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GHOSTS IN THE MACHINE – GENDER BIASES IN DATA ANALYTICS

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INTRODUCTION

For many institutions, including the Canadian Armed Forces (CAF), data analytics is no longer an aspiration, it is a reality. Popularized by sports and the financial sector, analytics has completely changed how organizations attain competitive advantage. Led by a vanguard of analytics-minded managers such as Daryl Morey, basketball teams like the Houston Rockets and Golden State Warriors have dominated so thoroughly that competitors have had no choice but to adapt to new coaching and recruiting strategies.[1] So compelling is the analytics approach that the Toronto Raptors recently revamped their culture and strategy using data analytics and were recently crowned the Eastern Conference Champions for the first time in their young history.[2] Similarly, the CAF is starting to see some promising returns on investment through analytics. Better decisions are being made on asset management and bottlenecks in supply chains are starting to be identified.

However, the CAF is relatively early in its analytics journey and have yet to encounter the growing pains other organizations have encountered, namely deep-rooted beliefs and biases within the organization that can override prevailing logic. In data analytics, the flow of data is susceptible to human biases and error, from how data is entered to how it is reported. One of the reasons why the subprime crisis occurred was that the foundational data valuing mortgage bonds was flawed by human error, leading analysts to improperly assess the riskiness of collateralized

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[1] Milton Kent, "SEP-Arating Value of Three-Point Field Goals Now Easier than Ever," *The Evening Sun*, 6 February 1991.

[2] Sportsnet, "Building Better Bombs," last accessed 22 April 2018, https://www.sportsnet.ca/basketball/nba/big-read-can-new-tech-make-raptors-three-point-juggernaut

debt obligations.[3] In professional sports, many teams have analytics departments but still fail because biases affect their analytical approach and decisions. For example, the Toronto Raptors inexplicably drafted an unknown Brazilian teenager who was eventually released because of the team's fixation on his wingspan length instead of his skillset.[4] Daryl Morey, general manager of the Houston Rockets employed predictive analytics, highlighting an undervalued Spanish center to draft. However, his coaching staff nicknamed the future all-star "man-boobs", and that stigma was enough for the organization to bypass him in the draft.[5] Perplexingly, despite the data, despite the robust architecture and procedures governing the data, organizations can still make exasperating and often illogical decisions.

To counter such biases, the CAF adopted GBA+ (Gender-Based Analytics). GBA+ is a form of stakeholder analysis that scrutinizes policy issues through the lens of gender (among other factors) to provide a more fulsome approach to policy implementation.[6] While certainly a positive step, GBA+ remains flawed because it does not address the underlying gender biases that are already affecting the use of data in the CAF's information systems. This paper argues that while it is important to advance the adoption of data analytics, it is equally important to establish safeguards, ensuring that analysts and decision-maker are conscious of the biases inherent in the systems used. The literature this paper explores on decision-making suggests that gender biases can influence how information is entered, interpreted, and used, impacting users, analysts, and decision-makers alike. Accordingly, this paper argues that the CAF must protect

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[3] Fortune, "Moody's, Nearly Seven Years too Late, Admits Miscalculation in Subprime Ratings," last modified 23 July 2015, http://fortune.com/2015/07/23/moodys-subprime-mortgage-bonds/

[4] Toronto Star, "Raptors took Bruno Caboclo on a Wingspan and a Prayer," last modified 8 July 2014, https://www.thestar.com/sports/raptors/2014/07/08/raptors_took_bruno_caboclo_on_wingspan_and_a_prayer.html

[5] Slate, "Basketball's Nerd King: How Daryl Morey used Behavioural Economics to Revolutionize the art of NBA Draft Picks," last modified 6 December 2016, http://www.slate.com/articles/arts/books/2016/12/how_daryl_morey_used_behavioral_economics_to_revolutionize_the_art_of_nba.html

[6] Government of Canada, "Gender-based Analysis Plus (GBA+)," last modified 25 May 2017, http://www.swc-cfc.gc.ca/gba-acs/index-en.html

the flow of its data from gender biases in the areas of data integrity, data analysis, and data reporting.

DATA INTEGRITY – WHOSE FAULT IS IT ANYWAYS?

For many, the major impediment preventing data analytics adoption is the issue of data integrity. Skeptics often dismiss the entire field of analytics with a sweeping generalization of, "garbage in, garbage out." However, it can be argued that the "garbage in" issue is not a data problem but rather an issue embedded within the design of the code. In a prescient observation, author Catharine Mackinnon observed that male needs "define auto and health insurance coverage, their socially designed biographies define workplace expectations and successful career patterns."[7] For information systems, faulty design interfaces and the ensuing business rules that govern them can permeate for years, contributing to deficiencies in data integrity. This has ramifications for systems such as the Defence Resource Management Information System (DRMIS). DRMIS is a customized SAP enterprise resource planning (ERP) software suite that integrates all CAF logistical, financial, and maintenance activities. The business and design rules encapsulating DRMIS were ported from two older systems, MASIS (Material Acquisition Support Information System) and FMAS (Financial Management Accounting System), which was influenced from another ERP called YORVIK (late 1990s).[8] During the implementation, the DRMIS team reassured users, declaring they would "find DRMIS familiar and be able to

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[7] Catharine A. Mackinnon, *Feminism Unmodified – Discourses on Life and Law* (Cambridge: Harvard University Press, 1987), 36.
[8] Vanguard, "A Single Solution for Tracking the Military's Materiel," last modified 1 September 2012, https://vanguardcanada.com/2012/09/01/single-solution-tracking-militarys-materiel/

navigate in the system as they do in FMAS or MASIS today."[9] While this allowed a smooth

transition, it also had the unintended consequence of carrying over old processes and obsolete

designs. Consequently, many of the interfaces and business processes within DRMIS are as old

as the original ERP itself. Thus, the demographic makeup of MASIS and FMAS users and

designers during the 1990s has had significant influence on the technology used by the CAF

today.

During the 1990s, women were largely absent in the field of IT. Female graduates in IT

were stagnant from the 1990s onward while females in life sciences and engineering increased.[10]

In fact, a 2011study estimated that only 3% of women pursued a diploma in computer and

information sciences.[11] What these statistics suggest is that during the developmental timeframe

leading up to DRMIS, males were the predominant gender influencings its design. As inferred

by Mackinnon, a male dominant environment unintentionally infuses gender biases into the

system. While it may seem absurd for computers and digital technology to exhibit bias, there is

evidence to suggest that gender design biases frequently occur in IT and have an impact on the

user experience. An example of this was a government funded software initiative in the

Netherlands called DDS. DDS was "freenet" software intended to connect all citizens of

Amsterdam to the internet.[12] In order to ensure full accessibility, the software was mandated by

the government to be user friendly for all citizens in Amsterdam. However, almost all the

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[9] Department of National Defence, *New Software will Streamline DND Business Processes (*DRMIS: December 2009).
    [10] Natural Sciences and Engineering Research Council of Canada, "Female in Science and Engineering in Canada." (Corporate Planning and Policy Division: Ottawa, October 2017): 24.
    [11] Statistics Canada, 89-503-X, *Female in Canada: A Gender-based Statistical Report* (Ministry of Industry, 2016): 19.
    [12] Nelly Oudshoorn, Els Rommes, and Marcelle Stienstra, "Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies." *Science, Technology, & Human Values* 29, no. 1 (Winter 2004): 33.

designers were male and technologically savvy.[13] This meant that the software unintentionally

reflected the designers' abilities, assumptions, and learning style. For instance, the designers

wrongly assumed that users had a similar confident view towards technology and would embrace

a "trial and error" style of learning. This was evident in the DDS design, which contained a

menu structure with hidden functionality that users had to openly explore.[14] Those assumptions

blinded the developers from gender differences with technology acceptance and learning. One

study on technology adoption observed that females disliked the "trial and error" style of

learning as they took failure personally.[15] A survey on learning styles also suggested that

females do not favour the traditional "abstract and reflective" learning method, instead preferring

the "watching and feeling or doing and thinking" method.[16] As a result, the adoption of DDS

was dismal as females comprised only 9% of the user base.[17]

Despite the success of the DRMIS implementation, it still had its challenges, especially

for users. The notoriety of DRMIS' poor user interface is well-known in the CAF. A KPMG

report noted that DRMIS lacked an intuitive interface and the "users have to navigate various

screens to perform tasks."[18] KPMG's observations eerily echo the DDS development story. It is

estimated that approximately 70% of ERP software implementations similar to DRMIS have

failed outright or have taken years to adopt with a difficult adjustment period and continuous

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[13] Nelly Oudshoorn, Els Rommes, and Marcelle Stienstra, "Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies." *Science, Technology, & Human Values* 29, no. 1 (Winter 2004): 44.

[14] *Ibid.*, 39.

[15] Sherry Turkle, "Computational Reticence: Why Female Fear the Intimate Machine," in *Technology and Female's Voices* (New York: Pergamon Press, 1986): 49.

[16] Marge Philbin *et al,* "A Survey of Gender and Learning Styles." *Sex Roles* 32, no. 7/8 (1995): 491.

[17] Nelly Oudshoorn, Els Rommes, and Marcelle Stienstra, "Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies." *Science, Technology, & Human Values* 29, no. 1 (Winter 2004): 44.

[18] KPMG, Defence Renewal Change Management Services, *Maintenance Execution Interim Report Volume II,* 14 July 2015*,* 215.

disruption to daily operations.[19] The similarities between DDS and DRMIS suggest that male-centric biases likely impacted the design of DRMIS. In the 1990s, a company called Phillips Research designed a citywide social network called New Topia.   Once again, the software was specifically designed for all users, even consciously avoiding a system for the "young male computer fanatics."[20] When the product was finalized and released, a survey on a thousand users was conducted to confirm the diversity of the user base. Lamentably, they discovered the users were primarily "male, aged eighteen to thirty-five."[21] Intuitively, programmers understand a good user interface is critical for user adoption. However, the prevalence of biases in a male-dominant field such as IT is enough to thwart the best intentions of a system's design, in turn affecting data integrity.

Another factor affecting data integrity is the business rules and performance expectations associated with data entry. From a naval maintenance perspective, two areas impacted by such pressures are maintenance completion rates on ships and hours of effort expended on maintenance activities. Labours hours are a contentious but common form of measurement across many industries. However, they are an added burden on employees when career progression is linked to such measures. The maxim, "what gets measured gets done" has notoriously created unintended consequences such as police officers manipulating crime statistics to satisfy politicians or executives improperly reporting their achievements to attain bonuses.[22] While the struggle for management remains ensuring accurate and timely data entry,

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[19] Vidyaranya B. Gargeya and Cydnee Brady, "Success and Failure Factors of Adopting SAP in ERP System Implementation." *Business Process Management* 11, no. 5 (2005): 501.

[20] Nelly Oudshoorn, Els Rommes, and Marcelle Stienstra, "Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies." *Science, Technology, & Human Values* 29, no. 1 (Winter 2004): 45.

[21] *Ibid.,* 49.

[22] Burt Perrin, "Bringing Accountability up to Date with the Realities of Public Sector Management in the 21st Century: New view of Accountability." *Canadian Public Administration* 58, no. 1 (March 2015): 191.

there is evidence to suggest that the very business rules guiding data entry have gender biases that can affect how data is entered. Within the law profession, it was found that on an annual basis, males on average billed 1,826 hours per year while females billed 1,677 hours, an almost 10% variation.[23] Typically for time recording, management will establish a targeted amount of hours for employees. Within the law industry, males were given an average target of 1,827 hours per year and females a target of 1,759 hours.[24] While there are gender implications on the difference in target hours, what is relevant for this paper is the delta between targets and actuals. When given targets, males would achieve those targets almost exactly, while females billed consistently less.[25] A possible explanation lies in research that links gender and reward sensitivity. The study found that males will focus on goals directly correlated to their long-term career while females will weigh long and short term considerations in addition to career goals.[26] Thus, measures that specify target hours may favour individuals with greater reward sensitivity bias. Another study performed on several hundred students examined reward sensitivity and gender through the lens of self-evaluation on tasks.[27] It found that males "tend either to be accurate or to overestimate" their performance while females "tend either to be accurate or to underestimate" their performance.[28] Further corroborating these nuances were observations on the tendency for male lawyers to bill all aspects of billable activity while women relaxed their

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[23] Ghazala Azmat and Rosa Ferrer, "Gender Gaps in Performance: Evidence from Young Lawyers," (Working Paper, London School of Economics and Political Science, 2015), 12.

[24] *Ibid.*

[25] *Ibid.*, 29.

[26] Kaileigh A.Byrne and Darrell A. Worthy, "Gender differences in reward sensitivity and information processing during decision-making." J Risk Uncertain 50 (2015): 69.

[27] Sylvia Beyer, "Gender Differences in the Accuracy of Self-Evaluations of Performance." Journal of Personality and Social Psychology 59, no. 5 (1990): 960.

[28] Sylvia Beyer, "Gender Differences in the Accuracy of Self-Evaluations of Performance." Journal of Personality and Social Psychology 59, no. 5 (1990): 967.

interpretation of billing rules.[29] This research certainly helps to explain the unintended

consequences of establishing difficult performance targets. While abandoning measures would

not be in the best interest of public accountability, there are some ways to negate such

unintended consequences. For example, the Canadian Office of the Auditor General linked

performance measures to learning activities instead of punitive action, empowering employees to

innovate.[30] For the CAF, a possible option would be to similarly link measures to continuous

improvement initiatives.

As indicated by the KPMG report, a consequence of the "trial and error" design of many

information systems is they encourage workarounds.[31] Accounting firms that adopted ERPs

similar to DRMIS have shown that when faced with a complex system, users develop

workarounds to expedite time spent on the system. Over time, users continue to evolve, finding

new ways to creatively bypass the system, impacting the quality of accounting information

entered.[32] Decision-makers and analysts may view an ERP as an objective software platform.

However, as shown, biases can be inadvertently baked into an ERP. The consequence of such

design biases is that when they do not meet the expectations of the user, the results can be

unpredictable. In addition, when the stresses of time and performance targets are added, the

quality of data entered is impacted by reward sensitivity biases. For leaders, the implications are

that the design and enforcement of business rules must factor gender responses to such rules. A

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[29] Nancy Reichman and Joyce S. Sterling, "Sticky Floors, Broken Steps, and Concrete Ceilings in Legal Careers." *Texas Journal of Female and the Law* 14, no. 1 (Fall 2014): 70.

[30] Burt Perrin, "Bringing Accountability up to Date with the Realities of Public Sector Management in the 21st Century: New view of Accountability." Canadian Public Administration 58, no. 1 (March 2015): 197.

[31] KPMG, Defence Renewal Change Management Services, Maintenance Execution Interim Report Volume II, 14 July 2015, 216.

[32] Dawna M. Drum, Aimee J. Pernsteiner, and Adam Revak, "Walking a Mile in their Shoes: User Workarounds in a SAP Environment." *International Journal of Accounting and Information Management* 24, no. 2 (2016): 196.

gender neutral approach such as delinking performance targets from career repercussions has the potential to mitigate such issues with data integrity.

GENDER BIASES IN THE ANALYTICAL PROCESS

Simplistically, analysts gather, analyze, and report information for decision-makers. It is typically an unheralded but critical position. Analysts usually work alone or in small teams and are given substantial autonomy because of their technical competence, corporate knowledge, and credibility with their superiors. The analytical process commences when a request for support is raised. For analysts, the struggle is to understand the problem with typically vague direction, which can lead to the pursuit of unexpected methodologies.[33] A classic example where this can go wrong is in costing. After assessing the CAF's costing of the F-35 Joint Strike Fighter, the Parliamentary Budget Officer (PBO) criticized the CAF's analytical "methodology, assumptions, uncertainties, or risks."[34] In contrast, the PBO pursued a different analytical approach suggesting that each fighter jet was $53 million more expensive.[35] Notwithstanding the political fallout, such a deviation demonstrates that the simple question of cost can produce different results, dependent on an analyst's interpretation of the problem.

An analyst will have a myriad of data sources at their disposal. However, tasks usually come with time pressures and analysts often resort to heuristics, sourcing data based on past reports or methodologies archived in their "shoebox," which can be vulnerable to selectivity

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[33] Gordon R. Middleton, "Human Functions, Machine Tools, and the Role of the Analyst." *Journal of Strategic Security* 8, no. 3 (Fall 2015): 71.

[34] Office of the Parliamentary Budget Officer, *Comparing PBO and DND Cost Estimates on Canada's Proposed Acquisition of the F-35 Joint Strike Fighter: Some Preliminary Questions and Answers on Key Issues* (Ottawa, 23 March 2011), 1.

[35] *Ibid.*, 2.

biases.[36] Studies on gender and information processing suggest that males and females will

employ certain gender-nuanced heuristics dictating how they embark on research, potentially

impacting their findings. In Canada, less than 3% of female degree holders are employed in

information science and approximately 15% women are employed in the CAF. [37] Therefore, it is

likely the majority of analysts in the CAF are male and consequently could succumb to similar

gender-biased heuristics; potentially impacting the diversity of thought and approach often

expected in research.[38]

To understand gender decision-making differences, researchers analyzed the gender

composition of business analysts and their performance in an online business simulation game

called the L'Oréal-Strat Challenge.[39] The purpose of the three-person game was to assess the

"market value of the company, as a consequence of the team's decisions, as well as the decisions

taken by the competing (simulated) firms."[40] Within the game, the stock price index (SPI) was

the indicator of success. With a sample size of 16,000 total teams from 1,500 universities, the

results demonstrated convincing differences in both performance and problem-solving as it

pertained to gender composition. Between all-female teams, all-male teams, and mixed gender

teams, the mixed gender teams had the highest SPI results. The best group composition results

came from teams with one female while the worst results came from all-female teams.

Researchers found that all-female teams achieved lower SPIs because they tended to incorporate

corporate social responsibility initiatives, which lowered profits. Thus, despite knowing SPI was

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[36] Gordon R. Middleton, "Human Functions, Machine Tools, and the Role of the Analyst." *Journal of Strategic Security* 8, no. 3 (Fall 2015): 73.

[37] Statistics Canada, 89-503-X, *Women in Canada: A Gender-based Statistical Report.* (Ottawa: Ministry of Industry, 2016), 31.

[38] Department of National Defence, Strong Secure Engaged: Canada's Defence Policy. (Ottawa: Canada Communications Group, 2017), 23.

[39] Jose Apesteguia, Ghazala Azmat, and Nagore Iriberri, "The Impact of Gender Composition on Team Performance and Decision Making: Evidence from the Field." *Management Science* 58, no. 1 (January 2012): 79.

[40] *Ibid.*, 80.

the prime objective, female decisions extended beyond the game's interpretation of profit.[41] For

analysts, "profit" or success equates to the timely provision of a quality analytical product.

When correlating such findings to analysts in terms of profit-seeking behaviour, it suggests that

gender diversity can positively influence the development of an analytical product. It also

suggests that success can be interpreted and prioritized differently by gender.

Unavoidably, the balance between time and quality of a product is a constant challenge

for analysts. As demonstrated, how one views which is more important influences the

thoroughness of research. For analysts, project risk means having to balance the quality of a

product versus the time constraints imposed.[42] Studies suggest that gender differences in

information processing can dictate an analyst's tolerance for risk, potentially resulting in

divergent approaches and products.[43] An experiment at Texas A&M University examined the

differences in males and females as it pertained to preference for external information in the

attainment of a reward in a digital "casino-type" game. The study concluded that gender

impacted success in very different ways. Males followed a "selectivity model of information

processing," disregarding external information in the completion of a task despite its potential to

be helpful in the decision-making process.[44] This single-minded approach was noted to

positively benefit the game under time-sensitive conditions. In contrast, females sought as much

information as possible, and success correlated to their trust in the quality of information

provided.[45] For decision-makers, this means that under a time constraint for an analytical

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[41] Jose Apesteguia, Ghazala Azmat, and Nagore Iriberri, "The Impact of Gender Composition on Team Performance and Decision Making: Evidence from the Field." *Management Science* 58, no. 1 (January 2012): 93.
    [42] Gordon R. Middleton, "Human Functions, Machine Tools, and the Role of the Analyst." *Journal of Strategic Security* 8, no. 3 (Fall 2015): 78.
    [43] Kaileigh A.Byrne and Darrell A. Worthy, "Gender Differences in Reward Sensitivity and Information Processing During Decision-making." *J Risk Uncertain* 50 (2015): 56.
    [44] Kaileigh A.Byrne and Darrell A. Worthy, "Gender Differences in Reward Sensitivity and Information Processing During Decision-making." *J Risk Uncertain* 50 (2015): 69.
    [45] *Ibid*.

product, the quality of research by analysts can vary by gender. In a male-dominant field such as analytics, one can therefore expect a fairly singular approach to research with similar results, which may not always be desirable if additional sources of information can improve the decision-making process.

Similarly, another study explored the impact of gender dynamics on the willingness of students to abandon an initial hypothesis in the event of additional information. The experiment performed on 82 third year accounting students in an auditing class found that males tended to be "hypothesis-confirming" while females tended to seek disconfirming information.[46] Case material on a fictitious company being audited was presented with an accompanying series of indicators. Students then had to hypothesize the solvency of a company, rating the importance of the information that either confirmed or disconfirmed their hypothesis. The study found males were quicker to identify information that reinforced their hypothesis while females were more open to factoring disconfirming information.[47] What this suggests is that there may be two distinctly gender-nuanced approaches impacting an analytics product. First, analysts may pre-emptively draw a conclusion and seek supporting evidence to confirm a hypothesis, especially in the absence of time. Alternatively, analysts may seek as much information as possible before developing a hypothesis, at the cost of timeliness or additional effort by the analyst. Both approaches are valid depending on the task and the key takeaway is that such behaviours exist and are a reaction to how an analyst interprets time or quality pressures from decision-makers.

In sum, the studies examining the differences between gender in decision-making and task orientation have implications for data analysts. There is no doubt that diverse teams and

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[46] Janne Chung and Gary S. Monroe, "Gender Differences in Information Processing: An Empirical Test of the Hypothesis-Confirming Strategy in an Audit Context." *Accounting and Finance* 38 (1998): 270.
[47] *Ibid.*, 276.

mixed-gender compositions are favourable. However, what the studies also suggest is that they are advantageous because they help to counterbalance any prevailing biases to time and quality that may be strongly held by a certain gender. From a technical standpoint, availability of data and ease of access to data sources can mitigate such pressures. For example, faster systems, integrated systems of record, and a greater pool of shared research can help neutralize gender biases, improving the speed and quality of research. From a decision-maker's perspective, information requests must carefully outline time and quality of research expectations because an analyst's interpretation of such requests will dictate the type of product they receive. Decision-makers often do not have the technical acumen or time to question the reports generated; there is an element of trust that is required. However, improvements such as architecture upgrades, training, and a more diverse analyst team can help ensure analysts do not succumb to biases impacting the conduct of their research.

HE SAID/SHE SAID: BIASES IN COMMUNICATING THE INFORMATION

The outcome of an analyst's task is to deliver a report for the decision-maker. However, as demonstrated, there are biases embedded in the analytical process that impair the quality of research conducted. These biases can be further amplified when presenting the results. Analysts often spend as much time strategizing how to convey the results in a meaningful way as it takes to gather and analyze the data. While data visualization may seem trivial, it can profoundly impact how decisions are made.[48] Though it is recognized that visualization choices can influence decisions, the magnitude is perhaps underappreciated. Ultimately, an analytical product must be tailored for the decision-maker so that the information is effectively consumed.

[48] Gordon R. Middleton, "Human Functions, Machine Tools, and the Role of the Analyst." *Journal of Strategic Security* 8, no. 3 (Fall 2015): 76.

No decision-maker is alike and thus it is important to understand how gender biases on heuristics can unknowingly affect how reports are presented and consumed.

When decision-makers are provided reports, they must attempt to make sense of the data and visuals. Understandably, heuristics are employed to break down that complexity in order to make a decision. In a landmark paper sponsored by the United States Department of Defense, researchers observed three key foundational biases that impact heuristics: representativeness, availability, and anchoring.[49] Representativeness occurs when assumptions are made based on preconceived biases. An example would be belief in a "lucky streak" despite the statistical likelihood of regression to the mean. Availability occurs when information close at hand influences decisions. A classic example is the phrase, "if you are a hammer, everything is a nail." Anchoring occurs when people link decisions and expectations to an internalized starting value, which is evident in the dynamics of the housing market. While all humans succumb to these biases, gender can further influence how they manifest during the communications phase of analytics.

For an analyst determining how to present information, biases can influence that process. For example, some analysts may favour emphasizing the vividness of an object or improperly conveying area and volume through bar graphs, which can accidentally mislead decision-makers.[50] The reasons why one prefers colourful charts over tabular data may lie in both professional experiences and physiological traits. A German study examining the impact of gender on visual cognitive abilities noted differences in how visual images were prioritized. It was trying to understand why reading scores were better for boys compared to girls and

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[49] Amos Tversky and Daniel Kahneman, "Judgement under Uncertainty: Heuristics and Biases." *Science* 185, no. 4157 (27 September 1974): 1124.
[50] Nicholas H. Lurie, and Charlotte H. Mason, "Visual Representation: Implications for Decision Making." *Journal of Marketing* 71 (January 2007): 173.

concluded that physiological gender differences in visuospatial abilities aided boys in reading.[51]

In contrast, due to better auditory cognitive pathways, females favoured an auditory approach

and were more responsive towards verbal communication.[52] The takeaway from this research is

that from a young age onward, males can favour visual information processing strategies. In

consideration of the availability heuristic, the gender of an analyst or decision-maker could thus

dictate preferences in how to present and receive information. Fortunately, understanding this

phenomenon can provide analysts the necessary tools to safeguard from bias. A report on the

effectiveness of visualization strategies suggests that an optimal way to mitigate such biases is to

thoughtfully combine and sequence complementary tabular and graphical reports for a task.[53]

The takeaway from these gender-nuanced preferences is a requirement for the

professionalization and standardization of analytical activities. Incorporating and instituting a

more thoughtful "information processing strategy"[54] for analysts could help address such

problems as well as improve the ability of senior leadership to understand the various reports

given.

As previously discussed, risk and rewards can be valued and viewed differently.

However, the interpretation of risk by the decision-maker is also an essential element of data

analytics that must be carefully considered. When providing reports with options and

recommendations, the degree of risk assessed is an aid that allows options to be effectively

compared. A generic example would be a "stoplight" risk matrix. However, there is evidence to

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[51] Lynn Huestegge *et al*, "Gender-specific Contribution of a Visual Cognition Network to Reading Abilities." *British Journal of Psychology* 103 (2011): 125.

[52] Max Coltheart, Elaine Hull, and Diana Slater, "Sex Differences in Imagery and Reading." *Nature* 253 (6 February 1975): 438.

[53] Bernard Hirsch, Anna Seubert, and Matthias Sohn, "Visualisation of Data in Management Accounting Reports: How Supplementary Graphs Improve Every-day Management Judgements," *Journal of Applied Accounting* 16, no.2 (2015): 232.

[54] *Ibid.*

suggest that the interpretation and acceptance of risk varies by gender, demonstrating anchoring and representativeness biases. Accordingly, it is important to counterbalance such gender biases when trying to conceptualization risk in a report. One study in gender and risk-taking examined its effect in high jump competitions. As these competitions were measurable and repeatable under controlled conditions, it provided a unique perspective on understanding risk tolerance. In high jump, the risk component occurs when athletes elect to pass on a jump.[55] The study found that women consistently took 4% less passes across a sample size of 3,996 competitors.[56] A competitor's past performance at a certain height can thus anchor their expectations of future success, affecting their decision-making process. With a 4% delta, this shows that there is an anchoring difference between genders that can impact how risk is interpreted. In sum, what is "yellow-risk" to one may very well be interpreted as "red-risk" to another.

Studies in business also support the findings in sports. For example, investment firm Charles Schwab found that 73% of females owned stocks versus 86% of males, which are known as a riskier investment vehicle.[57] Interestingly, a low appetite for risk does not necessarily equate to poorer performance. The National Association of Investors Corporation (NAIC) noted that all-female investment clubs earn significantly more than male clubs in profits, but in contrast contributed a quarter less to the clubs.[58] This demonstrates that gender does not necessarily equate to high or low risk-taking behaviour. Rather, risk appears to be interpreted differently. In the eighteenth and nineteenth century, high-risk speculative investments in the early capitalist

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[55] Rene Boheim, and Mario Lackner, "Gender and Risk Taking: Evidence from Jumping Competitions." *Journal of the Royal Statistical Society Series A* 178, no. 4 (2015): 885.

[56] Rene Boheim, and Mario Lackner, "Gender and Risk Taking: Evidence from Jumping Competitions." *Journal of the Royal Statistical Society Series A* 178, no. 4 (2015): 890.

[57] William L. Anthes, and Bruce W. Most, "Frozen in the Headlights: The Dynamics of Female and Money." *Journal of Financial Planning* 13, no. 9 (September 2000): 134.

[58] *Ibid*.

systems were predominantly made by the "wealthy aristocratic female."[59] To regulate the

markets, legislation was invoked to instill a "rational masculinized" approach to trading.[60] What

this demonstrates is that the absence or presence of information altered the female interpretation

of risk. Further exploring selectivity theory, another study examined the differences in heuristic

strategies employed by males and females in processing information for investments.[61] It found

that males simplified information and even deliberately filtered out additional considerations

while females sought information to the point of being overwhelmed.[62] Thus, decisions on risk

by gender correlated with the desire for more or less information. From an analytics perspective,

these gender differences suggest that when producing reports with options and risk, a strategy

that correctly prioritizes and sequences the amount and type of information presented is essential

for decision-makers. Further, analysts must be aware of their biases and the biases of decision-

makers so as to deliver the most effective report possible.[63] To illustrate, some decision-makers

may prefer a red/yellow/green approach to risk but may not truly appreciate the gravity of a

choice due to heuristic tendencies. In those cases, providing additional information through

amplifying details (i.e. charts that drill down) can improve the deliberation process. Conversely,

others may desire as much information as possible to render a decision but then become

overwhelmed. In those cases, an infographic to help condense the information can be beneficial.

In summary, the thoughtful sequencing and presentation of information is often undervalued but

is as critical as any other component of the analytical process. With the autonomy given

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[59] Susan Marlow, and Janine Swail, "Gender, Risk and Finance: Why Can't a Woman be More like a Man?" *Entrepreneurship & Regional Development* 26, no. 1-2 (2014): 87.

[60] *Ibid*.

[61] J. Graham *et al*, "Gender Differences in Investment Strategies: An Information Processing Perspective." *The International Journal of Bank Marketing* 20, no. 1 (2002): 19.

[62] *Ibid.,* 23.

[63] A common issue the author has observed are analysts who tend to favour a certain style of chart despite its distracting nature. For example, pie charts in excess of five variables are known to confuse decision-makers but some analysts will habitually produce such charts despite constant feedback.

analysts, standardization of training in visualization and information processing strategies can help to provide a more consistent and reliable report consuming experience for senior leadership.

CONCLUSION

To simply conclude that hiring more female analysts into an organization will resolve gender biases ignores broader social trends. Since 1984, when 37% of graduates in computer science were female, the figure has declined every year to below 10%.[64] Consequently, males have become the predominant gender in computing and analytics, even leading to the emergence of the "brogrammer" culture that has plagued Silicon Valley.[65] Therefore, similar to DDS and New Topia, future systems will likely continue to exhibit biases, impacting user adoption and data quality. In 2010, Google CEO Eric Schmidt stated that every two days, users create as much data as the dawn of civilization to 2003.[66] Humans simply cannot process such information effectively. Therefore as data continues to exponentially grow, the role of the data analyst will become prominent. As female participation in IT continues to decline, equipping the current cadre of analysts with the right decision-making strategies is likely the only short-term solution to improve the quality of analytical products. In contrast, some favour the solution of taking humans completely out of the loop and fully automating systems through algorithms. However, with the disproportionate amount of males in IT, this could be a dangerous proposition as these algorithms would likely reinforce programmer biases. Evidence suggests that this has

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[64] Anne-Marie Kermarrec, "Computer Science: Too Young to Fall into the Gender Gap." *IEEE Internet Computing* 18, no. 3 (May-June 2014): 4.

[65] Marie Hicks, "De-Brogramming the History of Computing." *IEEE Annals of the History of Computing* 13, no. 1 (January-March 2013): 86.

[66] Tech Crunch, "Eric Schmidt: Every 2 Days we Create as much Information as we did up to 2003," last modified 4 August 2010, https://techcrunch.com/2010/08/04/schmidt-data/

happened and that the "tyranny of the algorithm"[67] has resulted in discriminatory practices such as racial profiling in police work, insurance, national security, and banking.[68]

At the end of the day, decisions made with flawed data are still better than decisions made with no data at all. However, given how decision-makers instinctively employ heuristics, it is imperative that analysts provide the most unbiased information possible. With the current male-dominated systems and processes in computing, the data is already affected by the "ghosts" embedded in the machine. While this paper has outlined all the potential gender-bias traps, by no means does this paper suggest that gender is the only factor that causes biases in decision-making. Rather, the demonstration of how gender can impact data analytics suggests that data analytics will always remain a human endeavour; and there are opportunities to safeguard the process.

RECOMMENDATIONS

In consideration of the impact gender biases have on data analytics in a male-dominated field; this paper provides three suggestions as a way forward. First, in system design, the CAF must continually re-evaluate and re-invest in improving the user experience to maintain pace with the change in CAF demographics. This entails ensuring the diversity of user and focus groups order to help design the best product possible. While there can be a resistance to change in design when adopting new technology, the danger of porting over old processes is to release a product completely irrelevant to the current generation of users. By 2025, SAP will discontinue

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[67] Derina Holtzhausem, "Datafication: Threat or Opportunity for Communication in the Public Sphere?" *Journal of Communication Management* 20, no. 1 (2016): 23.

[68] Derina Holtzhausem, "Datafication: Threat or Opportunity for Communication in the Public Sphere?" *Journal of Communication Management* 20, no. 1 (2016): 24.

its current traditional database architecture and adopt in-memory computing with SAP HANA.[69]

This provides a unique opportunity for DRMIS to be redesigned to better serve users. Second,

the CAF must train its cadre of analysts to deliver the most bias-free products possible to

decision-makers. To facilitate this, there should be formalized data analytics training and

certification on analytical methodologies, data sourcing, and data visualization. Providing such

training can help to set a baseline for CAF analysts and perhaps foster a more strategic and

innovative analytical approach. Many industries and organizations have instituted their own

bespoke learning programs and the CAF already has formalized training such as Web

Intelligence author training that can be further enhanced.[70] Third, the CAF must integrate and

reduce its data siloes throughout the enterprise. Where possible, more sources of reliable data

needs to be under a single architecture in order to provide greater accessibility for analysts. A

simple example would be to integrate the various data siloes in the CAF such as Monitor Mass,

Peoplesoft, and other tailored databases under one umbrella. The power of reducing data siloes

is that it legitimizes the information presented and increases the speed and quality of research for

analysts. The CAF is on a great path as it evolves towards a data driven decision-making

culture. By and large, the enterprise architecture, leadership buy-in, and training are in place and

continue to positively progress. However, the ultimate goal of data analytics is to make optimal

evidence-based recommendations and decisions. In order to do so, the CAF needs both a

bottom-up approach that improves the user experience and analyst skill set, as well as a top-

down approach that helps decision-makers understand the role and influence biases play in the

analytical process.

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[69] Security Boulevard, "What is SAP S/4 HANA? – Business Introduction," last accessed 5 April 2018, https://securityboulevard.com/2018/04/what-is-sap-s-4hana-business-introduction/

[70] Forbes, "IBM Predicts Demand for Data Scientists will Soar 28% by 2020," last accessed 13 May 2017, https://www.forbes.com/sites/louiscolumbus/2017/05/13/ibm-predicts-demand-for-data-scientists-will-soar-28-by-2020/#29ee71577e3b

In basketball, hall of fame player Rick Barry had a career free-throw average of 90% by shooting underhanded or "granny-style." While the basketball world ridiculed him, analytics supported his intuition and confirmed that underhanded free-throws are a more consistent motion to replicate.[71] The great Wilt Chamberlain even improved his free-throw with the underhanded shot but later abandoned the approach because it made him look like a "sissy."[72] Such was the institutional stigma that nobody has shot underhanded in the National Basketball Association (NBA) since. Similarly, the CAF will likely encounter stiff institutional resistance in some areas despite the quality of analytics. It may never be possible to eliminate stigma associated with the CAF version of the "granny-style" free throw, but greater awareness of such a phenomenon can improve the CAF's relationship with the human side of data.

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[71] M. Venkadesan and L. Mahadevan, "Optimal Strategies for Throwing Accurately." *Royal Society Open Science* 4 (26 April 2017): 9.

[72] Sports Illustrated, "Malcolm Gladwell Q&A: The granny shot, Wilt Chamberlain and more," last modified 30 June 2016, https://www.si.com/nba/2016/06/30/malcolm-gladwell-wilt-chamberlain-rick-barry-nba-free-throw-granny-shot

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