The use of eye tracking in landscape perception research

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Workshop on Eye Tracking: Why, When, and How?
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Questions

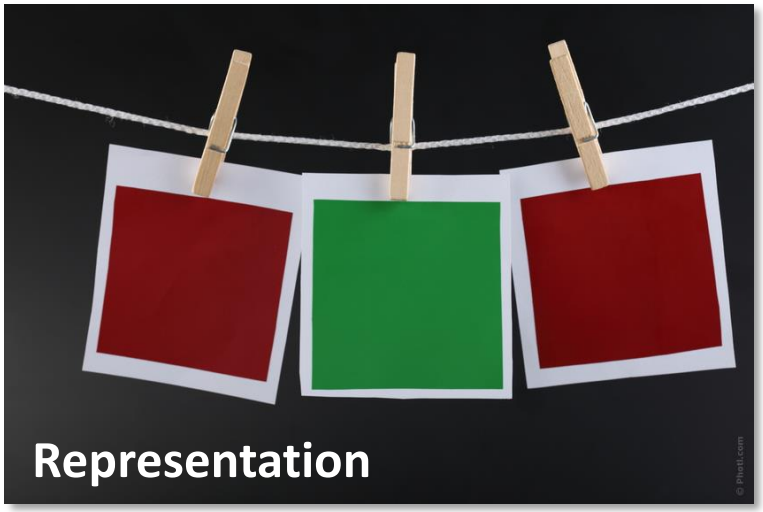
- When can/may/should eye tracking be applied in the geodomain?
- Why should eye tracking be applied?
- How should eye tracking be applied?
- What are the main issues/obstacles in eye tracking at the moment (both technical and in the analysis)?
- What are the main disadvantages of eye tracking?
- What are the advantages of using eye tracking as opposed to other user research techniques?

Introduction

- Reading the European Landscape Convention (2000)
  - Landscape is ‘an area, as **perceived by people** whose character is the result of the action and interaction of natural and/or human factors ’
  - Landscape is ‘**an important public interest**’ and ‘**an important part of the quality of life for people everywhere**’

But… how do people look at landscapes? How do they observe, perceive landscapes?

Observations are influenced by…



Global aims of the research

Which elements in a landscape catch the attention and in which context are they most eye-catching?

Important for the location of new infrastructures

But first...

- How do people observe landscapes in general?

Experiment 1

- Influence of the photograph properties?
  - Focal length, horizontal and vertical view angles
- Influence of the landscape characteristics?
  - Degree of openness
  - Degree of heterogeneity

Experiment 2

- Influence of the social/professional background of the observer?
  - Landscape experts versus novices

Methodology

- Eye tracking technology
  - Non-portable RED-system (SMI)
    - Measurement rate: 120 Hz
    - Both eyes are tracked
    - No chin rest
- Eye tracking experiments
  - Stimuli: landscape photographs
    - **Experiment 1:** 90 photographs
    - **Experiment 2:** 74 photographs
  - Random order
  - 5 seconds per photograph
  - Free-viewing
  - Measured eye tracking metrics
    - **Fixations**: number, duration (ms)
    - **Saccades**: number, amplitude (°), velocity (°/s)
    - **Scan path**: length (px)
  - Participants
    - **Experiment 1**: 23 geographers
    - **Experiment 2**: 21 landscape experts and 21 novices

EXPERIMENT 1

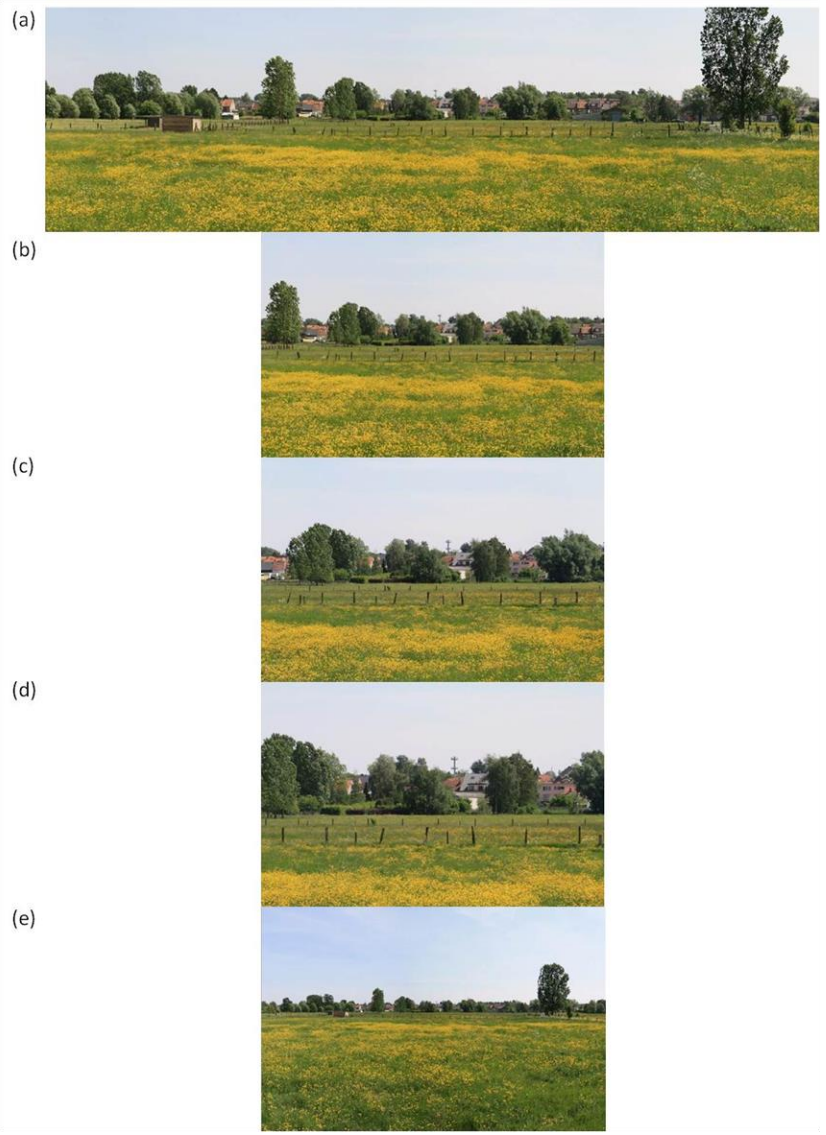
INFLUENCE OF PHOTOGRAPH PROPERTIES AND LANDSCAPE CHARACTERISTICS

- **Research questions**
  - *Do people observe the same landscape differently on different photograph types?*
    - *Influence of photograph properties (focal length, horizontal and vertical view angles)*
  - *How do landscape characteristics (degree of openness and heterogeneity) influence the observation pattern?*
    - *Influence of landscape type*

Methodology (1)

- Photograph sampling

	Focal length	Horizontal view angle	Vertical view angle
a) Panoramic photograph	50mm	70°	20,9°
b) Standard photograph	50mm	31°	20,9°
c) Zoom 1	70mm	22,4°	15°
d) Zoom 2	100mm	15,8°	10,5°
e) Wide angle photograph	18mm	75,1°	54,3°



→ 18 landscapes

→ 90 photographs in total

	Homogeneous	Heterogeneous
Open		
Semi-open		
Enclosed		

Methodology (2)

- Statistical analysis

	Photograph type					Openness			Heterogeneity	
	panorama	standard	zoom 1	zoom 2	wide angle	open	semi-open	enclosed	homogeneous	heterogeneous
Fixation number										
Fixation duration										
Saccade number										
Saccade amplitude										
Saccade velocity										
Observed horizontal area										
Observed vertical area										

Comparison of means between different groups: Mann-Whitney U test (2 groups) or Kruskal-Wallis test (k groups)

If significant ($p<0,05$): Dunn's test

Results: photograph type (1)

- Kruskal-Wallis test

Eye Tracking Metric	N	Panoramic	Standard	Zoom 1	Zoom 2	Wide angle	p
Fixation number	83,001	48,662	39,516	39,599	39,864	39,231	0.000
Fixation duration	83,001	38,469	42,468	42,077	42,284	42,474	0.000
Saccade number	81,300	47,773	38,644	38,764	39,059	38,371	0.000
Saccade amplitude	81,300	49,054	37,964	37,732	38,422	39,153	0.000
Saccade velocity	81,300	48,116	38,327	37,835	38,928	39,202	0.000
Observed horizontal area	2,070	1,848	858	838	768	866	0.000
Observed vertical area	2,070	889	1,014	1,055	1,144	1,075	0.000

- Panoramic
  - More fixations
  - Shorter saccades

More information extraction

  - Shorter fixation duration

Easier information extraction

  - More saccades
  - Larger saccades
  - Faster saccades

Stronger visual exploration

→ influence of larger size and surface of the panoramic photograph?

Results: photograph type (2)

- Kruskal-Wallis test

Results: landscape characteristics

- Kruskal-Wallis test

Eye Tracking Metric	N	Openness			p	Heterogeneity		p
		Open	Semi-open	Enclosed		Homogeneous	Heterogeneous	
Fixation number	17,749	8,419	9,005	9,190	0.000	8,696	9,050	0.000
Fixation duration	17,749	9,105	8,854	8,672	0.000	8,888	8,862	0.734
Saccade number	17,401	8,203	8,839	9,059	0.000	8,536	8,867	0.000
Saccade amplitude	17,401	8,919	8,539	8,651	0.000	9,059	8,357	0.000
Saccade velocity	17,401	8,961	8,524	8,625	0.000	8,934	8,478	0.000
Observed horizontal area	1,242	618	597	650	0.100	606	587	0.277
Observed vertical area	1,242	593	574	697	0.000	660	583	0.000

- **Open**
  - Less & longer fixations
  - Less saccades

  → **Weaker visual exploration**

- **Homogeneous**
  - Less fixations
  - Less & longer saccades

  → **Weaker visual exploration**

EXPERIMENT 2

THE INFLUENCE OF PROFESSIONAL OR EDUCATIONAL LANDSCAPE RELATED EXPERTISE ON THE VISUAL EXPLORATION OF LANDSCAPE PHOTOGRAPHS

- **Research questions**
  - From expert to novice. Do these groups of respondents observe landscapes differently?

How about different types of observers?

- Landscape experts versus novices
  - Landscape researchers, landscape ecologists, landscape architects, landscape planners,...

versus

  - Persons without any educational or professional background related to landscape science

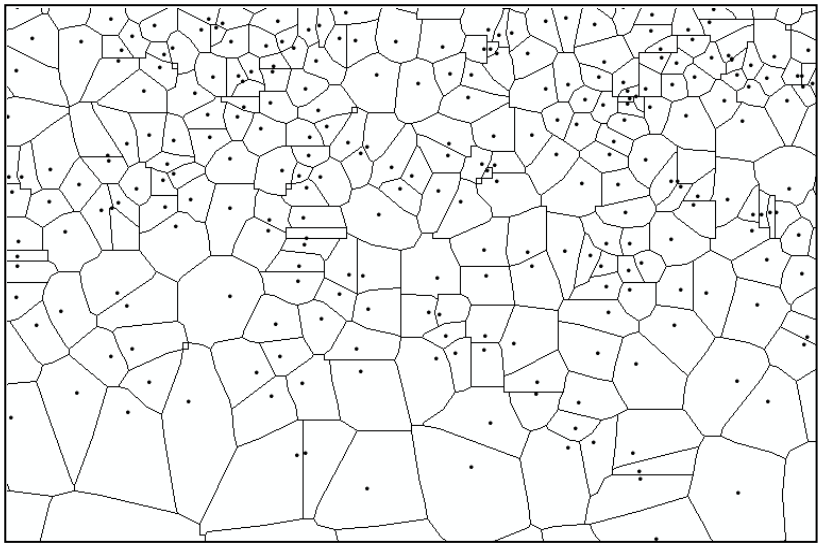


Methodology

- Statistical analysis

Eye tracking metrics	Participants group	
	Expert	Novice
Fixation number	Comparison of means between 2 different groups: Mann-Whitney U test	
Fixation duration		
Saccade number		
Saccade amplitude		
Saccade velocity		
Scan path length		

- Voronoi cell analysis
  - Large cells ➡ dispersed fixations
  - Small cells ➡ clustered fixations



Results: observer groups

- Mann-Whitney U test

Eye Tracking Metric	N	Mean rank per participants group		p
		Experts	Non-experts	
Fixation number	99,494	1,689	1,420	0.000
Fixation duration	99,494	48,993	50,536	0.000
Saccades number	99,840	1,648	1,461	0.000
Saccade amplitude	99,840	49,278	50,585	0.000
Saccade velocity	99,840	49,709	50,139	0.019
Scan path length	3,108	1,650	1,459	0.000

- Experts
  - More fixations
  - Shorter saccades
  - Slower saccades

  More information extraction
  - Shorter fixation duration

  Easier information extraction
  - More saccades
  - Longer scan path

  Stronger visual exploration

- Voronoi cell analysis

	Mean rank per participants group		p
	Experts	Non-experts	
Voronoi cell surface	48,968	47,875	0.000

Larger Voronoi cells → **dispersed fixation pattern**


Expert
Novice
Scan paths
More fixations & saccades
Shorter fixations
Longer scan path
Less fixations & saccades
Longer fixations
Shorter scan path
(a)
(b)
Focus maps
Larger visual span
Smaller visual span
(c)
(d)
Voronoi cells
Larger Vorornoi cells
Smaller Voronoi cells
(e)
(f)

Conclusions

- Experiment 1: **Photograph properties and landscape types**
  - Photograph properties
    - A landscape image is observed more extensively if represented on a panoramic photograph
  - Landscape characteristics (openness and heterogeneity)
    - The visual exploration of homogeneous and open landscapes is weaker
- Experiment 2: **Experts versus novices**
  - Experts: stronger visual exploration
    - More information is extracted in the same amount of time
    - Information is extracted more quickly

More information

- Papers
  - Dupont, L., Antrop, M., Van Eetvelde, V., 2013. *Eye Tracking Analysis in Landscape Perception Research: Influence of Photograph Properties and Landscape Characteristics.* Landscape Research, DOI:10.1080/01426397.2013.773966.
  - Dupont, L., Antrop, M., Van Eetvelde, V., 2013. *The Influence of Professional or Educational Landscape Related Expertise on the Visual Exploration of Landscape Photographs.* Submitted to Journal of Environmental Psychology
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