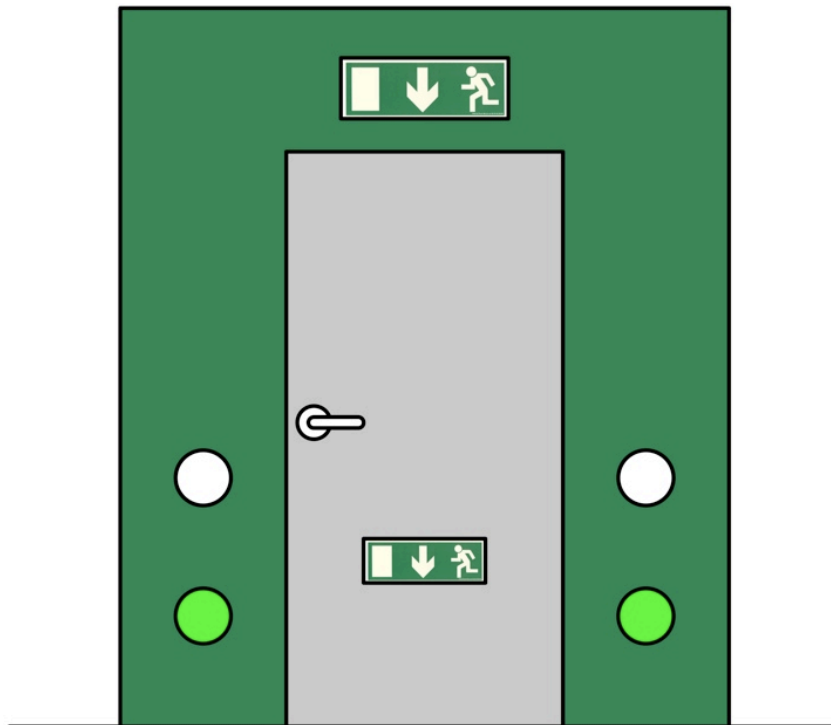and Systems Safety, Lund University

Outline

- Background
- Research strategy - Theory
- Research strategy - Example
- Theory of Affordances
- Conclusion

Background

- Underground transportation systems
  - Complex - Difficult evacuation conditions
    - Notification
    - Way-finding
  - Evacuation systems might be a solution
    - Evacuation alarms
    - Way-finding systems

- It is **<u>NOT</u>** self-evident how a system should be designed!

Background

- Way-finding system - Example
  - Design tested in experiment (2011)
  - Smoke filled tunnel - based on METRO

Background

- Alarm system - Example
  - Design in fire accident (2008)
  - Small truck fire - a lot of smoke in the tunnel
  - Signs with information
    - *"Evacuate tunnel"*
  - Behaviour
    - Some motorists <u>drove</u> out through the smoke

Outline

- Background
- <u>Research strategy - Theory</u>
- Research strategy - Example
- Theory of Affordances
- Summary

Research strategy - Theory

Step 1 - Identify problem

Step 2 - Solve problem

Step 3 - Test system

Laboratory exp.

Hypothetical scenario and laboratory exp.

Field exp.

Research strategy - Example

- Research project
  - Way-finding in tunnels - an <u>active</u> system
    - Flashing lights at emergency exits

Research strategy - Example
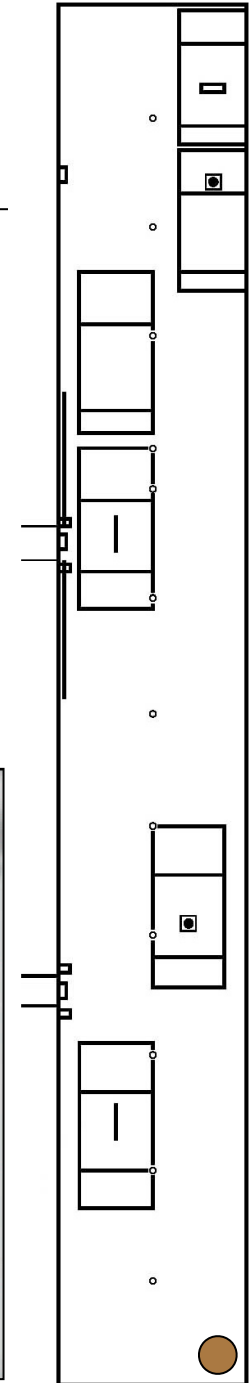
Step 1 - Identify problem

Laboratory exp.

↓

Hypothetical scenario and laboratory exp.

Step 2 - Solve problem

↓
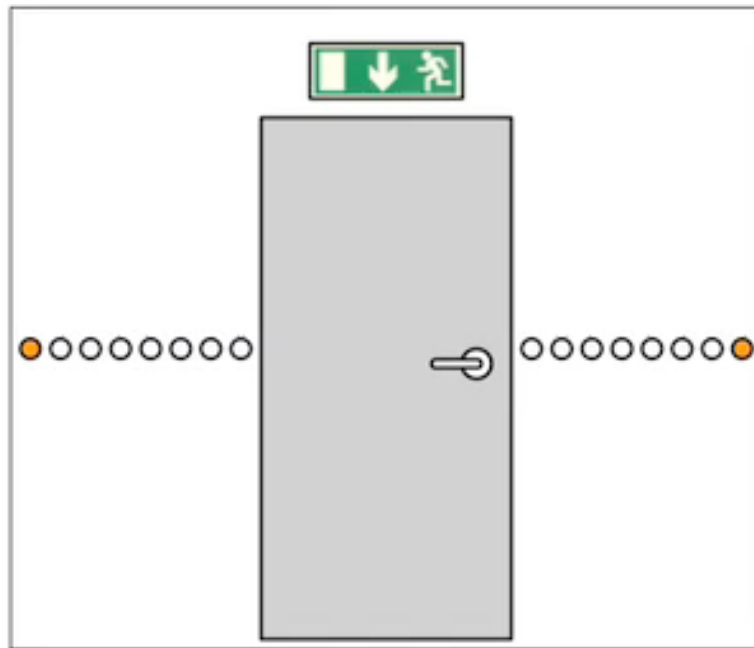
Step 3 - Test system

Field exp.

Research strategy - Example

- Step 1 - Identify problem
  - Road tunnel
  - Smoke and acetic acid
  - Laboratory experiment
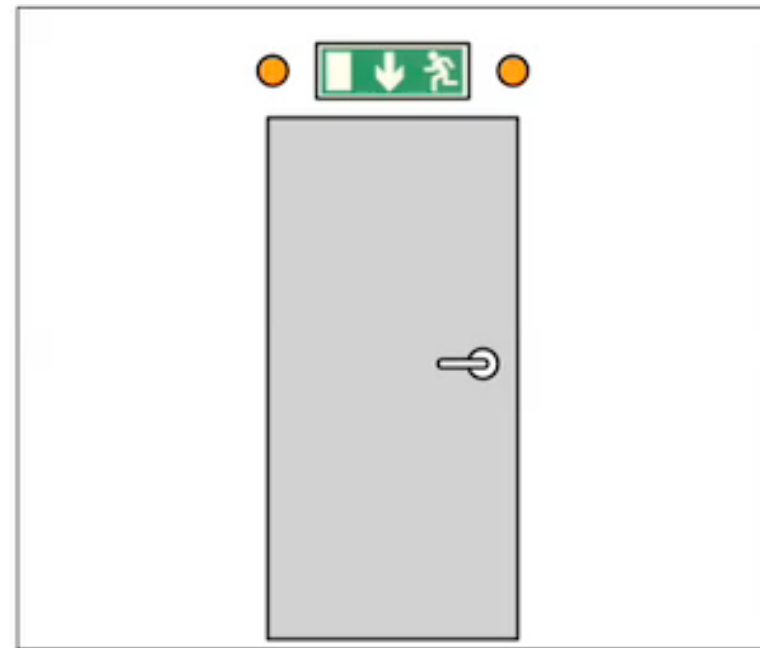
Research strategy - Example

- Step 1 - Identify problem
  - Test <u>two</u> different designs

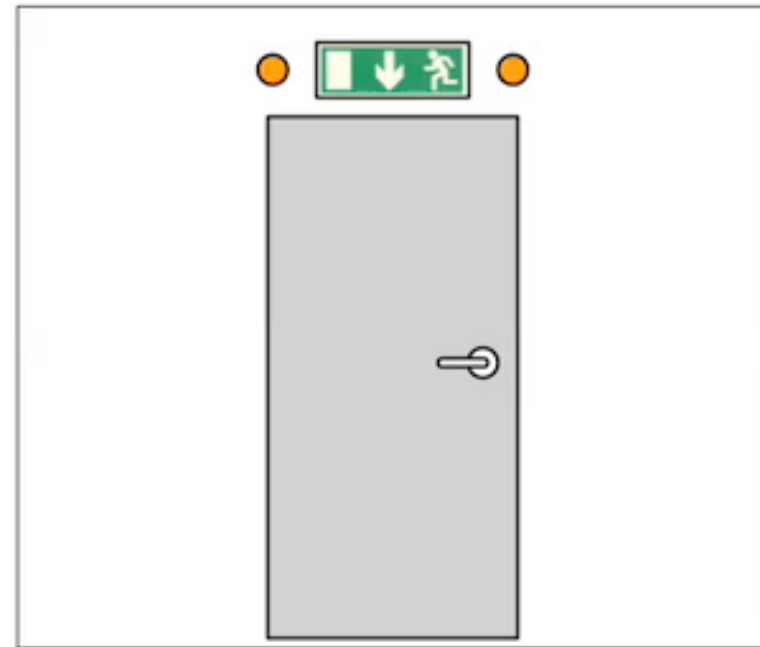
Design 1   Design 2

Research strategy - Example

- Step 1 - Identify problem
  - A simple design better
  - Colour important

Chosen design

Research strategy - Example
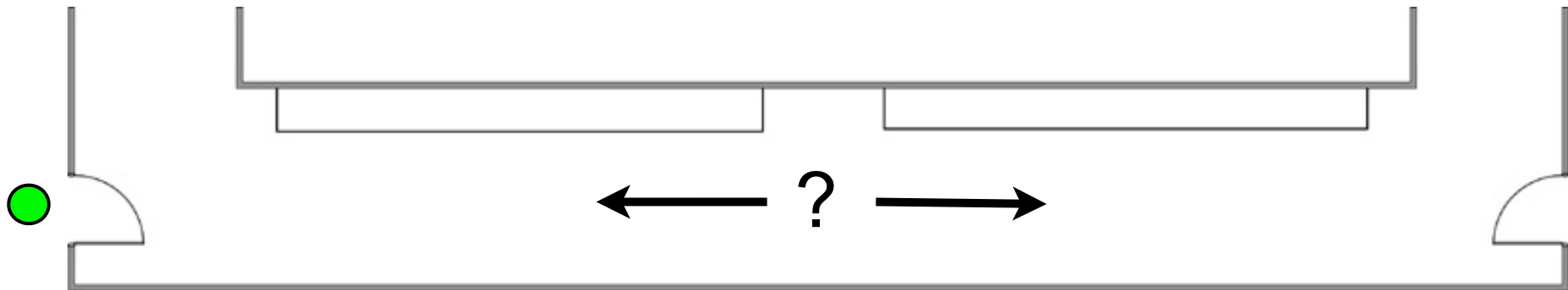
Step 1 - Identify problem

Step 2 - Solve problem

Step 3 - Test system

```
┌─────────────────────────┐
│     Laboratory exp.      │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│  Hypothetical scenario   │
│  and laboratory exp.     │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│       Field exp.         │
└─────────────────────────┘
```

Research strategy - Example

- Step 2 - Solve problem
  - Which colour is most appropriate?
  - Association and behaviour
  - Hypothetical scenario experiments
  - Laboratory experiments

Research strategy - Example

Step 1 - Identify problem

Step 2 - Solve problem

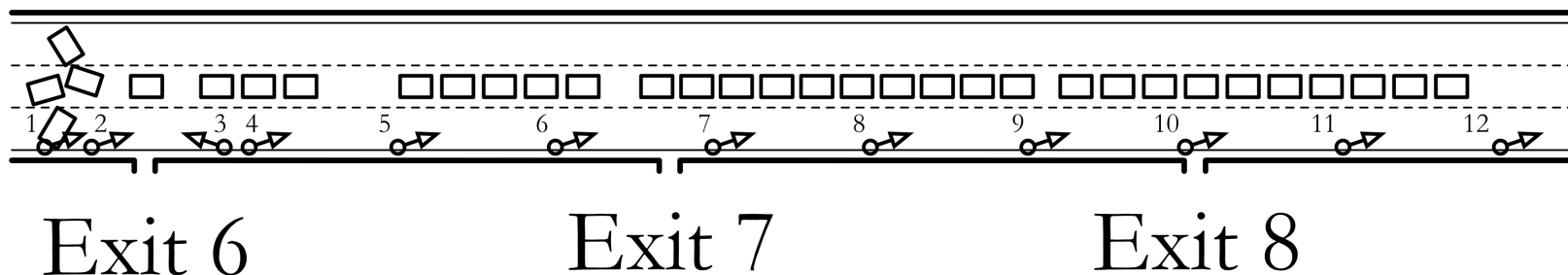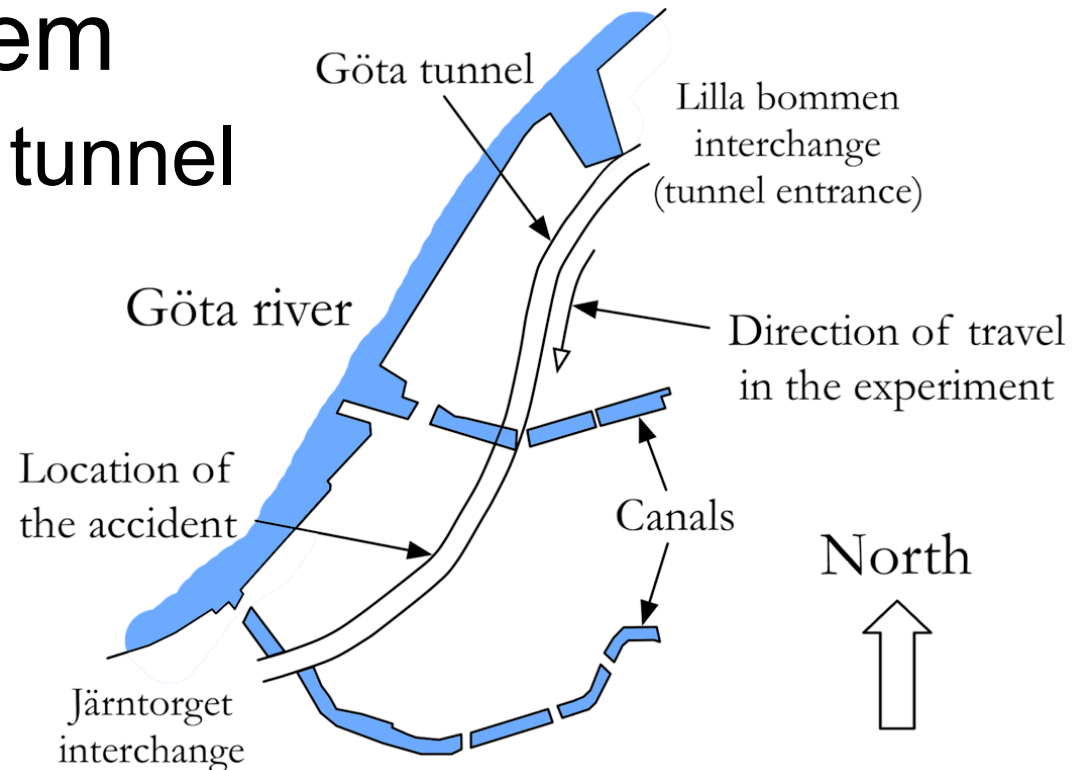Step 3 - Test system

Laboratory exp.

↓

Hypothetical scenario and laboratory exp.
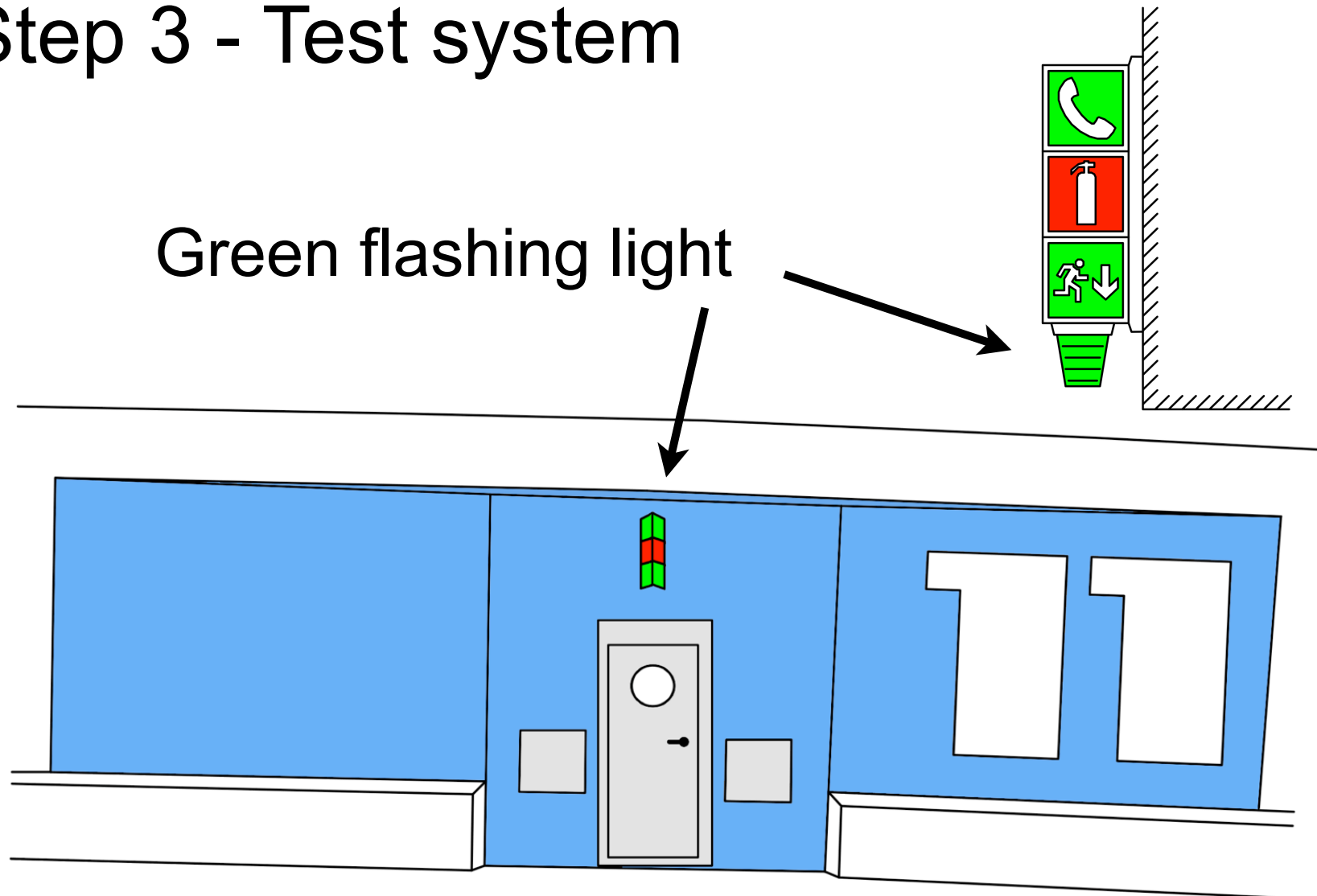
↓

Field exp.

Research strategy - Example

- Step 3 - Test system
  - Road tunnel - Göta tunnel
  - Field experiment
  - Partially informed participants

Research strategy - Example

- Step 3 - Test system

Green flashing light

Research strategy - Example

Step 1 - Identify problem

Step 2 - Solve problem

Step 3 - Test system

Laboratory exp.

Hypothetical scenario and laboratory exp.

Field exp.

Outline

- Background
- Research strategy - Theory
- Research strategy - Example
- <u>Theory of Affordances</u>
- Summary

Theory of Affordances

- Theory of affordances (Gibson,1978)
  - How an object supports the users to achieve their goals
- Types of affordances (Hartson, 2003)
  - Sensory - sensing or seeing
  - Cognitive - understanding
  - Physical - physically doing or using
  - Functional - fulfilment of goal
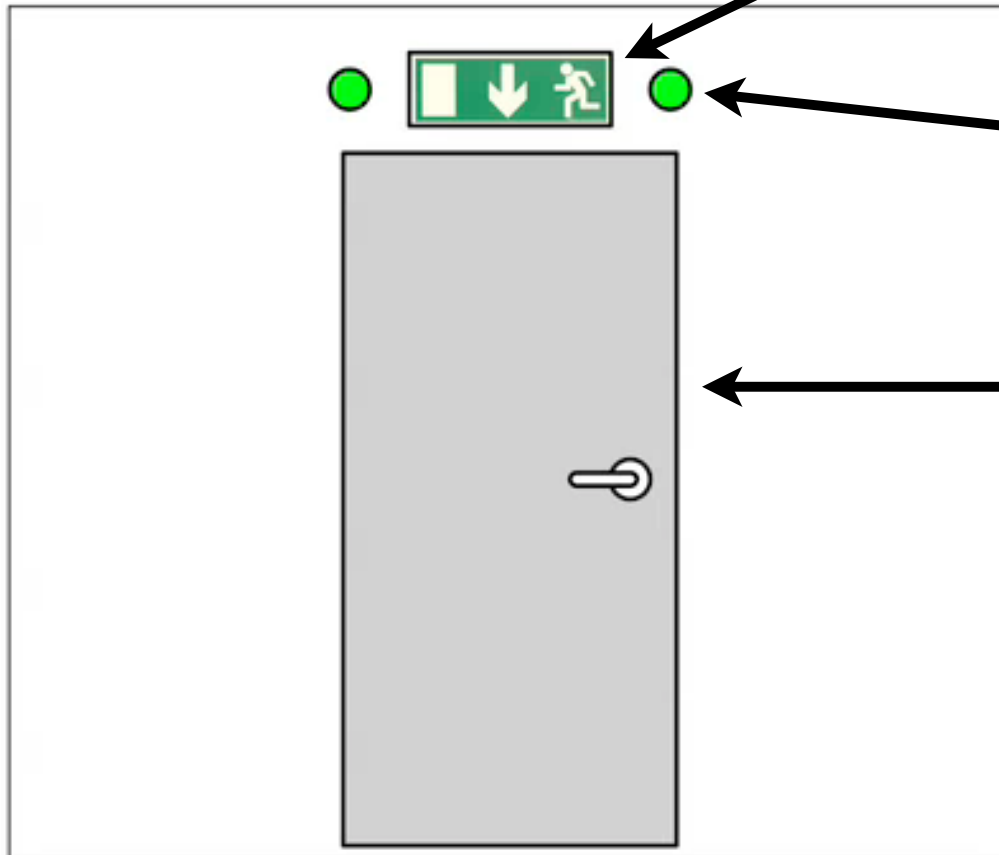- Conflicting affordances

Theory of Affordances

- ## Sensory affordance
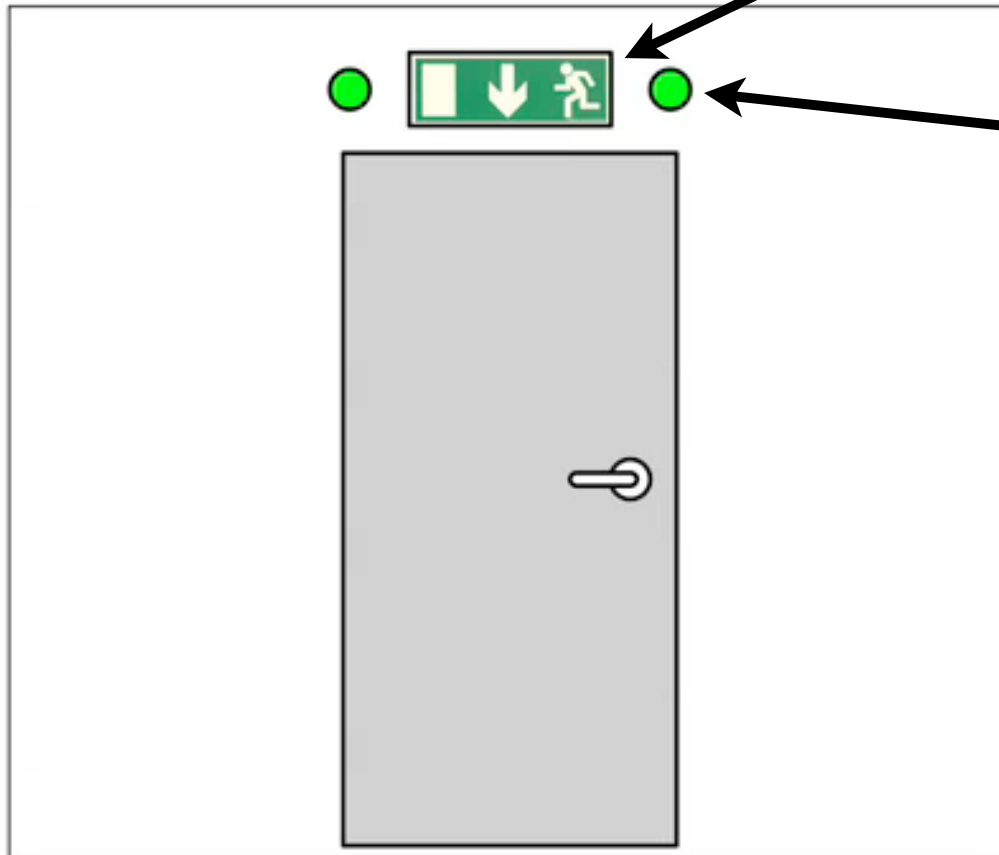 - Sensing or seeing

Focuses attention to the sign

Location - easy to see

Exit becomes easier to notice

Theory of Affordances

- Cognitive affordance
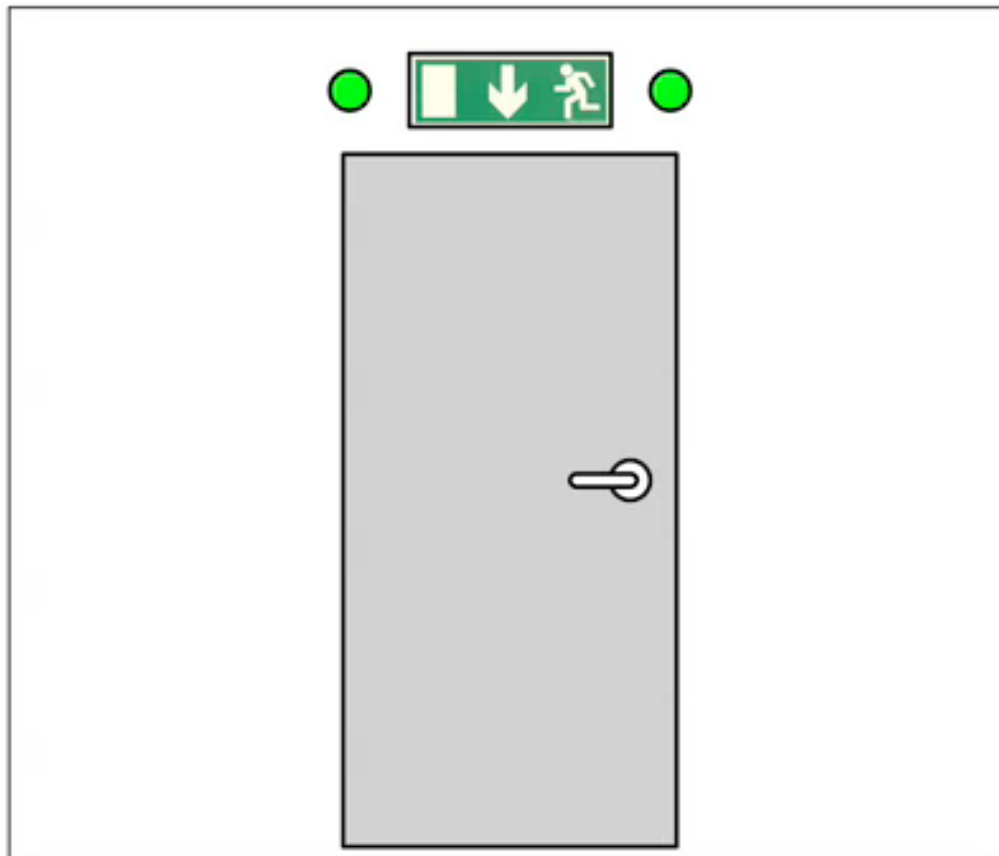 - Understanding

The sign is important

Green - *safety* or *go*

An active system - signals change

A simple design - easily understood

Theory of Affordances

- Physical affordance
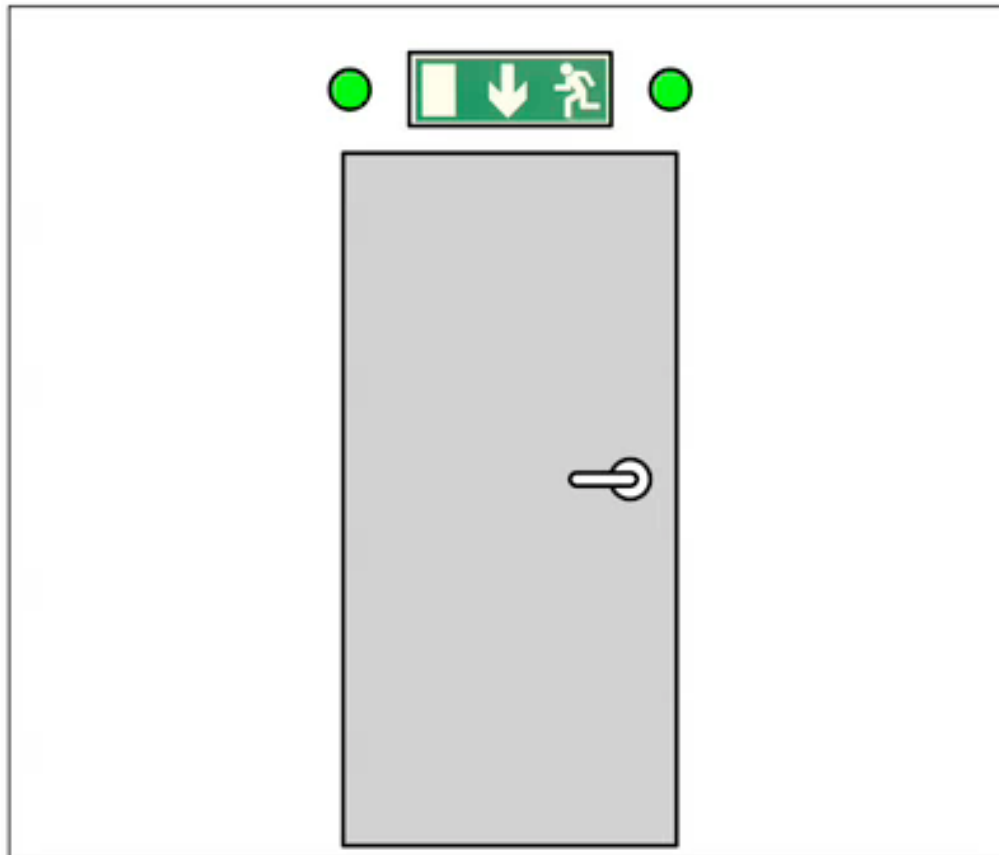 - Physically doing or using

Not studied here, but...
- Uncomplicated opening device
- Minimal force to open
- etc

Theory of Affordances
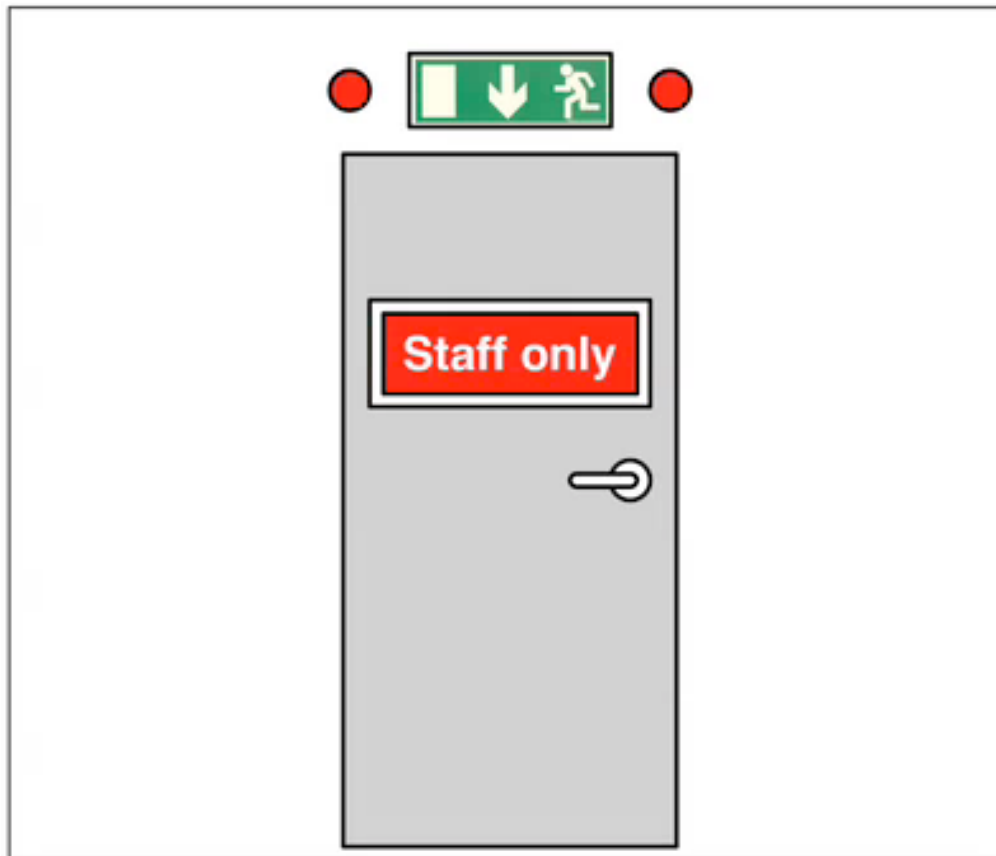
- Functional affordance
  - Fulfilment of goal

Possible goals
- Escape
- Social influence
- No injury, etc

Combination of sensory, cognitive and physical

Theory of Affordances

- Conflicting affordances
  - Should <u>always</u> be avoided

- Step 1 - Orange lights and green sign

- Example
  - Staff only and red lights
  - Green sign

Conclusion

- It is <u>not</u> self-evident how systems should be desinged
- The design <u>must</u> be tested
- A theoretical framework can aid the design process
  - Theory of Affordances (one possible theory)