A survey on the Role of Individual Differences on Visual Analytics Interactions

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Goals

Personality and other measurable individual traits influence how people interact with visualizations

Examine this research with respect to:

- Each individual trait
- The tasks that have been studied
- Interaction measurements taken

Explore future avenues for research

Conference Submission: IEEE VIS 2019

Individual Differences

Personality (Big 5: Openness to Experience, Conscientiousness, Extraversion, Agreeableness Neuroticism)

Locus of Control

Cognitive Abilities (Perceptual Speed, Visual and Verbal Working Memory)

Tasks

- Procedural vs Inferential Questions (Green et al)
- Retrieve Value • Filter • Compute Derived Value • Find Extremum • Sort • Aggregate (Amar et al)
- Rank visualizations in terms of preference
- Self-rate own performance, confidence

Evaluation Metrics

Accuracy (in answering questions about a visualization)

- Nearly all studies use this metric to assess results

Eye gaze interaction

Task Completion Time

Mouse interactions

Locus of Control

- Perceived degree of control over surrounding events
- Consistently shown to impact visualization interaction
- Heavily researched
- Difficult to make generalized statements about results

Using Personality Factors to Predict Interface Learning Performance (2010) - Locus of Control

- Examined impact of LOC on real-world visualizations
- Compared hierarchical relationships of level and containment
- External LOC: Faster completion times for inferential tasks

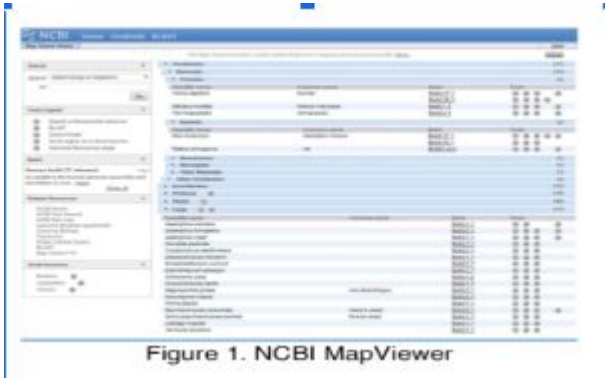


Figure 1. NCBI MapViewer

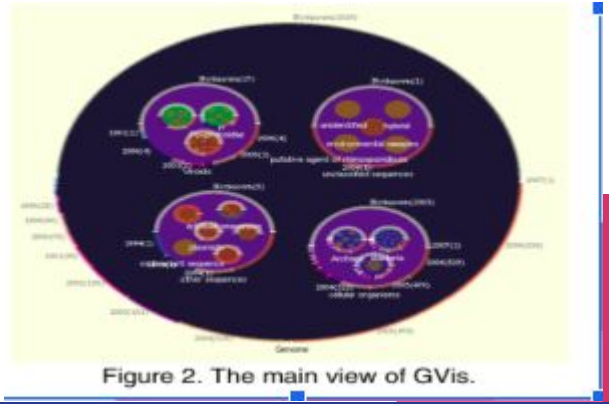
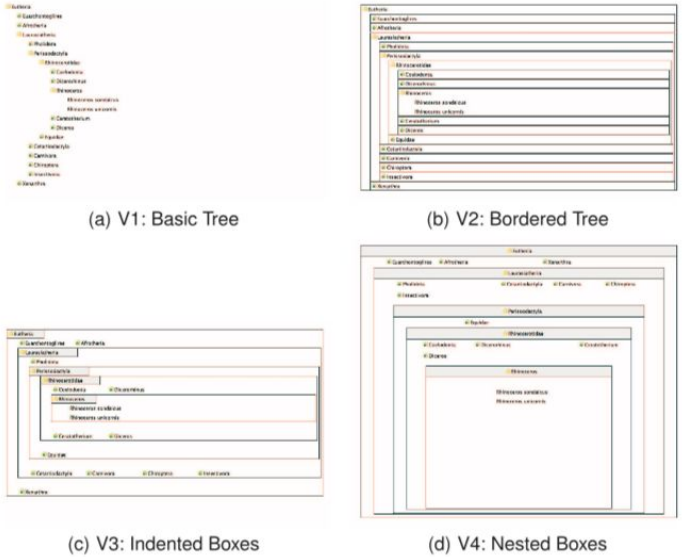


Figure 2. The main view of GVis.

How locus of control influences compatibility with visualization style (2010) - Locus of Control

- Isolated study of visualization layout structure



(a) V1: Basic Tree

(b) V2: Bordered Tree

(c) V3: Indented Boxes

(d) V4: Nested Boxes

Fig. 1. The four visualizations used in our study. Each view is showing the same portion of one of the phylogenetic tree data sets.

Priming Locus of Control to affect performance (2012) - Locus of Control

- Replicated Ziemkiewicz's study
- Participants were asked to recall situations in which they felt in control or out of control beforehand
- Effects of LOC on visualization interactions can be "swayed" towards a particular end

Finding Waldo: Learning about Users from their Interactions (2014) - Locus of Control

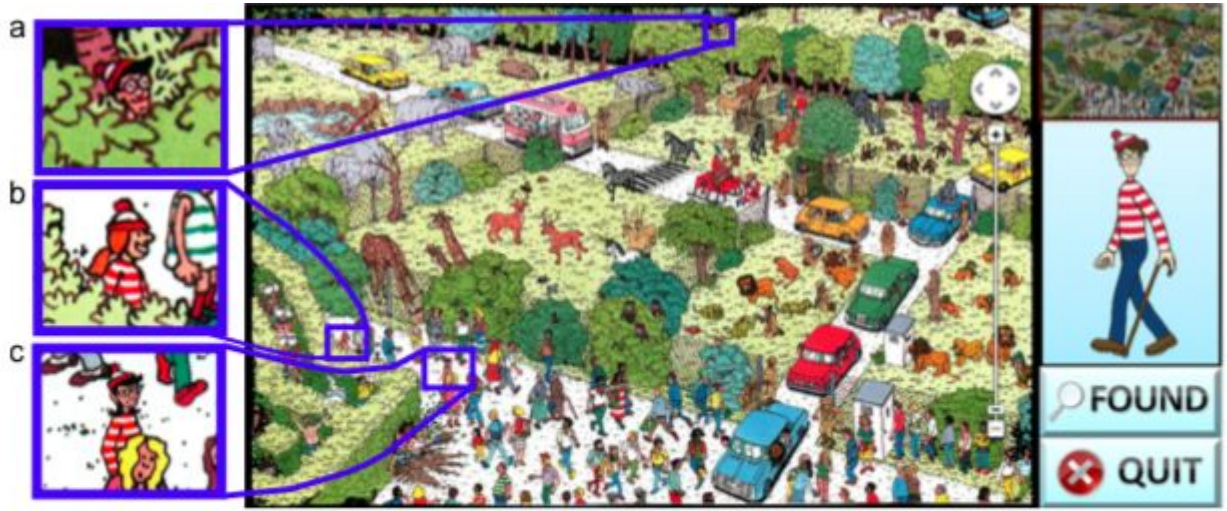


Fig. 1. The interface from our user study in which participants found Waldo while we recorded their mouse interactions. Inset (a) shows Waldo himself, hidden among the trees near the top of the image. Distractors such as the ones shown in inset (b) and (c) help make the task difficult.

Finding Waldo: Learning about Users from their Interactions (2014) - Locus of Control

- 3 encodings: State-based, event based, sequence based
- Each encoding of the interactions could predict completion times and infer levels of Locus of Control, Extraversion, and Neuroticism

Locus of Control Progression

- Using Personality Factors to Predict Interface Learning Performance
  - Examine LOC within a real world context, manner of interaction with different tasks
- How locus of control influences compatibility with visualization style
  - Isolate visualization layout for study with respect to LOC
- Priming Locus of Control to affect performance (2012) - Locus of Control
  - Examine whether effects of LOC can be influenced by priming
- Finding Waldo: Learning about Users from their Interactions
  - Present novel tasks and interaction encodings with promising use cases

Cognitive Abilities

- Commonly labeled as Perceptual speed, and Visual working memory, and verbal working memory
- Higher levels of cognitive abilities generally correlated with higher accuracy measurements

User-Adaptive Information Visualization - Using Eye Gaze Data to Infer Visualization Tasks and User Cognitive Abilities (2013) - Cognitive Abilities

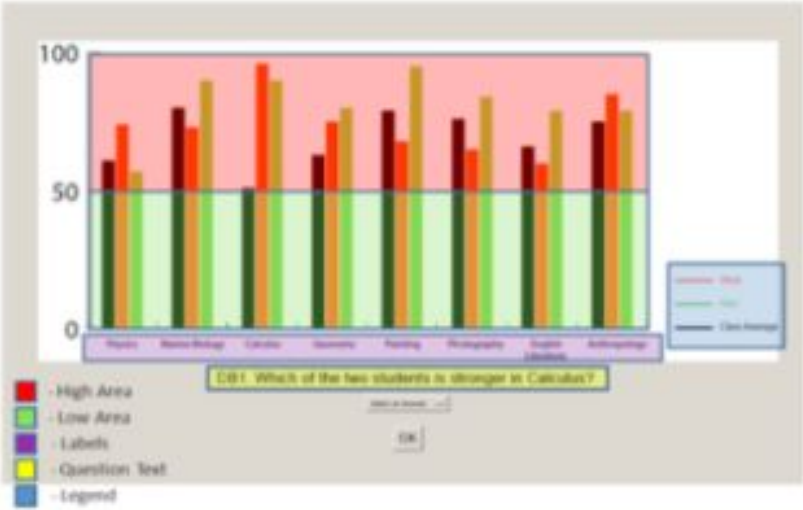


Figure 3: The five AOI regions defined over a bar graph

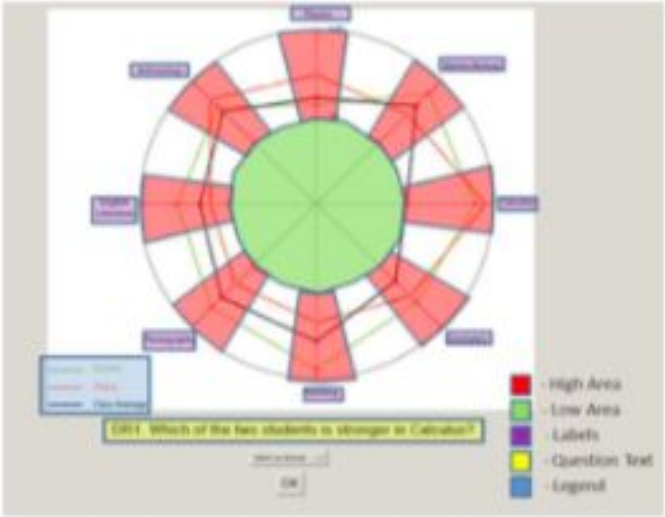


Figure 4: The five AOI regions defined over a radar graph

User-Adaptive Information Visualization - Using Eye Gaze Data to Infer Visualization Tasks and User Cognitive Abilities (2013) - Cognitive Abilities

- High Visual working memory: Lower times to first AOI fixation
- High Verbal working memory: Less time needed in AOIs
- Low perceptual speed: More focus in graph legends

Highlighting Interventions and User Differences: Informing Adaptive Information Visualization Support (2014) - Cognitive Abilities

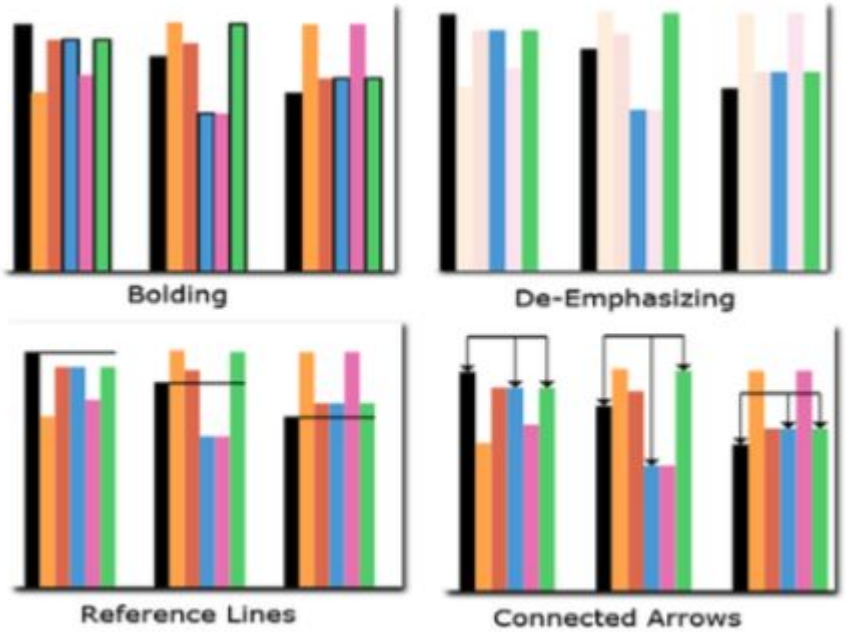


Figure 2. Interventions used in the study.

Highlighting Interventions and User Differences: Informing Adaptive Information Visualization Support (2014) - Cognitive Abilities

- Weak negative correlation between perceptual speed, locus of control
- Intervention time was not found significant
- High perceptual speed: Significantly faster task completion
- Low verbal working memory: Significantly worse performance

Evaluating the Impact of User Characteristics and Different Layouts on an Interactive Visualization for Decision Making (2014) - Cognitive Abilities

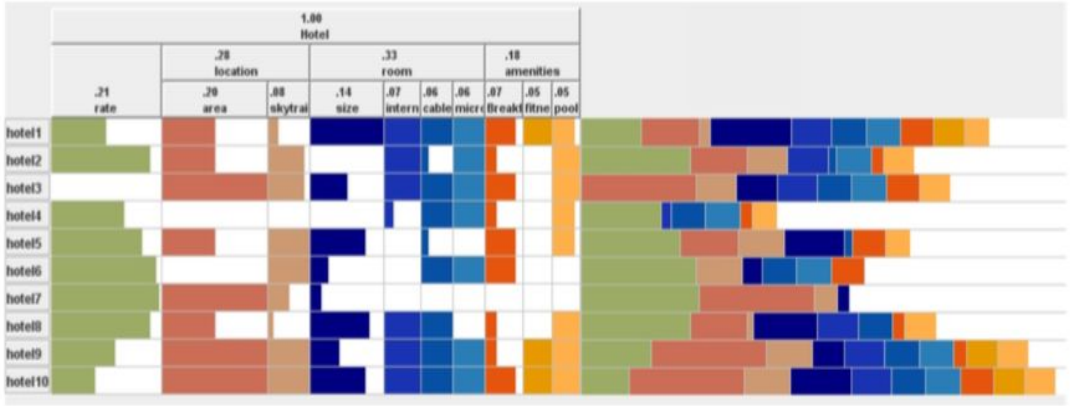


Figure 1: *ValueChart using horizontal layout (VC-H), in the sample domain of hotel selection.*

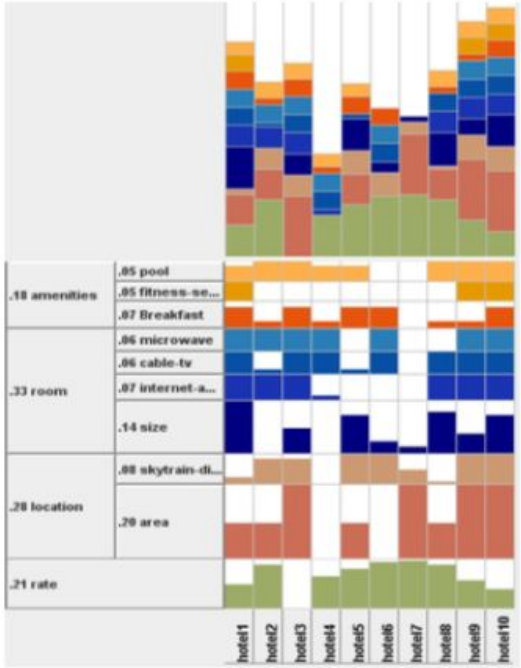


Figure 2: *ValueChart using vertical layout (VC-V).*

Evaluating the Impact of User Characteristics and Different Layouts on an Interactive Visualization for Decision Making (2014) - Cognitive Abilities

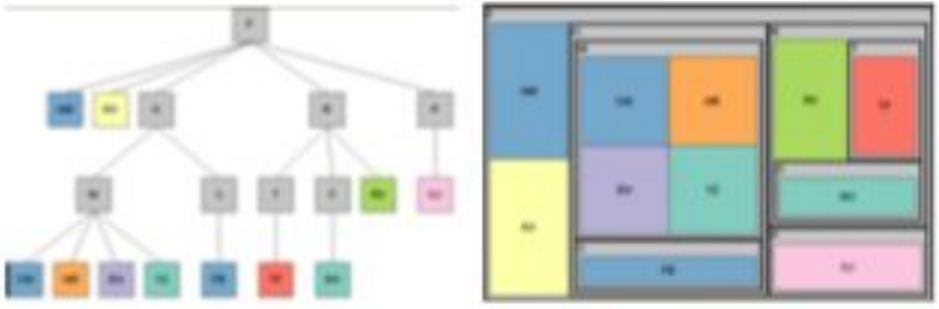
- Low Verbal WM: slower sorting times
- Low Visual WM : slower sorting times, faster with horizontal rather than vertical layout
- High expertise: faster completion times in general
- Perceptual speed: faster completion times in general
- Low Visual WM: Much faster with horizontal value charts than vertical ones

Openness

- Curiosity, Willingness to consider new ideas, experiences
- Most studies have not discussed it, or have found it nonsignificant

Preconceptions and Individual Differences in Understanding Visual Metaphors (2009) - Openness

- Examine the “compatibility” of visual metaphors and questions



(a) Node-link condition (b) Treemap condition

Figure 2: *The visualizations used in the study.*

Openness

Ziemkiewicz and Kosara / Preconceptions and Individual Differences

Containers	Levels
1. Does directory H contain a deeper hierarchy than directory P?	1. Does directory H have more levels under it than directory P?
2. Does directory W contain more subdirectories than directory H?	2. Are there more subdirectories under directory W than directory H?
3. Are there more files immediately inside directory R than directory F?	3. Are there more files immediately below directory R than directory F?
4. Are both file RV and file KH within directory R?	4. Do both file RV and file KH fall under directory R?

Participants have higher accuracy rates when dealing with compatible visualizations and questions

Except when exhibiting high levels of openness

Conscientiousness

- Trait characterized by carefulness, diligence, discipline
- Found to have a positive correlation with academic success
- Few isolated correlations found with respect to visualization interactions
- Correlations with Neuroticism, Extraversion

Towards incorporating personality into the design of an interface: a method for facilitating users' interaction with the display (2018) - Conscientiousness, Extraversion, Neuroticism

- Conscientiousness and Extraversion clustered together against Neuroticism
- Participants expressed preference for the design catered towards the clusters they belonged to

Towards incorporating personality into the design of an interface: a method for facilitating users' interaction with the display (2018) - Conscientiousness, Extraversion, Neuroticism

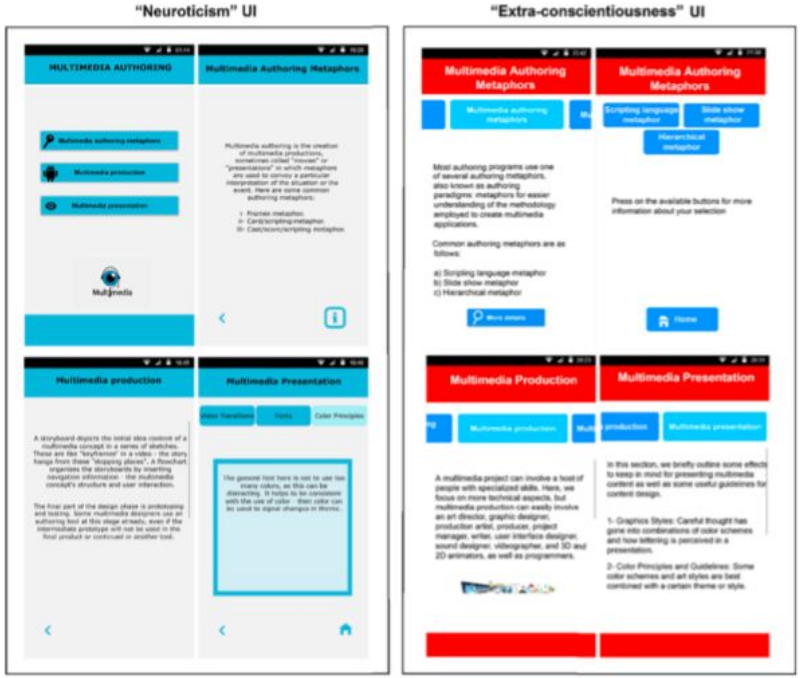


Fig. 3 Illustration of mobile device UI design for the two personality groups

Table 1 Association rules results

No.	Cluster name	Confidence (%)
Neuroticism cluster		
1	Alignment centre ==> Network structure	100
2	Network structure ==> Relative layout	98
3	Low information density ==> Buttons photo	100
4	Verdana header 53-point ==> Segmented control	100
5	Scroll thumb ==> Relative Layout	99
6	Font text size 40-point ==> Relative layout	100
7	Buttons photo ==> Expanding list	100
8	Font header 53-point ==> Verdana font type	96
9	Font text size 40-point = Verdana font type ==> Colour Hue	99
10	Stepping ==> Expanding list	100
Extra-conscientiousness cluster		
1	Slidable top navigation ==> Network structure	100
2	Font size 14 point ==> Relative layout	100
3	High information density ==> Buttons photo	100
4	Slidable top navigation ==> Scroll thumb	97
5	Buttons name and photo ==> Scroll thumb	100
6	Font header 75-point ==> Arial font type	100
7	Font text size 51-point ==> Arial font type	99
8	Scroll thumb ==> Colour hue	100
9	Align text left ==> Font text size 51-point	100
10	Scroll thumb ==> Segmented control	99
11	Relative layout = Font text size 51-point ==> Align text left	100

Extraversion

Trait associated with assertiveness, being energized by social situations

Consistent significance (Waldo, A First Look at the Effectiveness of Personality Dimensions in Promoting Users' Satisfaction With the System)

Neuroticism

Inclination towards experiencing negative emotions

- Negatively correlated with health, except when paired with high conscientiousness
- How Visualization Layout Relates to Locus of Control and Other Personality Factors: High neuroticism: Preference towards more explicit metaphors

Agreeableness

Characterized by cooperativeness, kindness, modesty

Has not been found significant

Raises the question:

For a trait that has not been found significant, what future avenues of research are there?

Where do we go from here?

Big Five Research

Others Traits (Anxiety, Need for Cognition, Expertise, Cognitive Load, Spatial abilities)

Questions?