Biais cognitifs dans la visualisation d'information: implications pour l'évaluation

Cognitive Biases in Information Visualization: Implications for Evaluation

Evanthia Dimara

English Abstract—Humans are often known to make poor or irrational decisions that manifest themselves as *cognitive biases*, but very few studies explored if these biases could persist when using visualization tools that support decisions. Most previous studies focused on biases related to information either not properly communicated or understood e.g. a user that could not compute a known risk or identify an unknown risk (uncertainty). In this talk, we would like to discuss our findings in another type of bias, called *attraction effect* in which users that were almost 100% accurate in selecting good alternatives using a visualization, were nonetheless irrationally influenced by the presence of irrelevant data. The main implication of these findings is that the current evaluation methods of visualizations in decision support that focus on data understanding may not be sufficient to ensure decision quality.

1 Introduction

Interactive data visualizations facilitate information processing, making data accessible and promoting informed decisions, i.e., decisions based on hard facts rather than mere beliefs. Moreover, visualization systems offer advantages over automated approaches by leaving room for human judgment [20], which is essential when decisions require expert knowledge [19] or subjective preferences [4].

However, humans often make poor or irrational decisions due to low conscious effort, time limitations or faulty reasoning [9]. One example is the "confirmation bias", where the user unconsciously seeks evidence to confirm what they already believe, rather than seeking disconfirming evidence [22]. Such systematic errors, also known as *cognitive biases*, could propagate through any human-in-the-loop system like a visual analysis tool.

Despite the recent growing interest of information visualization in decision support [2], [6], [15], there has been little work on how to detect and alleviate the potential cognitive biases involved. Most of this work focuses on two problems related to cognitive biases: fallacies in probabilistic reasoning [12], [17] or neglect of uncertainty in the data [27]. The challenge in these works is to assist users who either fail to estimate known risks or tend to ignore unknown risks (uncertainty) related to their decision. Thus, here the potential poor decision quality is derived from lack of information (risk) or its understanding.

In our recent work we investigated a cognitive bias called *attraction effect* in which user decisions were irrational even-though all information was fully understood, and without any uncertainty involved [7].

2 Cognitive Biases and Visualizations

The biases we usually study in visualizations are related to visual perception, mostly pre-attentive, of how our senses (mis) perceive visual variables e.g. color, magnitude, position or direction [5], [21], [26]. Cognitive biases differ since they refer to errors made during information processing once the visual information is well perceived.

Zuk and Carpendale [27] discuss how visualizations can assist to remediate uncertainty biases. Researchers have studied how visualizations, such as Euler diagrams and frequency grids, can reduce the base rate bias in probability estimation [10], [12]. The FinVis [17] tool presents investment alternatives using a risk plot, along with the overall aggregated risk as a Gaussian gradient, to help investors overcome the uncertainty aversion and diversification bias. Miller et al. [13] used scatterplots and histograms to help remediate regression bias in expert predictions. Zhang et al. [25] showed probability judgments in tabular visualizations can suffer from both conservatism and loss aversion biases. Most studies show that multiple biases can co-ocur in visualizations and their remediation can be challenging [11], [12].

3 The Attraction Effect

Most of these previous work explored poor decisions based on uncertain information, but even when there is no uncertainty in the data, peoples' choices may yet imperfectly reflect their true preferences.

In our recent work, we investigated whether the attraction effect, a common bias in consumer choices [8], that it has been also observed in political decisions

- *Evanthia Dimara: Inria, University of Saclay, France*
  E-mail: evanthiadimara@gmail.com.

[14] or in animals when they select their food [3], [18], could affect decisions made with visualization tools. Attraction effect is the shift in preference over an option for which there exists a similar, but slightly inferior (dominated), alternative. Our study showed that users were almost 100% accurate in selecting good (non-dominated) alternatives using a scatterplot, but their decision appeared irrationally influenced by, the presence of irrelevant (dominated) alternatives [7].

4 Implications of Pure Informational Approaches

Most evaluations of visualization systems tend to validate their effectiveness in supporting a decision by using analytic tasks, such as value retrieval [4], [23], finding extrema [4], [24] and outliers [23], range tasks [16], [23], and identification of patterns [23], correlations [24] or more complex analytic task combining multiple low-level tasks [1], [16].

Analytic tasks can be indeed informative since good decisions require a good understanding of the relevant data, but not necessarily sufficient. For example, visualizing a full house dataset [23] is important when the task to explore market trends but, as we show in the attraction effect findings, when the task is to choose a house the presence of all inferior house alternatives maybe bias users over certain alternatives [7] .

Our work suggests that examining tasks related to data understanding may not be enough and more sensitive measures are needed to evaluate the decision quality itself. As a consequence, decision support visualizations should not be designed and evaluated under the assumption that good decisions are the natural outcome of visual analysis based on reliable data and thus traditional visualization design rules may not apply when the goal is to support decision making.

References

[1] T. Asahi, D. Turo, and B. Shneiderman. Using treemaps to visualize the analytic hierarchy process. *Information Systems Research*, 6(4):357–375, 1995.
[2] B. A. Aseniero, T. Wun, D. Ledo, G. Ruhe, A. Tang, and S. Carpendale. Stratos: Using visualization to support decisions in strategic software release planning. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 1479–1488. ACM, 2015.
[3] M. Bateson, S. D. Healy, and Hurly. Irrational choices in hummingbird foraging behaviour. *Animal Behaviour*, 63(3):587–596, Mar. 2002.
[4] J. Bautista and G. Carenini. An empirical evaluation of interactive visualizations for preferential choice. In *Proceedings of the working conference on Advanced visual interfaces*, pages 207–214. ACM, 2008.
[5] M. Correll and M. Gleicher. Error bars considered harmful: Exploring alternate encodings for mean and error. *Visualization and Computer Graphics, IEEE Transactions on*, 20(12):2142–2151, 2014.
[6] M. Daradkeh, C. Churcher, and A. McKinnon. Supporting informed decision-making under uncertainty and risk through interactive visualisation. In *Proceedings of the Fourteenth Australasian User Interface Conference-Volume 139*, pages 23–32. Australian Computer Society, Inc., 2013.
[7] E. Dimara, A. Bezerianos, and P. Dragicevic. The attraction effect in information visualization. *IEEE Transactions on Visualization and Computer Graphics*, 23(1):471–480, 2017.
[8] J. Huber, J. W. Payne, and C. Puto. Adding asymmetrically dominated alternatives: Violations of regularity and the similarity hypothesis. *Journal of Consumer Research*, 9(1):90–98, 1982.
[9] D. Kahneman. *Thinking, fast and slow*. Macmillan, 2011.
[10] A. Khan, S. Breslav, M. Glueck, and K. Hornbæk. Benefits of visualization in the mammography problem. *International Journal of Human-Computer Studies*, 83:94–113, 2015.
[11] U. Khan, M. Zhu, and A. Kalra. When trade-offs matter: The effect of choice construal on context effects. *Journal of Marketing Research*, 48(1):62–71, 2011.
[12] L. Micallef, P. Dragicevic, and J.-D. Fekete. Assessing the effect of visualizations on bayesian reasoning through crowdsourcing. *IEEE Transactions on Visualization and Computer Graphics*, 18(12):2536–2545, 2012.
[13] S. Miller, A. Kirlik, A. Kosorukoff, and J. Tsai. Supporting joint human-computer judgment under uncertainty. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 52, pages 408–412. SAGE Publications, 2008.
[14] Y. P. S. O'Curry and R. Pitts. The attraction effect and political choice in two elections. *Journal of Consumer Psychology*, 4(1):85–101, 1995.
[15] S. Pajer, M. Streit, T. Torsney-Weir, F. Spechtenhauser, T. Muller, and H. Piringer. Weightlifter: Visual weight space exploration for multi-criteria decision making. *IEEE transactions on visualization and computer graphics*, 23(1):611, 2017.
[16] P. Riehmann, J. Opolka, and B. Froehlich. The product explorer: decision making with ease. In *Proceedings of the International Working Conference on Advanced Visual Interfaces*, pages 423–432. ACM, 2012.
[17] S. Rudolph, A. Savikhin, and D. S. Ebert. Finvis: Applied visual analytics for personal financial planning. In *Visual Analytics Science and Technology, 2009. VAST 2009. IEEE Symposium on*, pages 195–202. IEEE, 2009.
[18] S. Shafir, T. A. Waite, and B. H. Smith. Context-dependent violations of rational choice in honeybees (apis mellifera) and gray jays (perisoreus canadensis). *Behavioral Ecology and Sociobiology*, 51(2):180–187, 2002.
[19] A. Shen-Hsieh and M. Schindl. Data visualization for strategic decision making. In *Case Studies of the CHI2002*, pages 1–17. ACM, 2002.
[20] J. J. Thomas and K. A. Cook. *Illuminating the path:the research and development agenda for visual analytics*. IEEE Computer Society, 2005.
[21] C. Ware. *Information visualization: perception for design*. Elsevier, 2012.
[22] P. C. Wason. On the failure to eliminate hypotheses in a conceptual task. *Quarterly journal of experimental psychology*, 12(3):129–140, 1960.
[23] C. Williamson and B. Shneiderman. The dynamic homefinder: Evaluating dynamic queries in a real-estate information exploration system. In *Proceedings of the 15th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval*, SIGIR '92, pages 338–346, New York, NY, USA, 1992. ACM.
[24] J. S. Yi, R. Melton, J. Stasko, and J. A. Jacko. Dust & magnet: multivariate information visualization using a magnet metaphor. *Information Visualization*, 4(4):239–256, 2005.
[25] Y. Zhang, R. K. Bellamy, and W. A. Kellogg. Designing information for remediating cognitive biases in decision-making. In *Proceedings of the 33rd annual ACM conference on human factors in computing systems*, pages 2211–2220. ACM, 2015.
[26] C. Ziemkiewicz and R. Kosara. Laws of attraction: From perceptual forces to conceptual similarity. *Visualization and Computer Graphics, IEEE Transactions on*, 16(6):1009–1016, 2010.
[27] T. Zuk and S. Carpendale. Visualization of uncertainty and reasoning. In *International Symposium on Smart Graphics*, pages 164–177. Springer, 2007.