

MSc/PhD Thesis Proposals

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Human Factors in Data Visualization

How individuals **interpret** and **act** upon data visualizations, with particular attention to the mechanisms underlying **trust** and **decision-making**.

Emotion induction through data storytelling

Data storytelling has emerged as a powerful tool for conveying complex information in an accessible and engaging way. However, beyond mere comprehension, data stories have the potential to **evoke specific emotions** in the audience, influencing **perception, decision-making**, and **trust**. This study aims to explore how different **narrative and visual design techniques** in data storytelling contribute to emotional responses. The research is expected to help answer questions such as:

- 1. What visual and textual elements contribute to specific emotional reactions?*
- 2. How do emotionally engaging data narratives affect users' perception, trust, and decision-making?*

Note: may require development of Javascript code with the D3 library (intermediate level).

Impact of Aesthetics on Data Visualization-Supported Decision-Making

Visual elements such as icons, color gradients, shapes, or artistic compositions are increasingly used to capture attention. Although they can increase engagement and memorization, their cognitive and emotional effects on **trust** and **decision-making** remain unclear. This research aims to explore whether **visual embellishment** facilitates or distorts interpretation and how it **shapes trust** in the data presented. The research is expected to help answer questions such as:

- 1. How do different types of visual elements (e.g., icons, textures, illustrative elements) affect the accuracy and confidence of data-based decisions?*
- 2. To what extent do visual elements increase or decrease cognitive and affective confidence in a data visualization?*

Note: may require development of Javascript code with the D3 library (intermediate level).

Impact of Readability on Data Visualization-Supported Decision-Making

The **readability** of graphics is essential for correctly interpreting data. However, design choices that reduce readability (such as excessive labels, excessive colors, information overload, or inappropriate scales) can **compromise understanding** and lead to **biased interpretations**. This research analyzes how readability factors influence the user's **ability to interpret and their confidence**. The research is expected to help answer questions such as:

- 1. How does reduced readability affect the user's cognitive and affective trust in the visualization and underlying data?*
- 2. Do users perceive readable graphics as more credible even when they present misleading information?*

Note: may require development of Javascript code with the D3 library (intermediate level).

Impact of Data Source on the Trust-Building Process with Data Visualizations

Trust in a visualization depends not only on its design, but also on the perceived credibility of the **data source** (e.g., scientific institutions, governments, companies, media). The attribution of the source can create **expectations and biases** even before analyzing the graph. This research evaluates how **source identity** influences **trust** and **decision-making**, especially when faced with **ambiguous or potentially misleading visualizations**. The research is expected to help answer questions such as:

- 1. Does source credibility interact with chart design to reduce or increase misleading interpretation?*
- 2. Are users more tolerant of visual clutter or low readability when the source is considered trustworthy?*

Note: may require development of Javascript code with the D3 library (intermediate level).

Impact of Individual Differences on the Critical Evaluation of Data Visualizations

Not all users are equally vulnerable to misleading graphics. **Individual differences** such as visualization literacy, numerical ability, cognitive reflection, prior beliefs, and personality traits can influence the **ability to identify manipulative visual tactics**. This research seeks to identify which human characteristics best predict **resistance to visual misinformation and how they shape trust**. The research is expected to help answer questions such as:

- 1. Which cognitive or demographic characteristics best predict the detection of misleading graphics?*
- 2. Is it possible to predict, based on personality or cognitive profiles, whether a user will rely more on affective or cognitive trust when evaluating a graphic?*

Note: may require development of Javascript code with the D3 library (intermediate level).

You can suggest the **domain** (e.g., healthcare, finance, tourism) and whether we use **real** or **synthetic** data.

For instance, **health professionals**, **policymakers**, and the **public** rely on visual dashboards to track real-time data on diseases, vaccination rates, or hospital capacities (remember COVID-19?). Which factors make individuals perceive visualizations as more **accurate** and **transparent**? Is it more based on **affective** or **cognitive** trust?

You can also consider if the **visual marks** and **their encodings** allow users to understand the visualization and read the data and its features or if the layout may affect **investors' decisions** or **estimations** of annual reports (e.g., stocks, 10-K filings).

Finally, even if immigrants are distributed randomly across the city, areas with higher population density or different socioeconomic factors might naturally have both more immigrants and more crime, creating a **random overlap that appears clustered**. Have you considered how does the **clustering illusion** (seeing patterns in noise) affect user acceptance of public policies?

Helping Experts with Data Visualization

User-centered design approaches to develop **data visualization systems** (such as dashboards) for experts in other research domains.

I am also interested in conducting **design studies**. A design study in the context of information visualization, as described by Sedlmair et al. (2012), is a research approach that **investigates real-world problems through the iterative design and evaluation of visualization systems**.

It begins with a deep understanding of the **domain**, its **stakeholders**, and their **tasks**, which informs the generation of visualization concepts tailored to their needs. **Prototypes** are then developed and iteratively refined based on **user feedback**, combining design, implementation, and evaluation in a cyclic process.

The study concludes with **reflection**, producing both a validated visualization system that addresses the specific problem and generalizable insights that contribute to the broader visualization research community.

Which entities have already manifested interest in a design study?

- The ISCTE's **Research Support Office** would like to have a dashboard to understand how the university applies for and secures funding in national and international calls.

If you know some experts who would like a visualization system, let me know. We are already conducting one with the **Emigration Observatory (OEm)** and we have conducted one with the **Faculty of Psychology, University of Lisbon**.

Exploring Digital Heritage Collections @ DAViD Lab

How we design **human-computer interfaces** for the exploration and interpretation
of **digital heritage collections**.

Evaluating Multimodal Gestural Interfaces for Exploring 19th-Century Portuguese Transport Histories

Historical engineering plans (A0/A2) are dense, multi-layered, and spatially complex. Standard mouse/touch interfaces fail to convey the scale and depth of these documents or allow users to "step inside" the data. We can design and test a gestural and gaze-based navigation system specifically for large-format historical technical drawings. We want to answer some questions:

- 1. How do researchers interact with a 3D laser-scanned map using hand gestures vs. natural language commands?*
- 2. Does removing the physical barrier (mouse/keyboard) reduce cognitive load when analyzing complex infrastructure evolution?*

Note: may require development of C# code in the Unity game engine (intermediate level).

Adapting Narrative Complexity Based on User Engagement Signals

Users often get overwhelmed by the sheer volume of unstructured archival data or lose interest because the visualization doesn't adapt to their confusion or engagement level. We can leverage the lab's biometric sensors to create an adaptive visualization system. If the system detects user frustration (dilated pupils, erratic eye movement) while viewing a complex railway schedule, it could automatically simplify the view or offer a guided tour. If it detects deep engagement, it might unlock deeper layers of metadata. We want to answer some questions such as:

- 1. Can real-time biometric feedback effectively drive dynamic simplification of complex historical datasets without breaking the user's sense of agency?*
- 2. Does an adaptive AR environment that responds to physiological stress markers lead to higher retention of historical facts compared to static visualizations?*

Note: may require development of C# code in the Unity game engine (intermediate level).

Using Augmented Reality to Bridge the Gap Between 19th-Century Plans and Modern Urban Landscapes

There is a disconnect between the abstract 2D archival documents and the modern physical reality they describe. Researchers struggle to mentally map old road routes onto current cityscapes. We can develop an AR overlay framework that aligns laser-scanned 19th-century maps with the real-world geography of Lisbon (or other Portuguese cities). This thesis would focus on the registration accuracy required for historical data and the user experience of "seeing history" through the lens of a tablet or AR glasses while walking the actual sites. We can answer questions such as:

1. *How does spatial alignment precision in AR affect the researcher's ability to validate historical claims against current urban geography?*
2. *Does experiencing historical infrastructure changes through spatial AR (walking the route) foster a deeper emotional and intellectual connection to the material than viewing it in a 2D monitor?*

Note: may require development of C# code in the Unity game engine (intermediate level).

Speculative Reconstruction and Immersive Exploration of Never-Realized Architectural Plans from Historical Archives

This thesis investigates how immersive digital technologies can materialize unrealized architectural projects (plans that exist only on paper but were never built) using the DAViD Lab's archival holdings and visualization infrastructure. The focus is on creating an interactive "what if" framework where users can explore counterfactual urban histories through VR/AR reconstruction of unbuilt buildings from Portuguese historical archives. We can answer questions such as:

1. *What design patterns most effectively communicate certainty vs. speculation when visualizing unbuilt architectural projects in immersive environments?*
2. *How does interacting with counterfactual architectural environments in VR affect users' understanding of historical contingency compared to traditional 2D archival study?*

Note: may require development of C# code in the Unity game engine (intermediate level).

Serious Games and Gamification Frameworks

Developing games for **education** and integrating **game design elements** (like points, badges, and leaderboards) into non-game contexts.

Designing and Evaluating a Gamified Framework for Teaching Open Science and Intellectual Property Compliance to Researchers and Science Managers

This research investigates how serious games and gamification frameworks can effectively **educate researchers** and **science managers** about **open science practices** and **intellectual property (IP) compliance**—two critical but often poorly understood domains in academic institutions. The proposed approach involves developing an **interactive game-based learning module** that simulates real-world research scenarios where participants must navigate decisions around data sharing, licensing choices, patent strategy, and copyright considerations. The research aims to answer the following question:

1. *To what extent does a gamified learning intervention improve researchers' and science managers' understanding of open science principles and IP compliance requirements compared to conventional instructional methods?*

Note: may require development of C# code in the Unity game engine (intermediate level).

Any questions or interest in
working with me?

You can contact me at **tomas.alves@iscte-iul.pt**