Adaptive E-Commerce Applications: Using Eye Tracking to Identify User's Task and Working Memory Capacity

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E-Commerce Application Adaptation

MARIA:
Cognitive Abilities

Working memory capacity and Visual attention

MATEJ:
Tasks

Searching and Browsing

Better User Experience
Economic Growth

[1] GERMANAKOS, Panagiotis, et al. The PersonaWeb System: Personalizing E-Commerce Environments based on Human Factors. In: *UMAP Workshops*. 2015.
[2] STEICHEN, Ben; CARENINI, Giuseppe; CONATI, Cristina. User-adaptive information visualization: using eye gaze data to infer visualization tasks and user cognitive abilities. In: *Proceedings of the 2013 international conference on Intelligent user interfaces*. ACM, 2013. p. 317-328.

Eye Tracking Study: Searching and Browsing in the E-Catalog

Investigating influence of **working memory capacity** and different **search tasks** on eye movements.

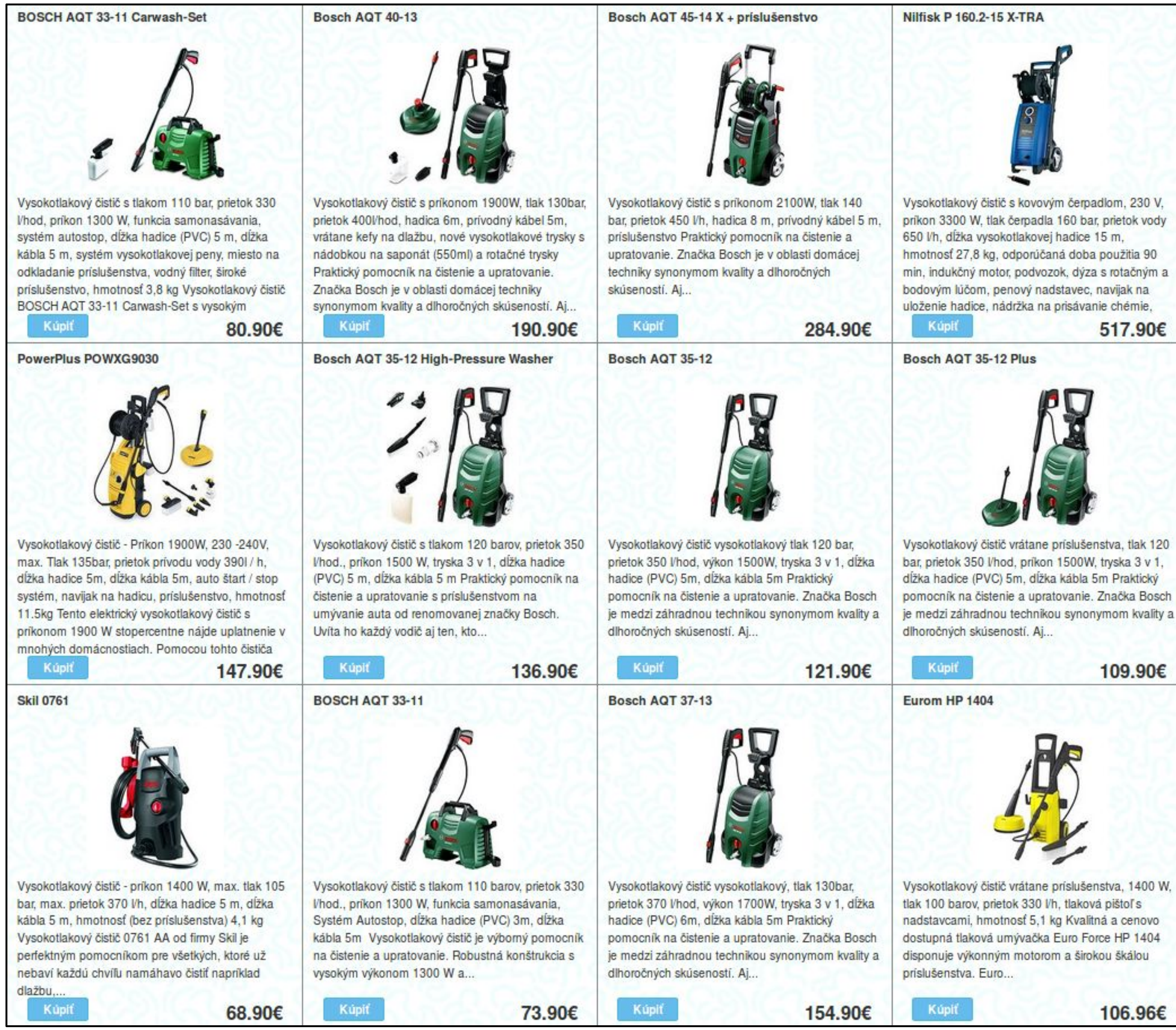
E-Catalog

STATIC

MATRIX LAYOUT

OUR IMPLEMENTATION

REAL PRODUCTS



Experiment in UX@Class (August 2017)

Tasks (flow designed in Tobii Studio):

I. **SSPAN - Symmetry Span Task**
  - *Implementation based on standard test* (2,3,4,5 elements x 3 trials)

II. **Visual Search Task**

III. **Searching Tasks in E-Catalog (30)**
  - Domain-oriented questions after every task

  A. Browsing (9)
  B. Searching with attributes (6)
  C. Searching without attributes (6)
  D. Searching (9)

PARTICIPANTS: 16; (age 18-25; 14 men)

Tasks

- 4 task types performed by users
- Identify task on e-catalogue

“Task is too abstract term...”

- But what kind of tasks have sense to identify using eye-tracker?
  - Low level tasks => peripheral devices (keyboard, mouse)
    - example - clicks and writing on site
  - High level tasks => site visits (logs)
    - example - Shopping
- On the basis of analyzed papers and approaches to task analysis (hierarchical task analysis)
  - **Searching in e-catalogue**
  - **Browsing in e-catalogue**

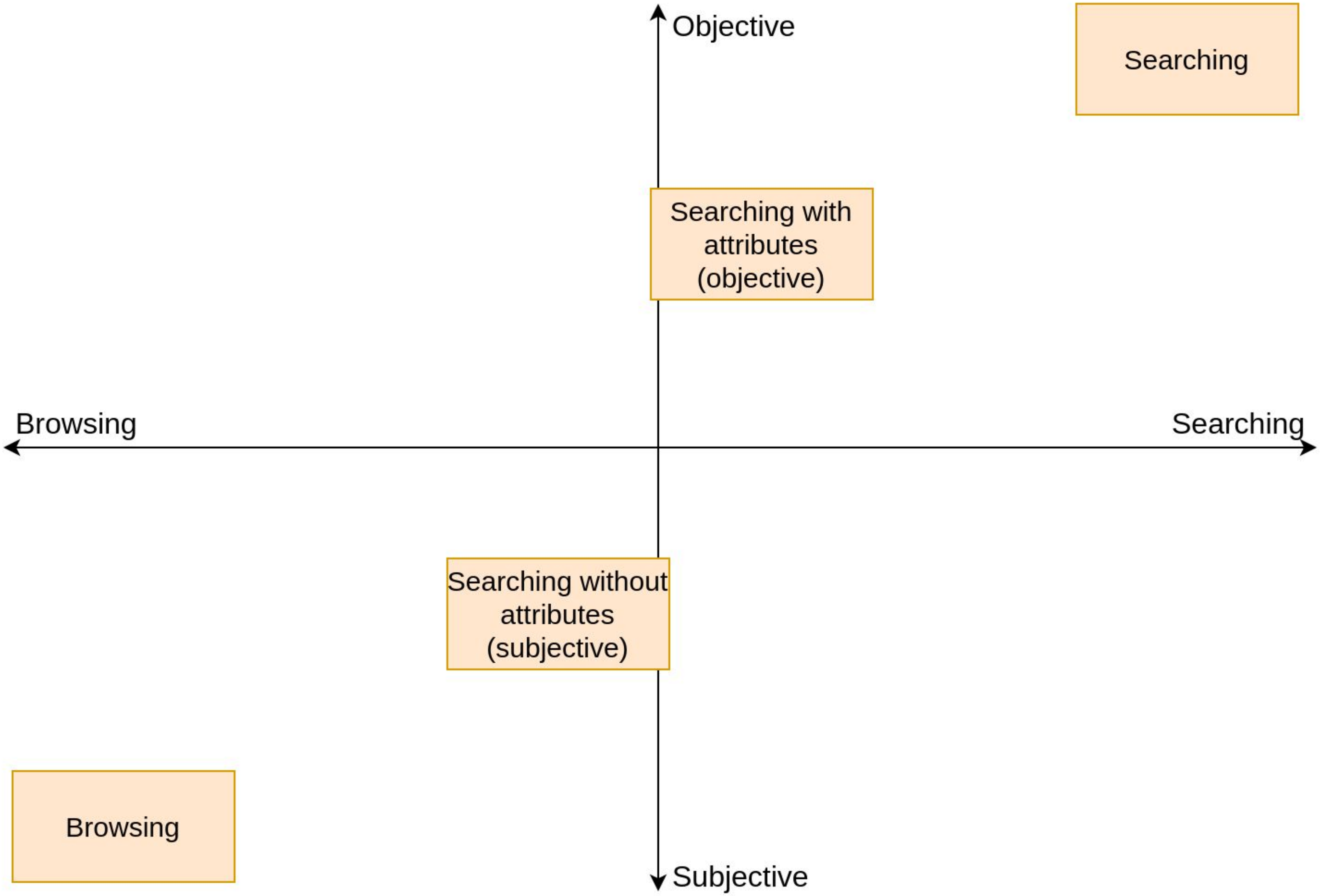
Browsing

- Target of searching is **undefined**
- Experiential behaviour
- Bottom-up attention
- Example:
  - “Check out our offer of televisions”

Searching

- Target of searching is **defined**
- Goal-directed behaviour
- Top-down attention
- Example:
  - “Find laptop - Lenovo E31-80 Black”

Task types


Objective
Searching
Searching with attributes (objective)
Browsing
Searching
Searching without attributes (subjective)
Browsing
Subjective

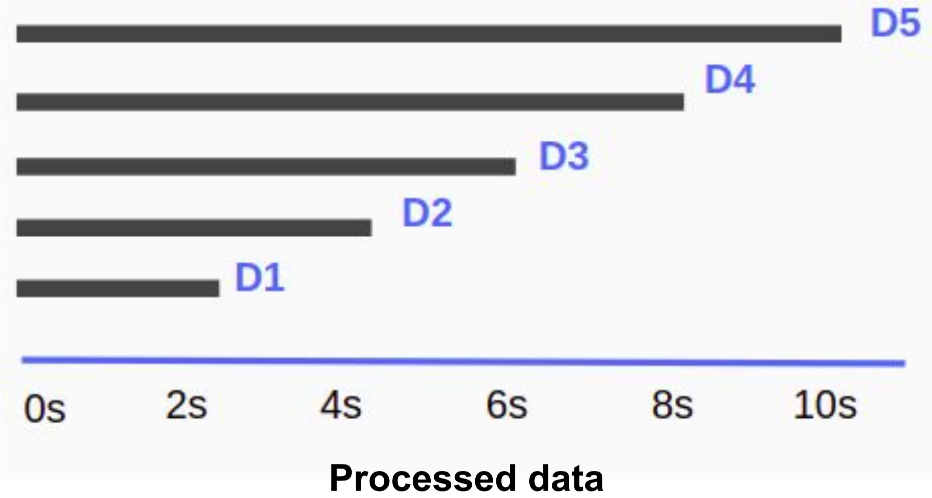
Design of our work

GOAL: Identification of tasks from eye-tracking data in e-catalogue

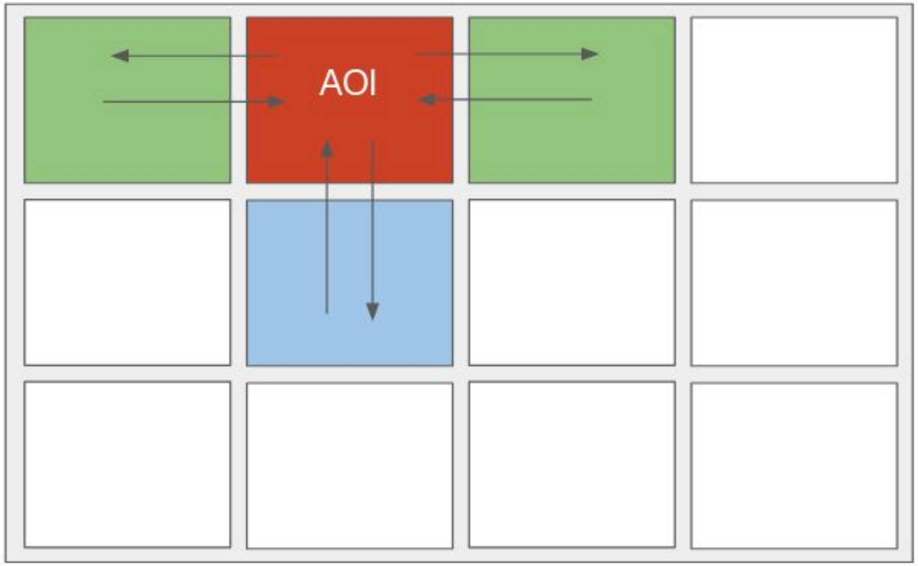
MOTIVATION: Adaptation of user interface on the basis of inferred task

METHOD:

1. Collect eye-tracker data
2. Split data into sub-datasets (*Di*)
3. Evaluation of our measures for each sub-dataset (*Di*)
4. Task classification for each sub-dataset (*Di*)



Measures



Basic measures:

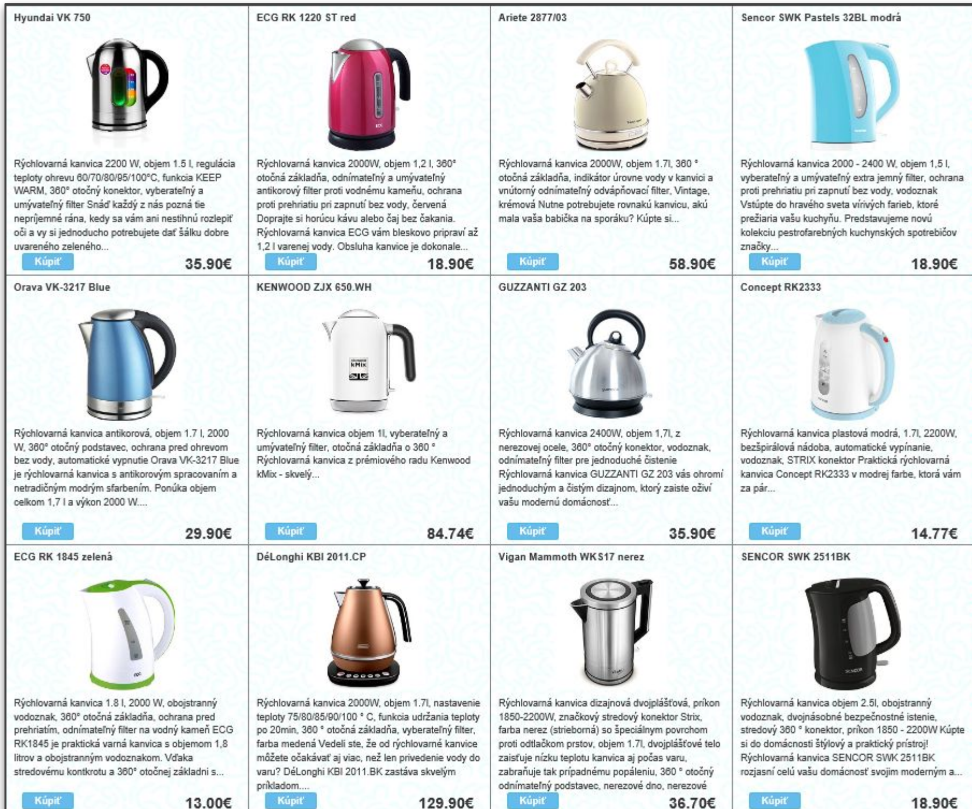
- Fixation length
- Number of fixations
- Frequency of fixations

AOI measures :

- Number of fixations in AOI
- Sum and mean of fixation duration in AOI
- Number of AOI visits
- **Number of horizontal and vertical transitions between AOI**

[2] STEICHEN, Ben; CARENINI, Giuseppe; CONATI, Cristina. Useradaptive information visualization: using eye gaze data to infer visualization tasks and user cognitive abilities. In: Proceedings of the 2013 international conference on Intelligent user interfaces. ACM, 2013. P. 317-328.
[11] SHRESTHA, S. and LENZ, K. (2017). Eye Gaze Patterns while Searching vs. Browsing a Website. [online] Software Usability Research Lab. Available at: http://usabilitynews.org/eye-gaze-patterns-whilesearching-vs-browsing-a-website/ [Accessed 25 Nov. 2017].

Experiment in UX@Class

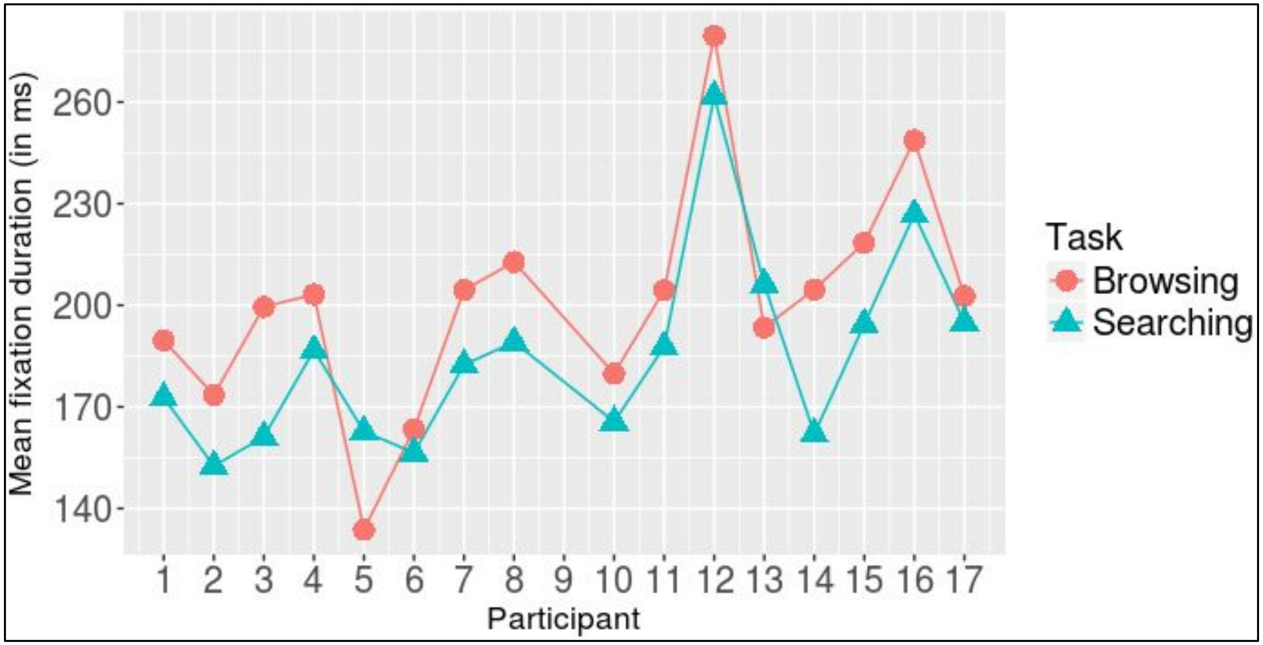


Analysis of gathered data

- Evaluated forms
- Statistics

First findings:

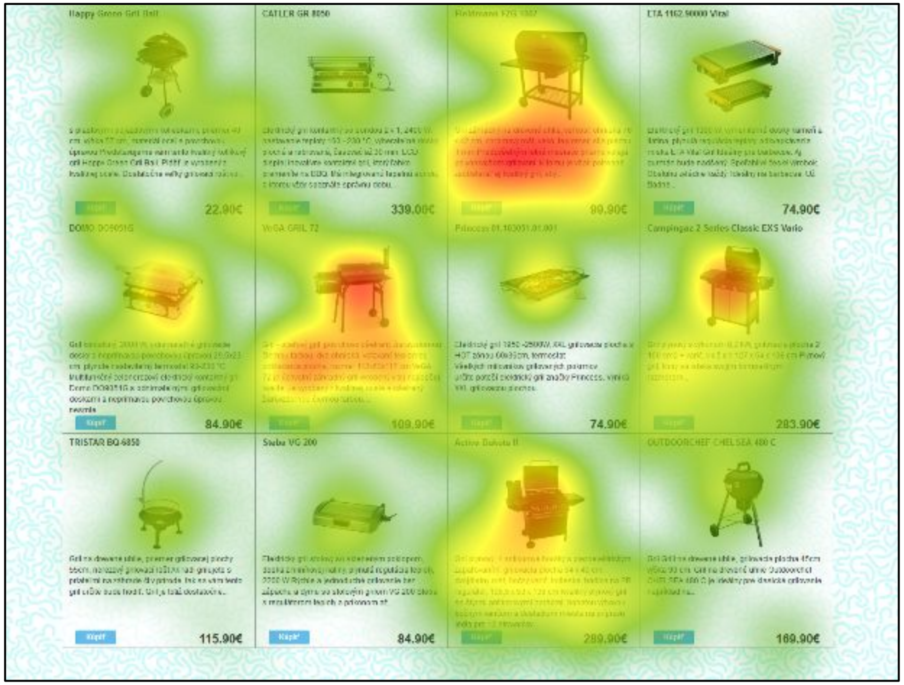
- Despite differences in mean fixation duration for each participant, in 14/16 cases searching tasks have lower mean fixation duration than browsing tasks
- paired t-test, p=0.0008



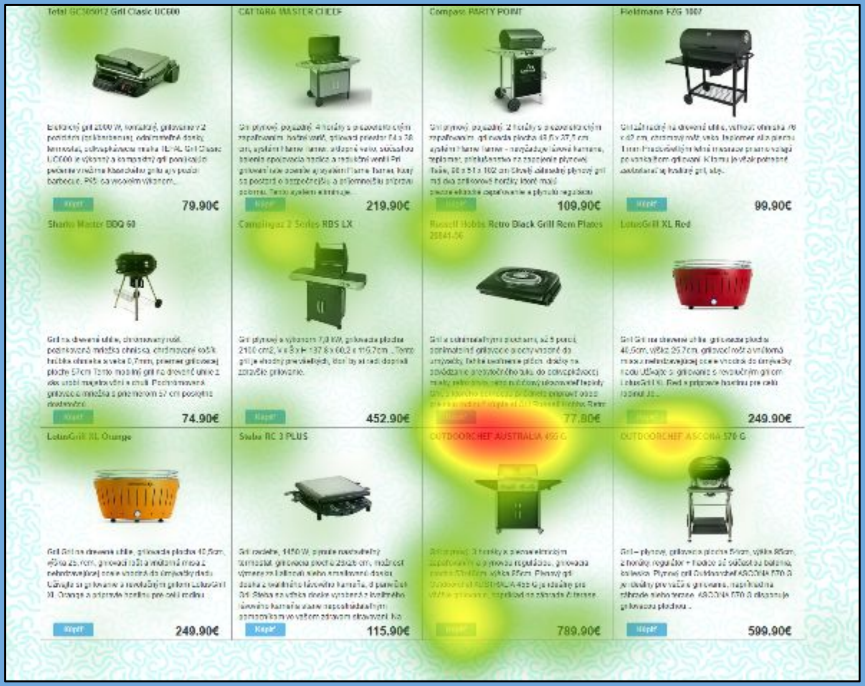
First results of performed study

- Confirmation of our first results with another study (Shrestha, 2017)

Browsing

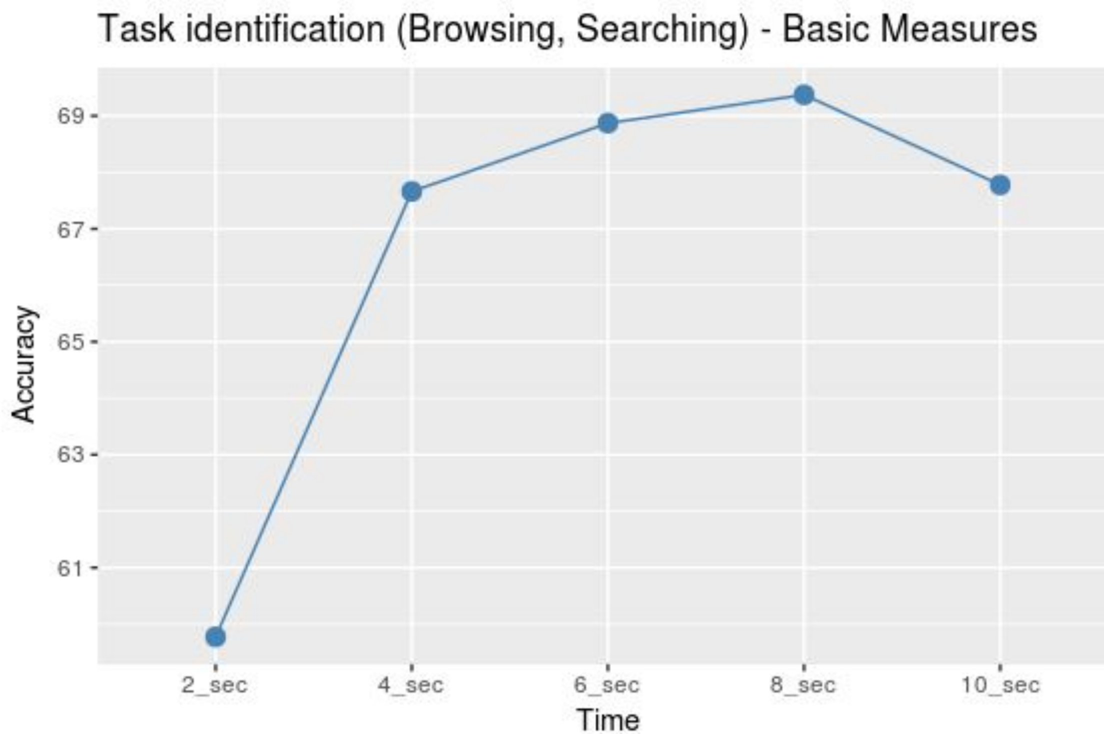


Searching

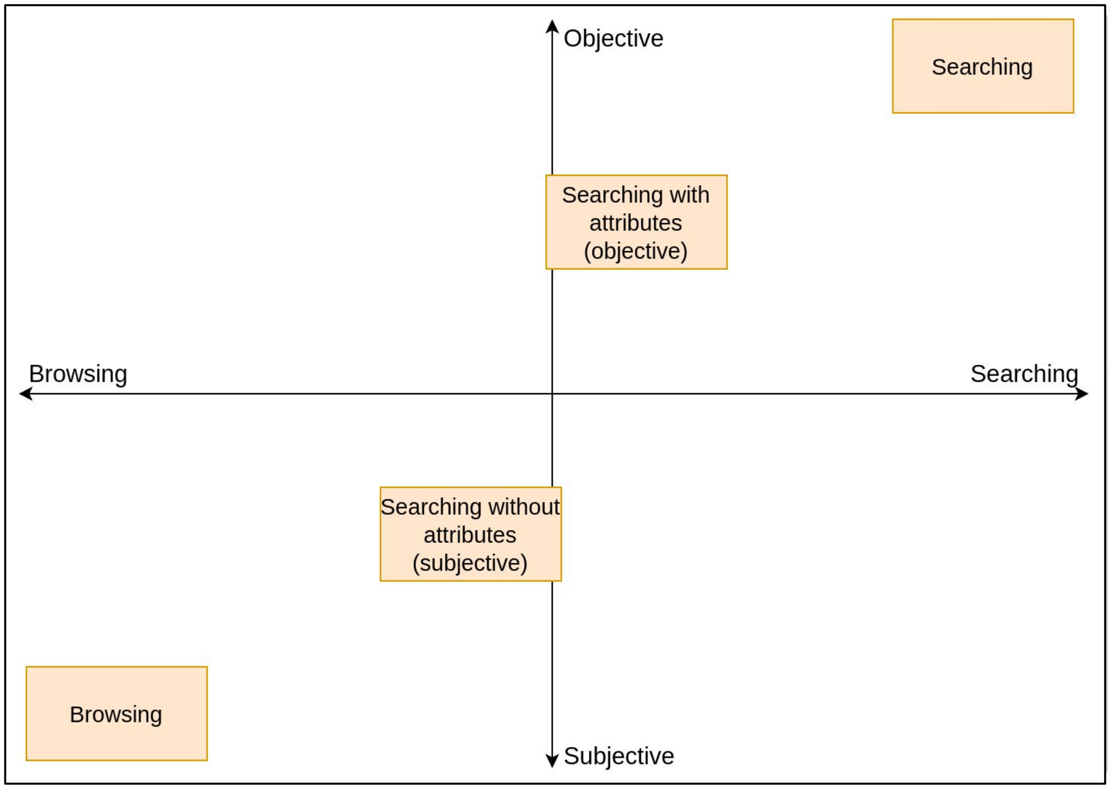


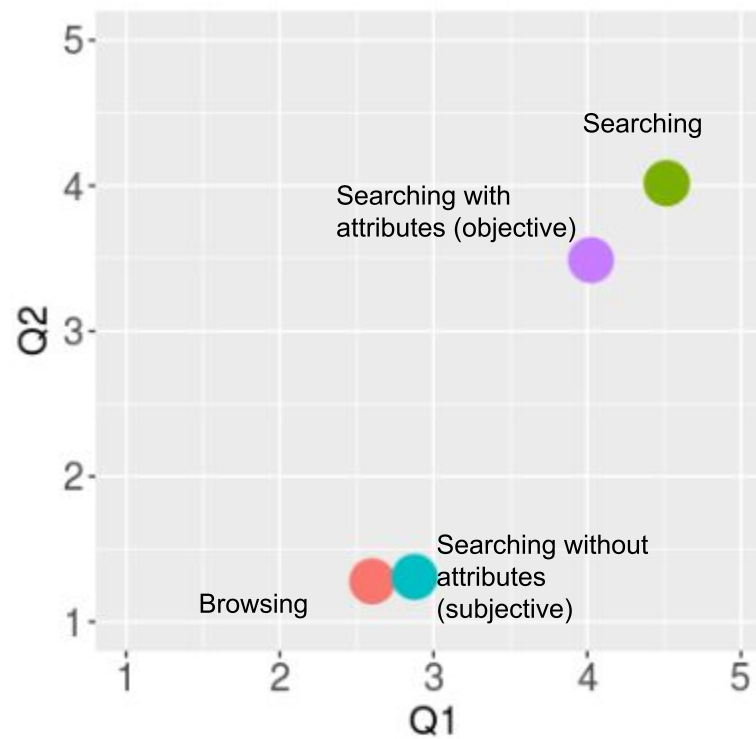
Task identification

- Mainly focused on Browsing and Searching
- Logistic regression
- Max accuracy 69,37%
  - K-fold cross validation
  - 50% baseline
  - Only basic measures



Evaluation of inferred task types on the basis of user's opinion



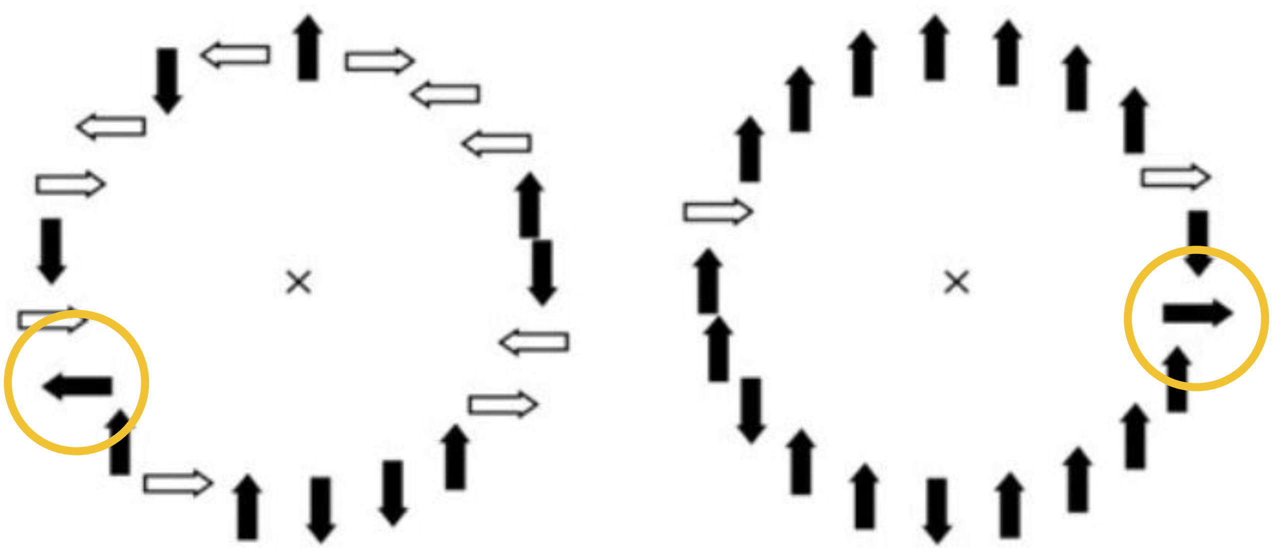


Working Memory Capacity

"The term working memory refers to a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension learning, and reasoning."

BADDELEY and HITCH, Working memory, 1974

Impact of Working Memory Capacity on Attention Guidance



Higher WMC = Better selective attention and distractors avoidance during visual search [3,4]

[3] POOLE, Bradley J.; KANE, Michael J. Working-memory capacity predicts the executive control of visual search among distractors: The influences of sustained and selective attention. *The Quarterly Journal of Experimental Psychology*, 2009, 62.7: 1430-1454.
[4] SOBEL, Kenith V., et al. Individual differences in working memory capacity and visual search: The roles of top-down and bottom-up processing. *Psychonomic Bulletin & Review*, 2007, 14.5: 840-845.

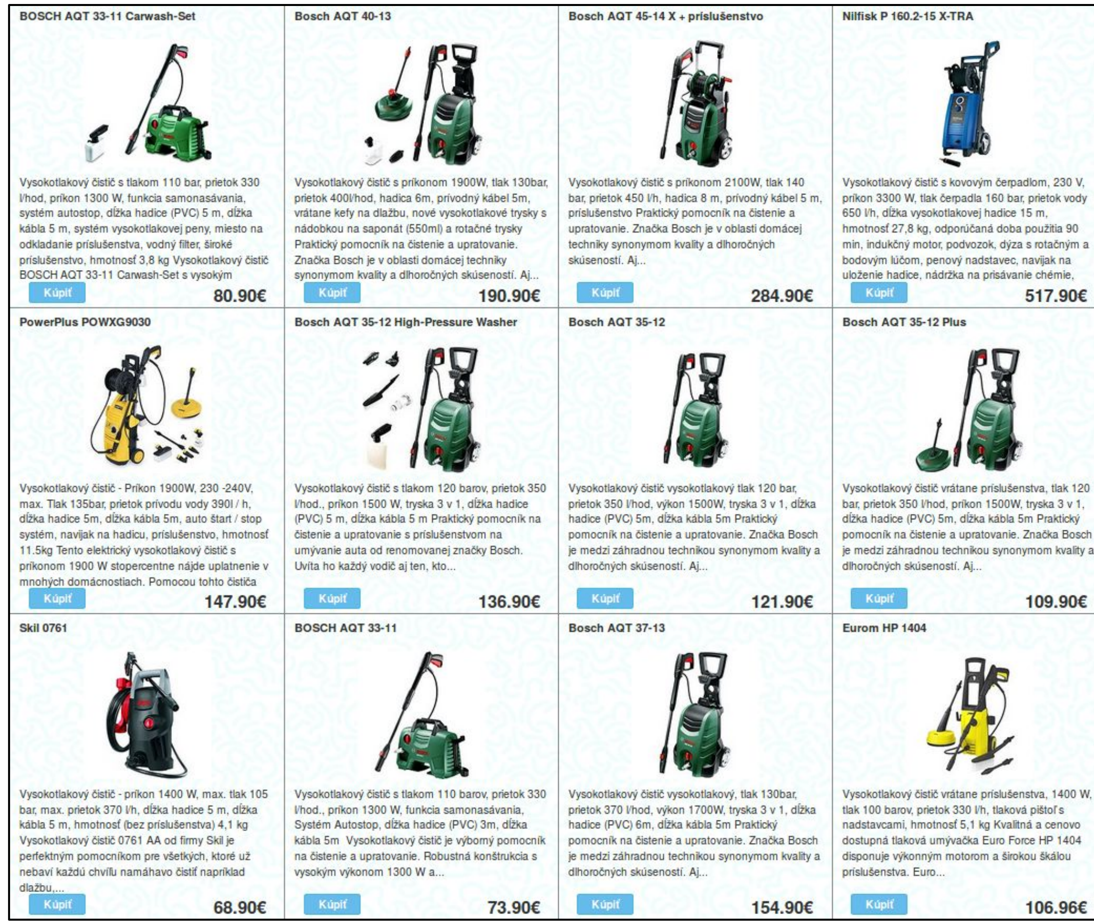
Identifying Working Memory Capacity Level Using Saliency-Based AOIs

1. **Track user's eye gaze while searching in e-catalog**
2. **Define areas of interest based on their *saliency***
3. **Evaluate eye tracking measures**
    a. Standard measures (evaluated without AOIs)
    b. AOI-based measures
4. **Classify user's working memory capacity level** (low/ standard/ high WMC)

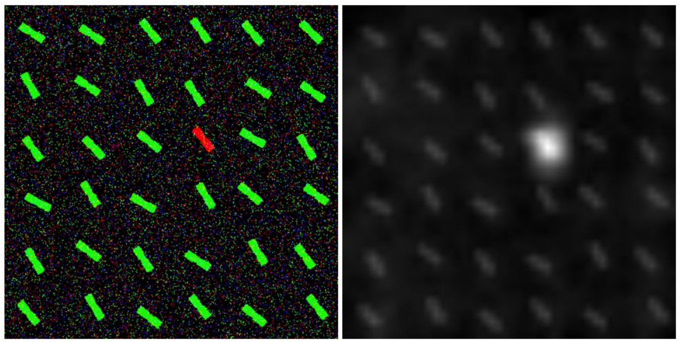
1. Eye Tracking while Searching in E-Catalog

Keeping **INVARIABILITY of the other factors:**

- ✓ **Search (Simple, Complex)**
- ✓ **Layout of Web Page**
- ✓ **Static Web Page**



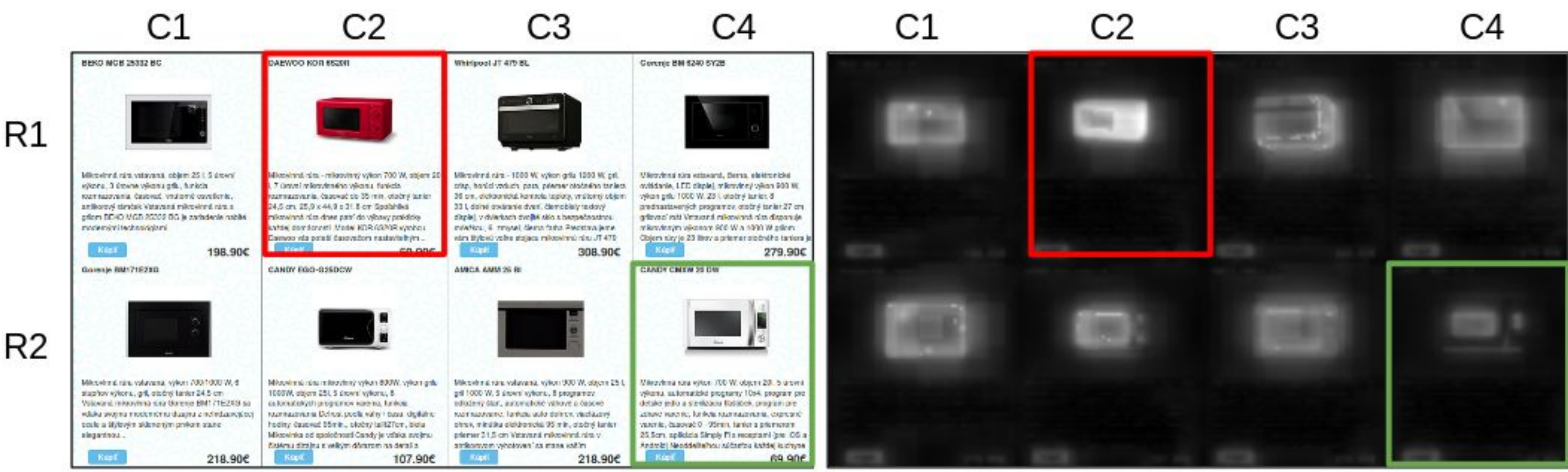
2. Defining Areas of Interest



A. **Itti** [5] - Create saliency map

B. **Pixel values summary** *Saliency*$_{Ri,Cj}$ calculated for each product area

C. **Most salient areas = AOIs**



[5] ITTI, Laurent; KOCH, Christof; NIEBUR, Ernst. A model of saliency-based visual attention for rapid scene analysis. IEEE Transactions on pattern analysis and machine intelligence, 1998, 20.11: 1254-125

3. Evaluating measures to detect WMC differences

AOI-Independent Measures:

- Number of fixations (n)
- Fixation Rate (n/ms)

} Information is extracted during fixation [6]

AOI-Dependent Measures:

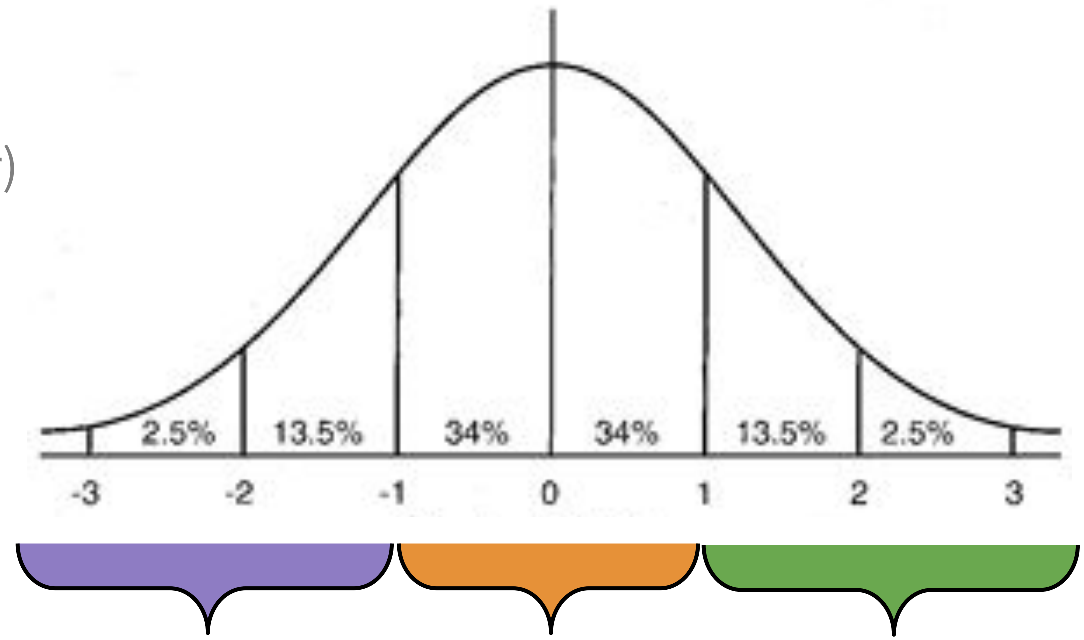
- Number of fixations in AOI
- Sum of fixation durations in AOI
- Time to first fixation on AOI
- Proportion of number of fixations on AOI to total number of fixations

[6] BOJKO, Aga. Eye tracking the user experience. Rosenfeld Media, 2013.

4. Classification of Users

Based on value **v**, which is a score in standardized SSPAN test used to determine WMC:

- **Low-WMC:** **v** < (μ − σ)
- **Standard:** (μ − σ) < **v** < (μ + σ)
- **High-WMC**: **v** > (μ + σ)



Using the mean and standard deviation from existing research (Draheim, 2017) [8])

[8] DRAHEIM, C., et al. What Item Response Theory Can Tell Us About the Complex Span Tasks. Psychological assessment, 2017

Evaluation of Measures

SSPAN - Results [8]:

Mean; st.dev: 34; 7 (Draheim: 31; 8)

VSEARCH - Results[9]:

Linear distribution - Wolfe

AOI-Independent Measures

Moderate correlation:

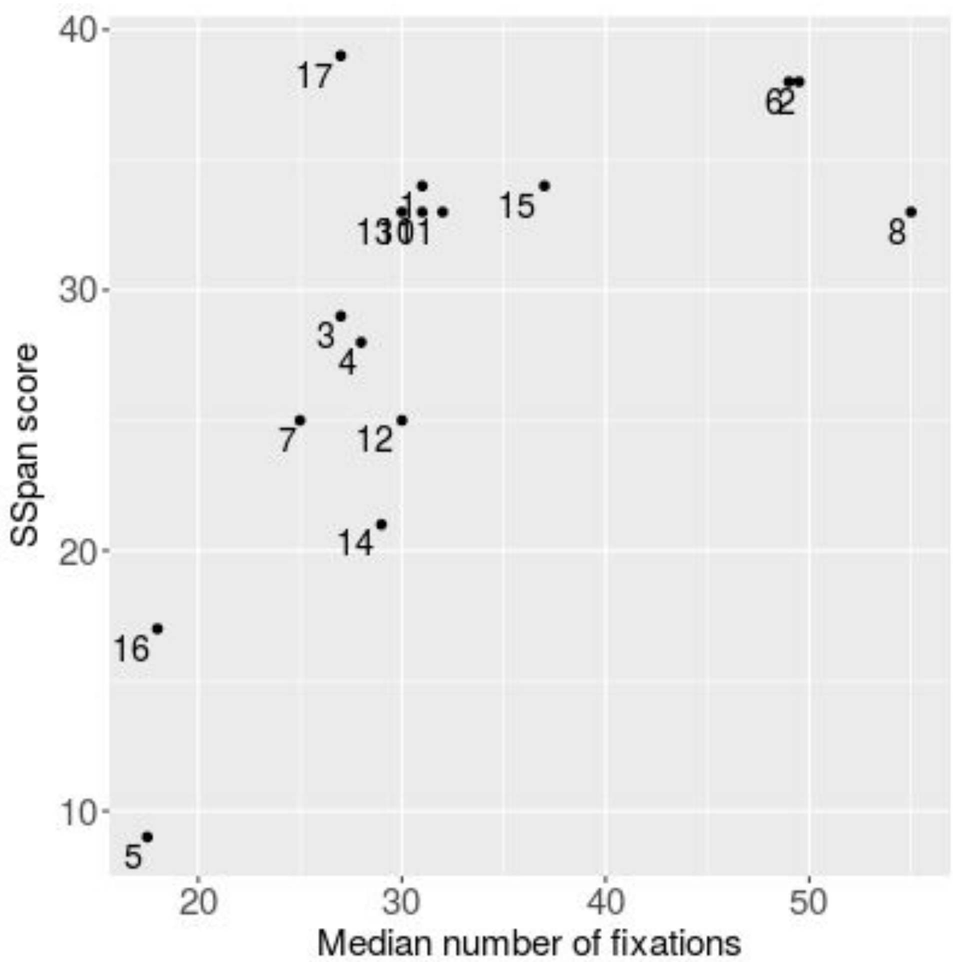
Fixation rate (r=0.46)

Median number of fixations (r=0.56)

AOI-Dependent Measures

Work in Progress

First insights -> we need more data



[8] DRAHEIM, C., et al. What Item Response Theory Can Tell Us About the Complex Span Tasks. Psychological assessment, 2017
[9]WOLFE, Jeremy M.; PALMER, Evan M.; HOROWITZ, Todd S. Reaction time distributions constrain models of visual search. Vision research, 2010, 50.14: 1304-1311

Next Experiment in UX@Class

Tasks (flow designed in Tobii Studio):

I. **SSPAN - Symmetry Span Task**
   - *The same configuration* = (2,3,4,5 elements x 3 trials)

II. **Visual Search Task**

III. **Searching Tasks in E-Catalog**
   - *Include more targets defined by color & shape*
   - *Reduce number of tasks to max.5 for each task type*
   - *Better explanation of 'Browse' type task to improve understandability*

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Tasks: Searching - Browsing

WMC: Measures investigated in saliency-based AOIs

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