Cognitive Abilities and Visual Complexity: Web Users' behaviour and perception

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Visual Complexity and Cognitive Abilities

- Introduction
- Aim of the study
- Methodology
- Results
- Conclusions
- Future Work

Visual Complexity

- The density and diversity of a web page's elements presented and overall layout of the page.
- ViCRAM is a visual complexity prediction algorithm based on structural elements of Web pages: Chunks (sections), Words and Images.

Cognitive abilities

- Describe how the individual acquires knowledge (cognition) and processes information. There are various terms encountered in the literature related to this area.

e.g. Field Dependent, Field Independent (Witkin, 1979)
and Field Neutral (Garton et al.,1999)

Aim:

- Relate users' visual complexity perception with their cognitive ability.
- Identify cognitive ability based on user web behaviour.

Research Question:

- How web visual complexity *perception* and user *interaction* is affected by user's cognitive ability?

  - Perception > user ranking score
  - Interaction > web user behavior

A comparative evaluation of two methodologies:

1. ViCRAM: Algorithm that predicts a web page's visual complexity based on the overall layout of the page

2. User's cognitive abilities identification based on the Field Dependent-Independent classification.

Eye tracking

- Task Oriented: For each page they had to find a given phrase

Online Survey

- Demographic Data
- Rank stimuli based on their visual complexity score
- Define visual complexity based on their perception

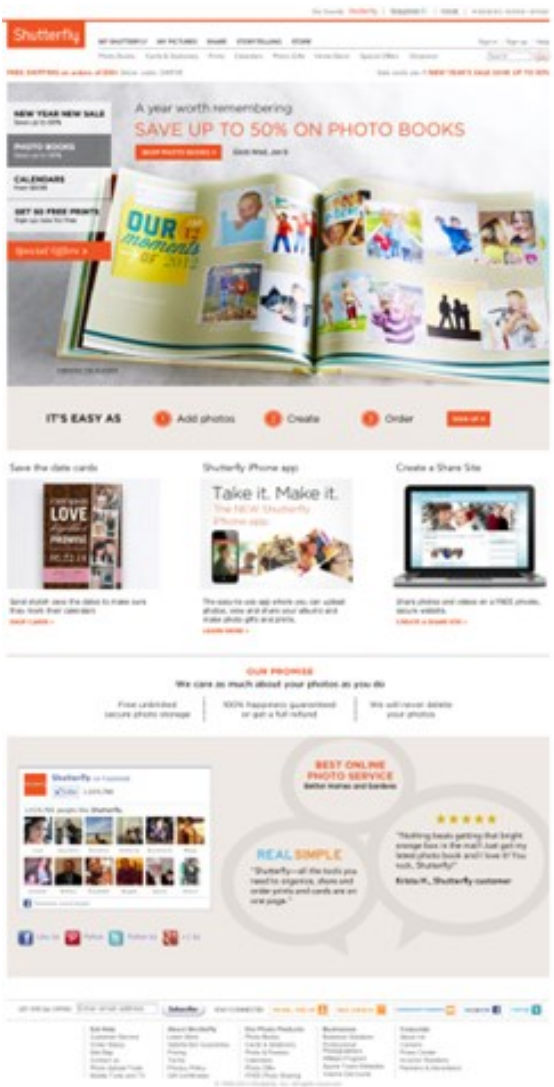
Participants

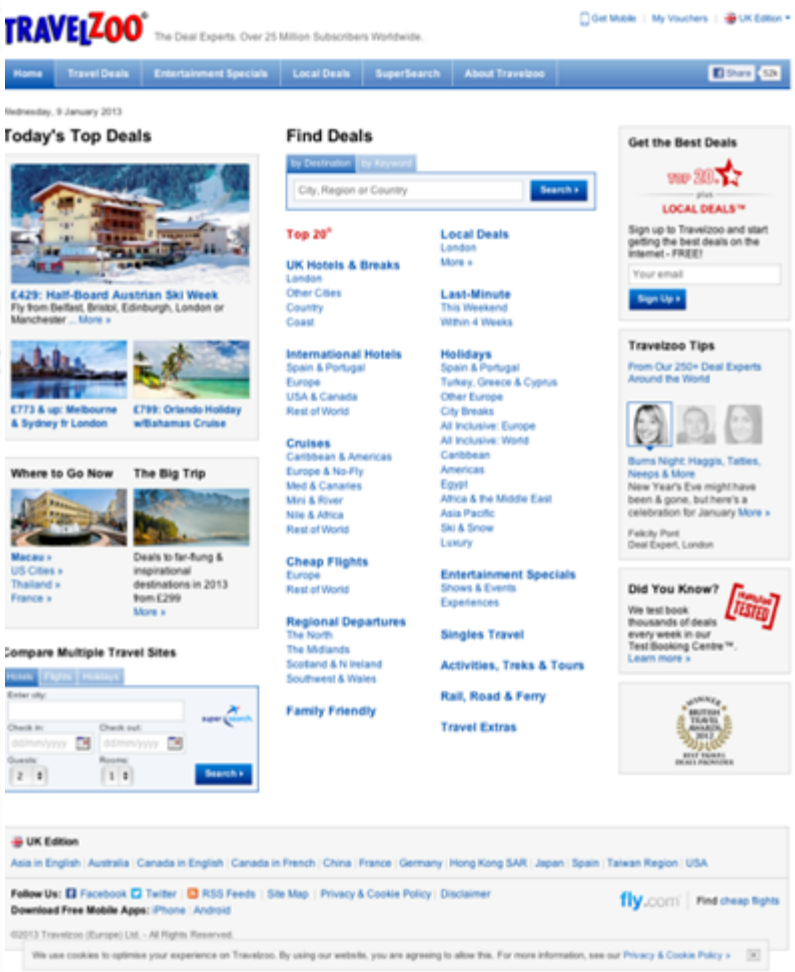
- 16 Subjects that participated on previous HFT (Hidden Figures Test) experiment (French, Ekstrom & Price, 1976)
  - FD: 7
  - FN: 3
  - FI: 6
- Age range 24-28
- Cyprus University of Technology

Stimuli

- 10 Web pages
- Categories: Shopping, Government, Leisure-Social, Education, News
- Complexity based on ViCRAM tool: 0 -10

Stimuli Examples:





Medium Complexity
TravelZoo

Simple Complexity
Shutterfly

High Complexity
Reuters

Qualitative Analysis

- Heat Map
- Scan Path
- Gridded AOI (Area of Interest)
- Gaze record analysis (time task completion)

Quantitative Analysis - SPSS

- Comparison between HFT cognitive ability scores and ET metrics
- Time to complete the task
  - Time x Visual Complexity Algorithm
  - Time x Cognitive ability
  - Time x Visual Complexity Ranking
- Comparison between user and algorithm rankings
  - Cognitive ability x Visual Complexity

Qualitative Analysis

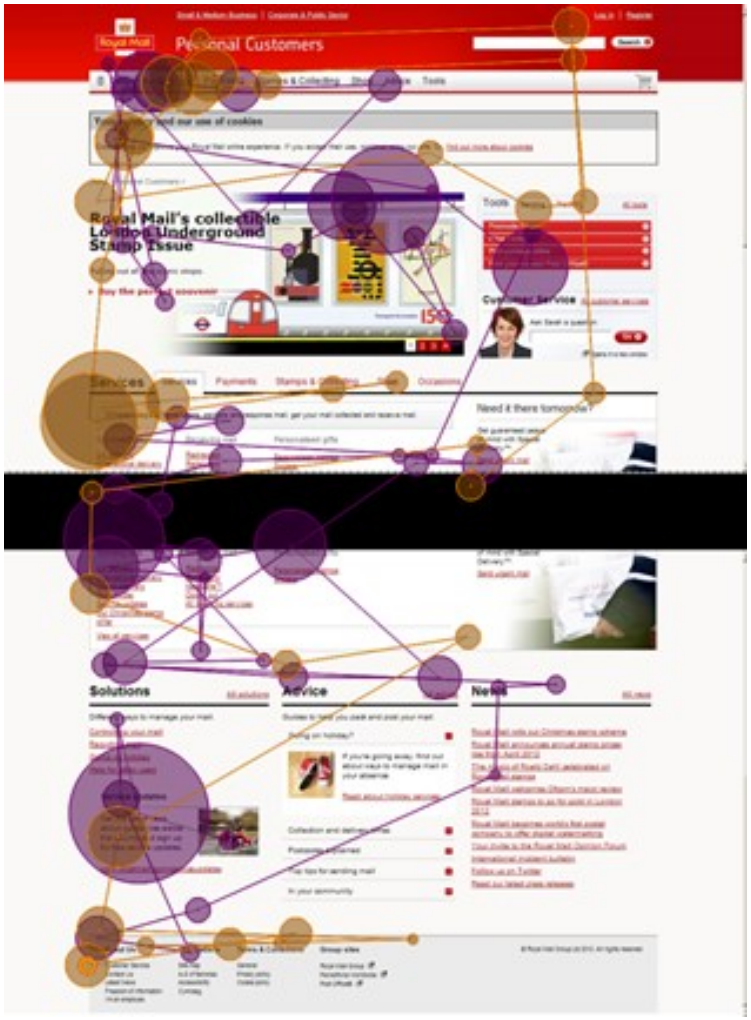
- Heat Map
- Scan Path
- Gridded AOI (Area of Interest)
- Gaze record analysis (time task completion)

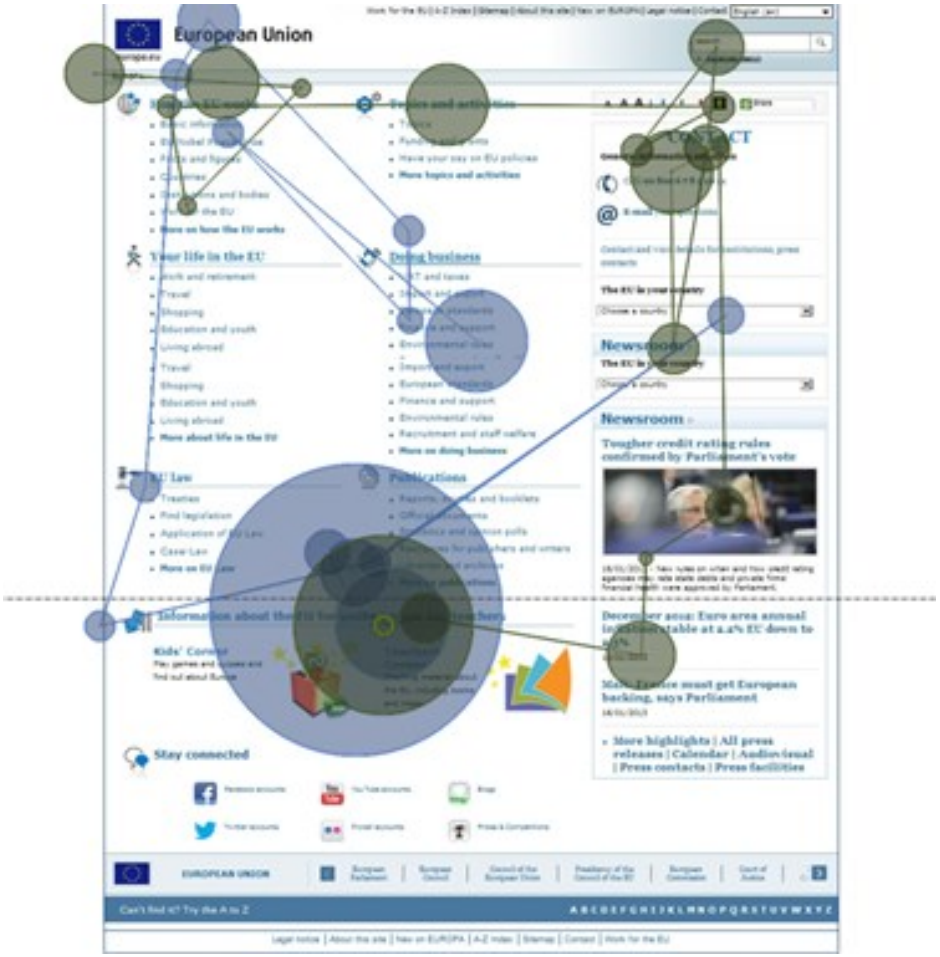
FD: Disoriented and scattered scanpaths and fixations on visual complex pages

FI: More oriented and organized scanpaths/ fixations

Common behaviour on simple pages: FI, FD and FN

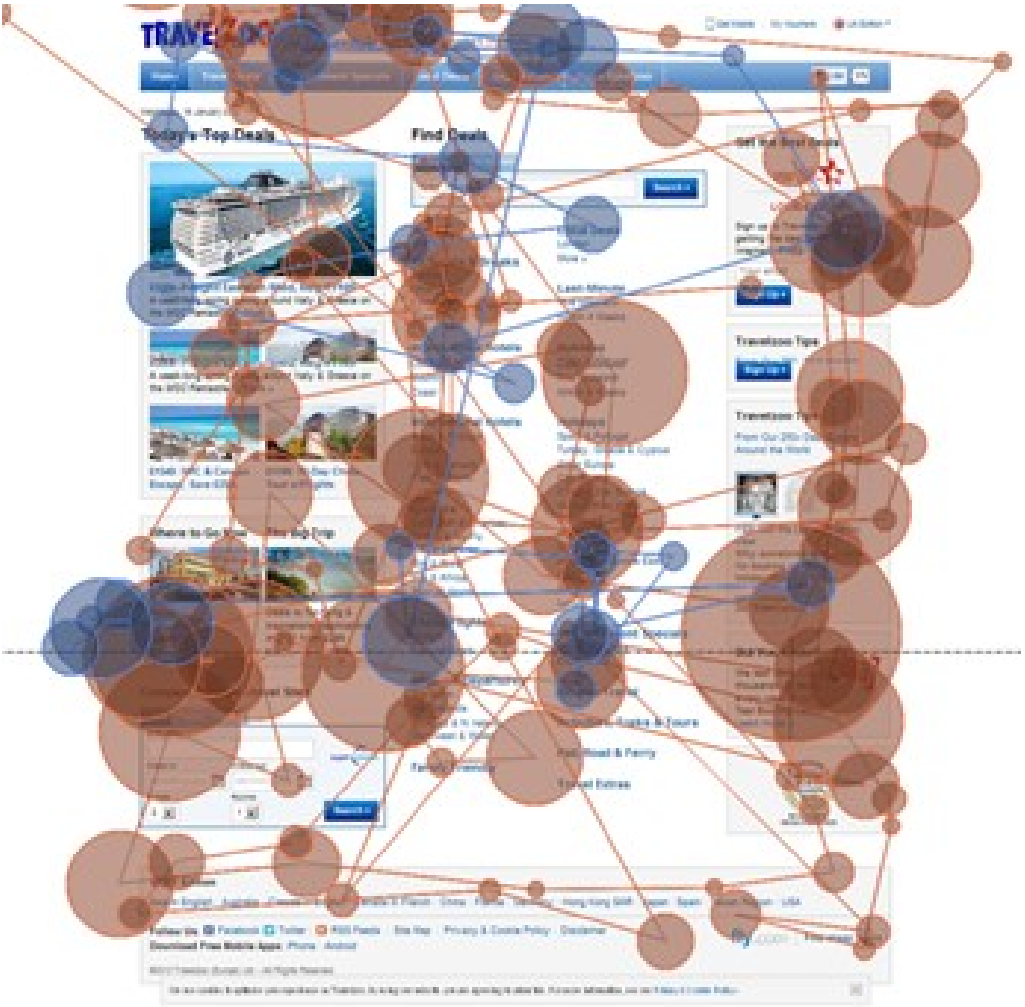
Common Behavior FI users

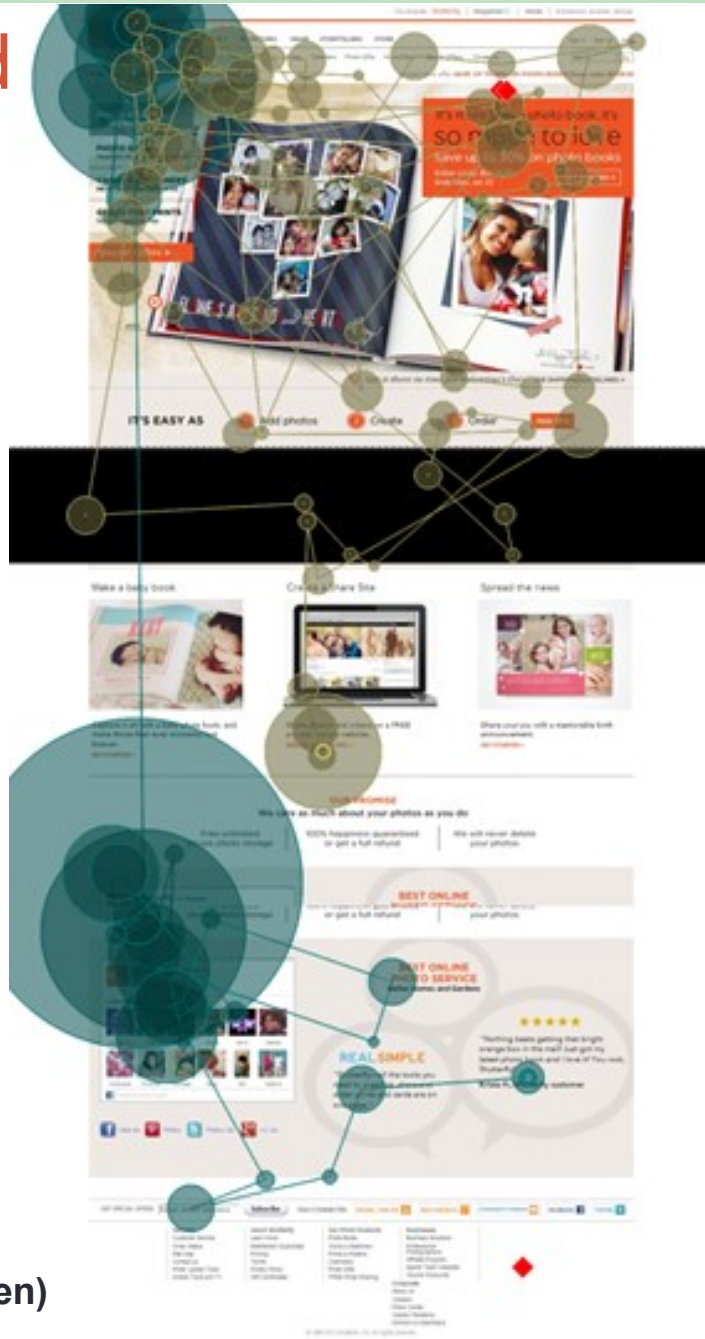




Common behavior FD

FD and FI differences on medium and complex pages





FD (red) | FI (blue)

FD (gold) | FI (green)

Quantitative Analysis

Comparison between HFT cognitive ability scores and ET metrics

- Time to complete the task
  - Time x Visual Complexity Algorithm
- Comparison between user and algorithm rankings
  - Cognitive ability x Visual Complexity

- Significant relation between HFT and ET results
- Significant correlation between user's behaviour on simple pages and their cognitive ability
- Significant differences exist among user's behaviour on medium and complex ranked pages and their cognitive ability

HFT scores and ET metrics

- We want to examine whether cognitive ability categorization can be achieved through users' mean average time of completion, relying on seconds instead of scores (as the HFT).
- Therefore propose a possible measurement of cognitive dimensions via ET and examine its potential in identifying these metrics.
- Classification of Cognitive ability based on the participants' mean average time of completion:

  - FI: < 10s

  - FM/FN: 11 – 17s

  - FD: >17s

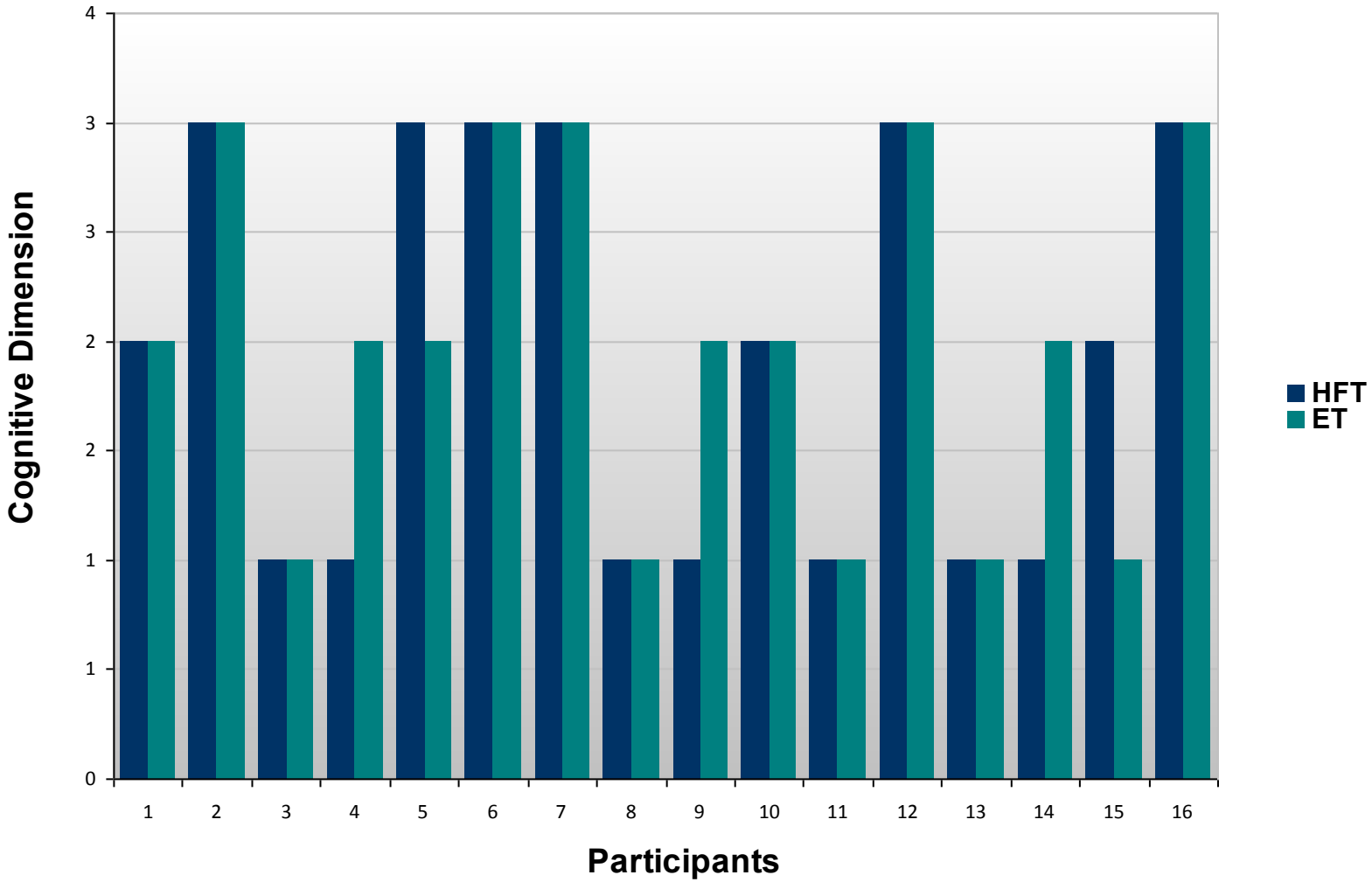


Figure 1. Comparison of the Hidden Figure Test and the Eye tracker metrics

Note. FD = 1, FN = 2, FI =3

Quantitative Analysis - SPSS

Table 1. Chi-Square values based on HFT and ET

Variables	N	X^2	df	Sig. (2-tailed)
Hidden Figure Test	16	16.653	4	0.002
Eye Tracker	16			

* The mean difference is significant at the 0.05 level.

Users' cognitive ability scores and webpages' visual complexity

Table 2: Independent sample T-test with regard to users' cognitive ability scores and webpages' visual complexity

		Levene's Test Equality of Variances		*t*-test for Equality of Means		
		F	Sig.	*t*	df	Sig. (2-tailed)
a) Complex	Equal variances assumed	3.821	0.074	2.338	12	0.038*
	Equal variances not assumed			2.338	9.132	0.044
b) Medium	Equal variances assumed	7.028	0.021	3.817	12	0.002
	Equal variances not assumed			3.817	6.816	0.007*
c) Simple	Equal variances assumed	3.601	0.082	1.407	12	0.185
	Equal variances not assumed			1.407	7.461	0.200

*The mean difference is significant at the 0.05 level.

Summary of Results

HFT scores were confirmed with gaze analysis with respect to user's navigation

- Predetermined FD users behaved the same for all 3 levels of complexity).
- Cognitive abilities matched
- Common behaviour between each cognitive group

FD and FI differences:

- Quantitative analysis revealed statistical difference between time and visually complex pages
- Qualitative analysis indicated differences on users behaviour between the last two types of complexity (medium, complex).

Conclusions

- The results of the study revealed the potential of the eye tracker technology in identifying users' cognitive dimensions.
- A statistical significant correlation exists between the scores retrieved from the HFT and the Eye tracker.
- Differences exist among the behaviour of the FD and FI cognitive groups, in terms of the time taken to complete the given tasks in the complex and medium complex webpages.
- In the simple pages no statistical differences appeared.

- Currently we are analyzing data collected from running the same study with a wider population.
  - Rank stimuli based on their visual complexity score.
  - Define visual complexity based on their perception.

- Expand research study with people with disabilities and further cognitive disabilities.

Design guidelines to be used by developers in order to design simpler web pages to enable interaction for all cognitive abilities

References

- French, J. W., Ekstrom, R. B., & Price, L. A. (1963). *Kit of reference tests for cognitive skills. Educational Testing Services.* Princeton: NJ.
- Garton, B. L., Spain, J. N., Lamberson, W. R., & Spiers, D. E. (1999). Learning styles, teaching performance, and student achievement: A relational study. Journal of Community development Education, 40(3), 11-20.
- Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1977). Field-dependent and field-independent cognitive styles and their educational implications. *Review of educational research*, 1-64.

Thank you for your attention!

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