Holistic Reviews in Admissions: Reviewer Biases and Visualization Strategies to Mitigate Them

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ABSTRACT

Visualizations of uncertainty in reasoning are being considered as complementary to visualizations of uncertainty in data and mainly aim to prevent cognitive biases of users to support more accurate decision making. Both of these uncertainty-visualization types work well for applications with large amounts of data and with definite or measurable uncertainties. However, in this paper, we aim to shed light on decision-making applications involving relatively small amounts of data with non-specific, abstract uncertainties but complex cognitive processes. We present an approach to support decision making in such applications wherein the possible biases in their reasoning processes are directly identified and addressed using visualizations. We present an example application - the *holistic* review process in undergraduate admissions in the United States. We identify potential reviewer biases in the process by matching the descriptions of common biases and reasoning heuristics under uncertainty with reviewer tasks ascertained through interviews and observations. We list examples of the biases identified and provide visualization strategies to mitigate them. While our initial steps look promising, there are also many challenges with this approach that are both specific to the holistic review process as well as generally applicable.

Index Terms: Information visualization, undergraduate or college admissions, holistic review, cognitive bias, decision making, uncertainty in data, uncertainty in reasoning.

1 INTRODUCTION

We set out to study the undergraduate admissions process at a highly-selective, private university in the United States that employs a holistic review process [1, 2, 9]. Our goal was to design visual tools to aid in the process.

The university receives approximately 20,000 applications every year and has an acceptance rate of less than 20%. Every application is carefully reviewed by one to two reviewers and several factors are considered before making a decision. Additionally, the information contained in the applications are perused by the reviewers in largely text-based formats. Given these constraints, we and the admissions officers believe that the review process can benefit from visual tools tailor-made for this purpose. The tools can, for instance, ease the cognitive load experienced by the reviewers, reduce the time taken to review the applications, visualize the multivariate information contained in the applications and also visualize collections of applicants to help the reviewers reflect upon their decisions.

In order to design the visual tools, we proceeded to obtain a thorough understanding of what the process entails and the challenges faced by the reviewers through observations and interviews. We conducted interviews with 4 reviewers as well as observed them while they reviewed a sample application. We also observed one committee meeting session where a list of undecided applications were revisited and jointly-judged by a committee of reviewers.

As a result of our study, we were not only able to obtain a very-detailed picture of the multifaceted admissions process but the process also turned out to be much more nuanced and complex than we had imagined it to be when we started out. One of the aspects that we had not considered previously but stood out following our study was the cognitive biases of the reviewers. These biases are understandable given the high-subjectivity inherent in holistic review processes.

During our study, the reviewers stated their biases as one of the challenges they faced and that there were certain aspects they each looked for in the applications or gave more importance to. They were also constantly introspective to ensure they were making reasonable decisions and when they were unsure about their decisions, they requested second reviews for those applications. The reviewers also preferred forming their own opinions and avoided reading the remarks and annotations left by other reviewers for an application before they themselves reviewed it in order to avoid being biased.

Cognitive biases have been studied extensively and in various fields [5]. They are known to occur even in several everyday-scenarios of decision making [13]. While not all of these biases have significant consequences, reviewer biases in the admissions process can have life-changing consequences. The admissions process is not only liable to the students but also to the respective institution's missions and goals. Hence we identify reviewer biases as important concerns that require attention and need to be addressed as part of our research.

We begin by describing the holistic review process and then present our arguments for developing bias-mitigating visualizations to support decision making in such applications. We then present the first steps towards realizing this goal. We identify possible biases occurring during holistic reviews and suggest visualization strategies to mitigate them. Our approach can prove useful in solving problems of a similar nature. The potential visualization strategies presented to mitigate the biases can also contribute to the relatively new and upcoming research area of addressing biases using visual tools [10]. We conclude with a section on the potential challenges in our approach and ideas for future work.

2 HOLISTIC REVIEWS AND UNCERTAINTY

In this section, we describe the holistic review process and demonstrate that uncertainty and biases are inherent in it.

In a holistic review, every application is viewed in "context". Some of the factors that are considered by the reviewers include the applicant's high school grades and scores on standardized tests, applicant's high school, courses and opportunities offered by the school, other student-profiles in the school, relation between the courses taken by the applicant and his or her "major" preference(s), family background, adversities faced, trends in grades, explanations for dips in performance, non-academic accomplishments of the applicant, leadership qualities, special talents, and qualities of

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the applicant gleaned from letters of recommendation and the applicant's essays (e.g., "risk-taker", "perfectionist", and "vulnerable"). Additionally, the reviewers are also guided by the university's missions and policies, such as diversity and upholding the values and personal qualities advocated by the institution.

There is no set protocol that the reviewers must follow while reviewing the applications. Reviewers have their own heuristics that they employ and we gathered from our study that there is a substantial overlap in how the reviewers consider the application-attributes. While the reasoning employed to judge certain objective aspects of the application, such as the student's class rank or scores on standardized tests, is somewhat straightforward, the reasoning process involved in judging many other aspects, such as the applicant's "fit" to the institution or how good a roommate the applicant would be cannot be well-articulated and depends almost entirely on individual reviewers' experiences and intuitions.

This process falls under the category of uncertain and ill-structured problems [18, 21]. They have a vague problem specification, the relevance or predictability of the information used to make decisions is unclear, there is no definite solution route and no clear indication of when to stop. Decisions are made based on the subjective assessments of the reviewers. Tversky and Kahneman list certain heuristics employed in the reasoning process under uncertainty in their 1975 paper and state that these heuristics can sometimes lead to systematic errors or biases [17]. These biases are not only exhibited by naive or inexperienced people but even experienced reviewers are very likely to make such errors when they think *intuitively*.

Biases can not only occur at various points in the process but can also accrue. Our study findings indicate that the final judgments reviewers make on applications can be viewed as combinations of smaller judgments made on several individual aspects of the application. While some of these aspects are somewhat independent, such as the academic and non-academic attributes, some others are incremental, such as the perceived affluence of the student's family and the availability of opportunities to the student. Hence biases occurring in the judgment of one aspect can propagate to the judgments made on other related aspects.

3 Visualizing uncertainties vs. visualization solutions to mitigate biases

In this section, we compare the types of visual decision-support systems, namely, visualizing uncertainty in data, visualizing uncertainty in reasoning, and visualization solutions to mitigate biases, and explain why the uncertainty-visualization types are not suitable for certain kinds of applications. Instead decision support for these applications can be provided by identifying the biases in their reasoning processes and addressing them in the visualizations.

Visualizing uncertainty in data has gained importance due to the need for communicating uncertainties present in the generally large quantities of data processed in visual analytics to users. This is intended to make aspects pertaining to their decision making, such as knowledge generation and trust in the system more reflective of the actual data [14]. Visualizing uncertainty in reasoning has mostly been considered as complementary or an extension to that of data and hence has been studied in conjunction with visualizing uncertainty in data [6, 10, 14, 21]. The goal of visualizing reasoning uncertainties is to make the users aware of the uncertainties in their reasoning and hence to keep their biases in check.

While visualizing uncertainty in data is suitable for applications with large amounts of data and with specific or measurable uncertainties, it may not be feasible for decision-making applications involving relatively simple data and complex reasoning processes, for example, the holistic review process. The possible uncertainties in such data, according to Thomson et al.'s typology [16], can at best be described as abstract uncertainties, such as 'completeness of the data', without being able to specify the uncertainties any further. Visualizing uncertainty in reasoning can be considered for these applications but it may not be as effective in the absence of visualizations of data uncertainty given their complementary relationship and it also has other drawbacks which we outline in the following paragraphs. Therefore, we propose that for such decision-making applications involving uncomplicated, small amounts of data with possibly abstract and non-specific uncertainties but with significant thought processes, decision support can be provided by directly identifying the possible biases in their reasoning processes. Visualization solutions can then be designed to address these biases.

Visualizations of reasoning uncertainty and visualization solutions for mitigating biases have the same end goal of reducing user biases and enabling them to make more accurate decisions. However, their approaches are different. The former aims to make the users aware of the uncertainties in the reasoning heuristics and the biases they may lead to and as a result, the users make decisions more consciously. The latter approach frees the users from consciously worrying about biases and the biases are automatically addressed in the visualizations. The former approach also demands more introspective assessments which may prolong the decision-making time.

There are also many challenges with visualizing reasoning uncertainty. While numerous methods have been suggested to visualize data uncertainty to support decision making, visualizing reasoning uncertainty is an open problem [21]. Uncertainties in reasoning can be difficult to ascertain or may consist of abstract uncertainties for some applications. While initial efforts have been made to define a typology for reasoning uncertainties based on a typology for data uncertainties [21], it is still far from being a well-established area. Cognitive biases, on the other hand, have been studied extensively and hence can be more easily identified. Given the above distinctions between the two approaches, we think that the approach of identifying biases and designing visualization solutions to mitigate them is both feasible and suitable for the holistic review process and other similar applications.

4 Possible reviewer biases and visualization strategies

We take a user- and task-centered approach to deconstruct the types of biases in reasoning in the holistic review process. As a result of our interviews and observations, we were able to obtain an exhaustive list of the tasks the reviewers perform while reviewing every application. These tasks mainly consist of the various application-attributes they examine, and their thought processes contributing to the judgments they make concerning each attribute and overall. To identify potential reviewer biases, we matched these task descriptions with the tasks associated with the heuristics of reasoning under uncertainty and the common biases in decision making found in popular literature [3, 5, 12, 17].

For example, the *representativeness* heuristic [17] is generally associated with tasks or questions that ascertain how similar A is to B or how representative A is of B. We found such tasks performed during the application reviews and matched them with this heuristic. We provide a few such examples below and suggest potential visualization strategies to address those biases where applicable.

4.1 Reasoning heuristics and associated biases

The following are some holistic review tasks that fall under the three heuristics used in reasoning under uncertainty, namely, *representativeness*, *availability*, and *adjustment and anchoring*, described in the paper by Tversky and Kahneman [17]. While these heuristics are effective in enabling accurate judgments to be made in many scenarios, they can also lead to biases in certain situations. Readers are referred to the paper to find more details on these heuristics.

1. Representativeness: This heuristic is used when assessing how representative an applicant's attributes are of an existing or predetermined set.

   (a) In assessing an applicant's fit to the university, reviewers assess how *representative* an applicant is of the values and key aspects advocated by the institution by considering attributes such as the overlap between the interests of the student and those of the institution, and judging the applicant's personal qualities. The biases due to *insensitivity to predictability* and *the illusion of validity* [17] can occur in this case when the attributes considered are not actually predictable of the student's fit to the university but nevertheless, the reviewer is very confident of his or her judgments.

   (b) Reviewers assess how *representative* an applicant is to the group of students from the same school who were admitted to the university in the previous years. In doing so, the biases due to *insensitivity to prior probability of outcomes* and *insensitivity to sample size* [17] can occur when the reviewers consider only the application attributes such as the average Grade Point Average, i.e. GPA (when the sample size is small, the sample statistic can differ significantly from the population parameter), but leave out potentially vital information, such as the GPA ranges and percentages of students from this school admitted to the university in the past years.

   Visualization strategies: Assessing "fit" is a largely subjective task. It may be helpful for the reviewers to collectively discuss and formulate the various definitions of what they look for or what the university represents and order them from the most important to the least important. This ordinal/nominal information can be presented visually alongside the attributes considered in the application. This will not only help reduce the bias but also somewhat standardize the task assessment.

   Since prior statistics are sometimes left out when assessing representativeness, visual representations of such statistics, such as the GPA ranges and percentages of students admitted in the past years in the second example above, can be included along with the respective attributes to enable the reviewers to make more accurate evaluations [10].

2. Availability: This heuristic plays a role when the evaluation of the application attributes is affected by the ease with which instances or information pertaining to the attributes can be recalled.

   (a) Reviewers tend to better remember the students they interacted with during their high-school-visits and immediately recognize the student from his or her application. This will lead to the bias caused by the *retrievability of instances* [17].

   (b) Reviewers are generally very familiar with the high schools they've visited and hence tend to recall a lot of information about a school from memory when reviewing an applicant from the school. In recalling various kinds of information about the school, biases due to the *retrievability of instances*, *effectiveness of a search set*, and *imaginability* [17] can occur. The information recalled or constructed from imagination using some rules may be incomplete or biased.

   (c) Reviewers tend to remember the attributes of an applicant that stand out and this may influence their judgments regarding other aspects of the applicant. For example, if a reviewer perceives a student as coming from a privileged background, the reviewer may use this information to form opinions on other aspects of the student such as having ample opportunities to pursue certain activities or start non-profit organizations. Such instances can lead to the biases due to the *retrievability of instances* as well as *illusory correlation* [17] wherein strongly-associated events are thought to frequently co-occur.

   (d) Reviewers present applications during committee meetings and use their notes and summaries recorded previously to recall the respective applications. Since committee meetings take place at a later time, the biases due to the *retrievability of instances* and *imaginability* [17] may play a role when reviewers discuss their applications.

   Visualization strategies: Availability bias can be mitigated by presenting visually all the information needed including those easily recalled and not recalled by the reviewers when evaluating an attribute [10].

   The strength of holistic or comprehensive reviews lies in the ability of reviewers to make connections such as example (c) above throughout the process and draw explanatory inferences. However, as seen above, such heuristics can sometimes lead to biases. Hence our goal is to design the visual tools in such a way so as not restrict or hinder these capabilities of reviewers but to augment or aid them in making more accurate decisions.

   Visual tools can be designed to enable better note-taking both for the purpose of revisiting applications during committee meetings as well as while individually reviewing an application. The tools can enable the reviewers to take quick snapshots or visual summaries which will help them recall application-attributes or even entire applications better.

3. Adjustment and Anchoring: This heuristic tells us about the tendency to be biased towards the judgments made on the initial attributes considered in an application and this bias affecting the judgments made on the attributes that follow.

   (a) We observed in our study that the reviewers generally reviewed the academic scores of an applicant first before evaluating other attributes. Hence the academic performance of an applicant can be thought of as the *anchor* or starting point proceeding from which other aspects are estimated by *adjustment*. This makes possible the biases of *overestimating conjunctive events* and *underestimating disjunctive events* [7, 17]. For example, if a student has excelled academically, then the reviewers may be more optimistic regarding the student's success in other aspects (conjunctive events) and underestimate the chances of finding an aspect in which the student has performed poorly (disjunctive event).

   Visualization strategies: To counter the biases associated with conjunctive and disjunctive events in the application review process, the order of attributes in the visual application can be rearranged so that conjunctive attributes are presented non-sequentially.

4.2 Common biases in decision making

The following are common biases in decision making that are likely to occur during the admissions process.

1. Confirmation bias [12]: Reviewers may be inclined to find or favor evidence in the applications that confirms their judgments about an applicant and ignore or disfavor evidence that

disconfirms their judgments. Additionally, it has been found that people exhibit confirmation bias even when recalling information [5] and hence reviewers may also be subject to this bias while presenting their applications during the committee meetings.

2. The avoidance of cognitive dissonance [3,4]: Reviewers may find themselves in situations wherein they are both impressed by certain aspects of the applicant and not very impressed by certain other aspects. In order to make a decision, they will have to resolve this dissonance by *adjusting* their beliefs. As a result, they may overestimate the achievements and underestimate the setbacks and decide to admit the student or vice versa.

   Visualization strategies: Many types of biases including confirmation bias, anchoring bias, and biases due to illusory correlation and cognitive dissonance can be mitigated by presenting alternative visual representations of the application attributes to enable the reviewers to consider other possible interpretations [21]. This may not only enable them to weigh the attributes more suitably but also permits more introspective evaluations.

4.3 Time- and stress-induced biases

The negative effects of time pressure and stress on human judgment and decision-making have been studied extensively [15]. These effects include a reduced search for information, making defensive choices, reinforcing the choices made, a tendency to process information according to their perceived priority, giving more importance to negative information, and forgetting crucial data [20].

Time is a critical factor in the application review process in admissions. One of the main challenges that the reviewers face is the sheer volume of the applications and the limited time to review them which often results in the reviewers putting in extra hours of work. The reviewers we interviewed each review between 1000-2000 applications in a time period of roughly 2 months and typically take about 15 minutes to review each application. This time not only includes their thought processes and consideration of the different application attributes but also the time taken to write notes and enter ratings. Needless to say, the reviewers are subject to considerable time pressure and stress while reviewing the applications and hence the time-induced biases mentioned above are likely to occur during the process.

Visualization strategies: As stated earlier, the applications are read by reviewers in largely text-based formats. Designing visual tools for the application review process may not only communicate certain types of information more easily but could also potentially ease the cognitive load of the reviewers. Many of the time- and stress-induced biases mentioned above can be mitigated by some of the visualization strategies mentioned previously, such as those for the *availability* reasoning heuristic.

In addition to studying the effects of time on decision making, cognitive models have been developed aiming to explain time perception processes [15]. These models can also be examined and employed in the design of the visual tools.

5 Challenges and Future Directions

In taking our approach, we encountered the following concerns and challenges that are both specific to our application as well as generally applicable that will need to be addressed in the future.

- **Disadvantage of domain-specific approaches:** While domain-specific approaches such as the one described in this paper result in better decision support tools tailor-made for the respective applications, there is a need for developing more general models for identifying biases and visual solutions for addressing them. These models and solutions can then be customized for a specific purpose.

- **Identifying *important* biases:** While we may be able to identify potential biases in the review process, it is challenging to find out which biases are the most prominent or have the biggest consequences in the process. It may also be possible to define reasoning heuristics or biases that are specific to the review process.

- **Not all biases can be addressed using visual tools:** It should be noted that only some of the identified biases in the admissions process can be mitigated using the visual tools. Many judgments are made by reviewers based on their knowledge from previous reviewing experiences and visits to high schools, such as examples (a) and (b) listed under the availability heuristic above. The basis for this reasoning can be attributed to the *ignorance* variant of uncertainty presented by Kahneman and Tversky [8]. It remains to be seen for what kinds of biases can effective visualization solutions be formulated.

- **Integrating the proposed visualization strategies in the design process:** As stated in the beginning of this paper, our aim is to design visual tools for the admissions process which currently uses largely text-based formats. We will employ Munzner's nested model [11] in our visualization design process to build these tools. However, integrating the proposed visualization strategies for mitigating the biases in the design process can be challenging. We will also need to be careful not to introduce additional biases with our visualization tools.

- **Lack of specificity in the provided visualization strategies:** The proposed visualization strategies are somewhat broad and lack details, such as the types of data encoding that will be used. The details will only be apparent as the above-mentioned design process unfolds and these strategies will have to be designed and refined for the purpose of bias-mitigation but also in line with the principles of visual perception.

- **Bias mitigation tools vs. time:** It has been suggested that uncertainty visualizations may prevent the necessary tasks from being performed in a timely manner [19,21]. This may be the case even with bias-mitigating visualizations that necessitate more introspection. Since time is a critical factor in many applications, visual tools should be designed in such a way that they reduce biases without compromising time.

- **Need for a better understanding of the distinction and relation between uncertainty in reasoning and cognitive biases:** While both these topics are generally associated with each other, the exact connection between them and how they influence each other generally and also in the context of visualizations is unclear. This understanding is vital to the development of more effective visualizations.

In conclusion, we have looked at an example decision-making application, the holistic review process in admissions, in which the decisions are mainly influenced by the reasoning processes involved. We have presented an argument for why it might be more useful to identify the biases in reasoning and aim to mitigate them in the design of visual tools to support decision making in such applications.

To the best of our knowledge, this is the first study aiming to address cognitive biases in the college admissions process with the help of visual tools and enable more accurate decision making. Our ideas can be adapted and used in a similar fashion at other universities also employing a holistic review process. Additionally, they can be extended to be used in other areas also involving subjective assessments such as Intelligence analysis and academic peer-review processes.

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