

Women in Science, Technology, Engineering, Mathematics, and Management

Implicit Bias Challenges and Interventions

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Abstract

This scientific report focuses on factors that can impede the participation and advancement of women in Science, Technology, Engineering, Mathematics, and Management (STEMM). In particular, attention is paid to unconscious, implicit gender biases and how these may impact the hiring, selection, or promotion of women in STEMM fields/non-traditional roles. This report satisfies one of the objectives of the Working Group on Women in STEMM at Defence Research and Development Canada (DRDC), namely, to create awareness within DRDC about challenges faced by women in STEMM, and contributes to the aim of developing an action plan for achieving a balanced representation of women in non-traditional roles. The report also provides insight into an issue of importance to the ADM S&T, as champion of Employment Equity within DRDC. Specifically, this report provides statistics on women's representation in STEMM, nationally, internationally, and within DRDC; discusses the particular role of implicit or unconscious bias, rooted in gender stereotypes, as one possible explanation for the under-representation of women in STEMM, and, based on a review of empirical research, identifies the potential impacts of such biases on employment-related evaluations and decisions, including those pertaining to hiring, selection, and promotion. Women and leadership within the STEMM context is given specific consideration, as are implications of implicit bias and discrimination for individual health and well-being, as well as organizational outcomes. Possible interventions for reducing implicit bias, for instance through bias literacy training, are reviewed, and recommendations, along with suggestions for future research in this area, are offered.

Significance to defence and security

This report provides valuable insight into the challenges that women may face both entering and advancing in STEMM fields, including managerial or other non-traditional roles. The report also identifies a number of recommendations that managers can implement to counter the negative impacts of implicit biases, in particular, thereby better supporting women in STEMM, and achieving a more inclusive workplace environment. Such results will help to ensure that human talents are applied most effectively and that the potential gains from such diverse talents are maximized. Ultimately, such results and recommendations may help to ensure equitable representation of women at all organizational levels.

Résumé

Le présent rapport scientifique porte essentiellement sur les facteurs pouvant nuire à la présence et à l'avancement des femmes dans les domaines des sciences, de la technologie, de l'ingénierie, des mathématiques et de la gestion (STIMG). On s'intéresse tout particulièrement aux préjugés sexistes implicites ou inconscients, ainsi qu'à leurs répercussions éventuelles sur l'embauche, la sélection ou l'avancement des femmes dans les domaines STIMG et les rôles non traditionnels. Ce rapport a atteint l'un des objectifs du groupe de travail sur les femmes en STIMG à Recherche et développement pour la défense Canada (RDDC). Il a permis, entre autres, de sensibiliser l'Agence aux obstacles que doivent surmonter les femmes en STIMG et de contribuer à l'élaboration d'un plan d'action dans le but d'arriver à une représentation équilibrée des femmes dans les rôles non traditionnels. Le rapport présente également un aperçu d'une question d'importance pour le SMA S&T, en tant que champion de l'équité en matière d'emploi au sein de RDDC. Plus précisément, ce rapport contient des données statistiques sur la représentation des femmes en STIMG à l'échelle nationale et internationale, et au sein de RDDC. On aborde le rôle particulier que joue la partialité implicite ou inconsciente, bien ancrée dans les stéréotypes sexistes, qui pourrait expliquer la sous-représentation féminine en STIMG. Également, sur la base d'une revue de recherche empirique, on détermine les répercussions possibles de tels préjugés sur l'évaluation et les décisions relatives à l'emploi, notamment celles ayant trait à l'embauche, à la sélection et à l'avancement. On accorde une attention particulière aux femmes et au leadership en STIMG, de même qu'aux implications de la partialité implicite et de la discrimination fondée sur la santé et le bien-être personnel, ainsi qu'aux résultats de l'organisation. On énonce des moyens possibles de diminuer la partialité implicite, entre autres par une formation contre les préjugés, on formule certaines recommandations et on propose des suggestions de recherches futures dans ce domaine.

Importance pour la défense et la sécurité

Le présent rapport fournit un bon aperçu des obstacles auxquels les femmes peuvent se heurter lors de leur recrutement et dans leur avancement en STIMG, lorsqu'elles exercent des fonctions de gestion ou d'autres rôles non traditionnels. Ce rapport contient également un certain nombre de recommandations que les gestionnaires peuvent mettre en application afin de contrer les répercussions négatives de la partialité implicite, surtout en encourageant davantage la présence féminine en STIMG et en instaurant un milieu de travail qui soit plus inclusif. Ainsi, on contribuera à assurer une utilisation plus efficace des talents humains et à tirer le maximum de talents aussi diversifiés. Les succès obtenus et la mise en application des recommandations contribuera enfin à assurer une représentation équitable des femmes, et ce, à tous les niveaux de l'organisation.

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1 Introduction

1.1 Women's representation in Science, Technology, Engineering, Mathematics, and Management (STEMM)

In recent years, women have comprised the majority of university graduates in Canada, but men have still held the majority of university degrees in Science, Technology, Engineering and Mathematics (STEM) fields¹ (Hango, 2013). In 2011, among university graduates aged 25 to 34 with STEM degrees, 39% were women, and among women who chose to pursue a degree in STEM, most did so in biology or science programs, resulting in even fewer women in engineering, computer science and mathematics programs (Hango, 2013).² Accordingly, the national enrollment of women in first-year engineering classes at Canadian universities is 19% on average, and only 12% of Canada's 280,000 professional engineers are women (Schwartz, 2015).³ Similarly, the number of women in leadership roles in STEM fields is also comparatively low. For example, at universities, only 12% of full professors in STEM are women, according to 2009 data from Statistics Canada; women are more likely to be working as contract faculty or as assistant professors (see Schwartz, 2015). Further, only 11 of 60 members of the [Canadian Science and Engineering Hall of Fame](#) are women (18%); 22 out of 186 prizes worth more than \$200,000 were awarded to women by the [Natural Sciences and Engineering Research Council \(NSERC\)](#) between 2004 and 2014 (12%); and 23 out of 202 people named to the [Royal Society of Canada's Academy of Sciences](#) in the past four years have been women (11%; Schwartz, 2015). Since its inception in 1991, no woman has won NSERC's Hertzberg medal, which is awarded each year to Canada's top scientist or engineer "for sustained excellence and overall influence of research work" and comes with a \$1-million prize (Schwartz, 2015). Currently, 461 women out of 1,650 (28%) hold prestigious Canada Research Chairs, which come with \$500,000 to \$1.4 million in research funding. For the highest tier, the Canada Excellence Research Chairs, which come with a \$10-million prize, only one of 22 (less than 5%) are presently held by women (Schwartz, 2015).

The representation of women in STEM in Canada is similar to that in other parts of the world (Jackson, Hillard, & Schneider, 2014). For example, in the United States, women make up only 26% of computer science and mathematical science professionals (National Science Foundation, 2012). These numbers are even more striking when considering that, while the conferment of degrees for women in STEM has been increasing in general in the United States, women's

¹ STEM fields may include disciplines such as biology, chemistry, computer science, physics, physiology, psychology, technology, engineering, and mathematics. The term STEMM (science, technology, engineering, mathematics, and medicine) has also been used. However, an exhaustive list of STEM disciplines does not exist, because the definition varies by organization (see also LeBlanc, 2015). In this report, we will use the term STEMM to refer to science, technology, engineering, mathematics and *management*, unless otherwise indicated.

² In 2011, women represented 23% of graduates in engineering, 30% of graduates in mathematics and computer science, and 59% of graduates in science and technology (LeBlanc, 2015). Women had achieved parity or the majority in certain STEM occupations, such as architecture (49%), chemistry (49%) and biology (65%) (LeBlanc, 2015).

³ In 2011, women made up 12% of mechanical engineers, 15% of aerospace engineers, and 24% of civil engineers (LeBlanc, 2015).

participation in computer science, specifically, has declined to 18% from a peak of 37% in the mid-1980s (National Center for Education Statistics, 2012; as cited in Jackson et al., 2014). Likewise, in the United States, according to National Science Foundation statistics in 2013, women earned 42% of all doctoral degrees in science and engineering, but occupied only 28% of tenure-track faculty positions in those fields (Jackson et al., 2014). Further, despite achieving near-parity in some fields (e.g., earth sciences and agricultural sciences), women are over-represented in biology and the social/psychological sciences, similar to the situation in Canada, while the under-representation of women persists in other fields, such as physics and engineering, as well as computer science (Jackson et al., 2014; see also Leslie, Cimpian, Meyer, & Freeland, 2015).

As in the Canadian context, the situation for women in leadership roles, both within STEM fields and other non-traditional domains, reflects a similar story internationally. For instance, using data from the Association of American Universities, Niemeier and Gonzales (2004) found that 90% of engineering departments had male department chairs and just 2.5% had female chairs (the remaining percentage were of unreported gender). The data for the physical and mathematical sciences were almost identical, with 88% male and 5.5% female department chairs. Indeed, the situation regarding leadership for women in STEM reflects the general lack of leadership roles for women, particularly at the highest levels of organizations, and especially in non-traditional domains. For example, recent statistics show that the major tech and social-media companies, including Microsoft, are at least 80% male, not including administrative or support jobs (Anderssen, 2014). Similarly, although women now occupy more than 40% of all managerial positions in the United States, they are rarely found at the very top levels of business organizations (Eagly & Carli, 2007). Women comprise only 15.2% of the corporate boards of Fortune-500 companies (Heilman, 2012; Ratcliff, Vescio, & Dahl, 2015), and only 2.6% of the CEOs in such companies (5.1% in Canada; Catalyst, 2014; as cited in Wilson, 2015). The situation has been similar in other industrialized countries. In the 50 largest publicly traded corporations in each nation of the European Union, women made up, on average, 11% of the top executives, and 4% of the CEOs and heads of boards. Just seven companies, or 1%, of *Fortune* magazine's Global 500, had female CEOs (Eagly & Carli, 2007).

1.2 Women in STEM at Defence Research and Development Canada

Looking at our own organization, recent workforce analyses have indicated that women are slightly under-represented within Defence Research and Development Canada (DRDC) as a whole (31.7% internal representation vs. 33.2% external availability as of March 2013).⁴ However, the gap is much larger in non-traditional domains (ADM S&T Employment Equity Workforce Analysis, 2013; ADM S&T 2013-14/2015-16 Human Resources Strategy and Plan),

⁴ Here, internal representation refers to the proportion of DRDC employees who are women, based on voluntary employment equity self-identification data. External availability refers to the representation of women that one would expect to see within DRDC if this representation matched "local availability estimates," that is, the availability of qualified women in the larger Canadian workforce based on Statistics Canada data. Canadian workforce availability is based on the aggregation of local availability estimates with appropriate weight assigned to each local area according to the number of employees in each area. Such indices of external availability, which are based on labour market availability, reflect employment equity objectives, which are to be representative of the Canadian work force.

as well as in management positions overall. Likewise, informal data collection conducted in May 2013 (see Table 1) indicated that the proportion of women in S&T staff roles was approximately 25% on average, ranging from a high of 39% at DGMPPRA⁵ to a low of 14% at Atlantic Research Centre. This proportion compares to an average of 58% of women in support staff roles within DRDC. Further, women represented, on average, 19% of S&T managers (Section Head and above) across the organization. Percentages varied among centres, and in some cases workforce analyses have indicated an over-representation of women in certain scientific and managerial categories (when considering internal representation vs. external availability). Nevertheless, the overall proportions within DRDC are consistent with other statistics on the general under-representation of women in Science, Technology, Engineering, Mathematics, and Management (STEMM) in the Canadian, American, and other international contexts.

Table 1: Percentage of women by DRDC Centre.

Staff Type	Atlantic	CORA	CSS	Corp	DGMPPRA	Ottawa	Suffield	Toronto	Valcartier	Overall
S&T Manager	8%	14%	0%	33%	50%	38%	0%	25%	0%	19%
S&T Staff	14%	19%	22%	33%	39%	16%	28%	37%	16%	25%
Support Staff	47%	83%	80%	61%	48%	82%	34%	70%	13%	58%

1.3 Simply a pipeline issue, or a reflection of bias?

Decades of research have indicated that the under-representation of women in STEMM is not due to a lack of competence or inherent ability on the part of women (see, e.g., Eccles, 2005, 2007). Thus, some have argued that the relatively low numbers of women in STEMM is mostly a pipeline issue—that as more young girls and women become interested in pursuing STEMM subjects, the issue will resolve itself over time. But such an argument is challenged by trends in women’s representation in certain STEMM fields. For instance, the percentage of women in computer science has actually decreased in recent years (Lottero-Purdue, 2013; J. C. Williams, 2015; see also Eagly & Carli, 2007). [Another theory](#) is that women are choosing to forgo careers in STEMM to attain better work-family balance, or due to lack of interest, rather than being pushed out by bias.⁶ Although work-family balance issues may partly explain why some women

⁵DGMPPRA is the Director General Military Personnel Research and Analysis. Also in Table 1, CORA is the Centre for Operational Research and Analysis; CSS is the Centre for Security Science; and Corp is Corporate Headquarters.

⁶ To explain the under-representation of women in certain STEM fields, some researchers have examined women’s/girls’ concerns about balancing career and family, as well as the comparatively lower value that girls/women may place on science-related domains (“lower subjective task value”), based on stereotypical perceptions of these domains/tasks (for instance, as lacking human relevance) (see, e.g., Eccles, 2005, 2007; Frome, Alfeld, Eccles, & Barber, 2006; Jacobs, 2005; Jacobs, Davis-Kean, Bleeker, Eccles, & Malunchuk, 2005; Jacobs & Simpkins, 2005; Jacobs, Vernon, & Eccles, 2005; Sáinz & Eccles, 2012; and Wang, Eccles, & Kenny, 2013). Such researchers have largely ruled out gender differences in actual performance or ability to explain the under-representation of women in STEM fields, even as girls/women have sometimes reported lower ability self-concepts (lower self-perceptions of competence or expectations of success) regarding some STEM fields (e.g., Sáinz & Eccles, 2012). Importantly, such researchers have also noted the role of gender-role socialization pressures (especially parental influences), cultural norms,

choose not to pursue a career in STEMM, or may choose to exit such a career, a growing body of evidence suggests the role of gender bias in driving women out of science careers (Heilman, 2012; J. C. Williams, 2015). Indeed, such biases may, themselves, play a role in decisions regarding work-family balance, or in the value placed on pursuing a career in a STEMM field, in interests in pursuing such careers, or in expectations of success in such careers (Eccles, 2005, 2007; Sainz & Eccles, 2012). In many cases, such biases are implicit or unconscious, reflecting gender stereotypes that people may not realize they have (see J. C. Williams, 2015). Accordingly, in 2006 the National Academies of Science rejected the pipeline argument and concluded that gender inequities in STEMM arise from systematic bias deeply rooted in assumptions about gender—sometimes conscious but more frequently unconscious—that are embedded into the cultural fabric of society, and that individuals’ differential responses toward females and males are habitual or automatic (Carnes et al., 2012; see also McCullough, 2011). International research also suggests that the same challenges confront women in STEMM around the world and that the primary cause of this under-representation is cultural in nature (Jackson et al., 2014). Further, recent research indicates that prejudiced attitudes and discriminatory behaviours in the workplace, such as regarding gender and race, tend to be more implicit and subtle than in the past (Lalonde, 2011).

There may be many possible explanations for the pattern of women’s representation in STEMM fields, including but not limited to gender bias. However, given the potential role of gender bias in continuing to hinder women’s participation in STEMM fields, it is necessary to gain a deeper understanding of such bias—and in particular, of implicit or unconscious gender bias.

1.4 Defining implicit or unconscious gender bias

To understand gender bias, whether implicit or explicit, one must first understand gender stereotypes, as gender bias is rooted in gender stereotypes (Heilman, 2012). Stereotypes are generalizations about groups that are applied to individual group members simply because they belong to that group, and gender stereotypes (or gender schemas) are generalizations about the attributes of women and men as groups. According to social role theory (Eagly & Carli, 2007), gender stereotypes are themselves rooted in the traditional gendered division of labour, in which women and men occupy particular social roles, requiring particular behaviours. Thus, men’s traditional participation in the paid labour force has resulted in them being stereotypically viewed as possessing *agentive* characteristics that emphasize confidence, self-reliance, and dominance (Hoyt, 2012). Likewise, women’s traditionally greater involvement in domestic responsibilities and care-related employment has given rise to the stereotype that women possess *communal* characteristics that highlight a concern for others (Hoyt, 2012).

Gender stereotypes have both descriptive and prescriptive properties (Heilman, 2012). Descriptive gender stereotypes designate what women and men are perceived to be like, whereas prescriptive gender stereotypes designate what women and men *should* be like. Both descriptive and prescriptive gender stereotypes can give rise to biased judgments, expectations and decisions—workplace bias—that can compromise women’s career progress. For instance, descriptive stereotypes may promote negative expectations about women’s performance by creating a perceived “lack of fit” between the attributes women are thought to possess and the

and gender stereotypes in affecting subjective task value as well as related unconscious and conscious achievement-related behavioural choices (see, e.g., Eccles, 2007).

attributes thought necessary for success in traditionally male positions and roles, including STEMM positions and roles (Heilman, 2012). Prescriptive stereotypes, on the other hand, establish normative expectations for men's and women's behaviour that induce disapproval, derogation and social penalties when they are directly violated, or when violation is inferred because a woman is successful within a non-traditional domain (Heilman, 2012).

As indicated earlier, research suggests that the nature of prejudice and discrimination has evolved over time into more implicit forms (i.e., a male supervisor who prefers hiring men because he assumes that women with child care responsibilities are less reliable and unable to meet short deadlines; Lalonde, 2011). Such assumptions may not be verbalized to others. Or they may be held by individuals who, for instance, explicitly favour women in the paid workplace in general, or on a conscious level when speaking to others, but who nevertheless assume that women with children, but not men with children, will be less reliable. Thus, an understanding of workplace bias must consider implicit (covert, subtle, non-verbal, unconscious) sources of bias, as well as explicit (overt, direct, verbal, conscious) forms. The construct of implicit social attitudes, for instance, is based on the theory that learning can be unintentional and can occur outside of one's own consciousness. Such implicit learning theory posits that implicit social biases are acquired through past experiences, and express themselves through attitudes such as cultural stereotypes. These resulting cultural biases, including gender biases, tend to be difficult to articulate, and individuals are often unaware of how such biases can influence their behaviour. For example, individuals can consciously believe that their actions are non-discriminatory, yet they may still hold implicit biases that can negatively colour their perspective, leading to unintentional discrimination or exclusion, and thus disadvantaging certain demographic groups (Cagnassola, 2015; Lalonde, 2011; Lottero-Purdue, 2013). Indeed, such implicit stereotypes or biases—such “mind bugs” or “habits of mind”—may include stereotypes or biases that individuals might consciously and overtly reject, but that may be revealed in subtle micro-behaviour, such as avoiding eye contact during a handshake with someone from a different race (Anderssen, 2014; Carnes et al., 2012). Similarly, “unconscious bias” has been defined as “the instinctive blind spot created by [one's] own experience” (Anderssen, 2014) that can slip by undetected in ways that reinforce racial and gender inequities, for instance, in the workplace (Ratcliff et al., 2015). Along the same vein, “gender schemas” are defined as non-conscious expectations or hypotheses about the characteristics of a person, based on their group membership, which may influence judgments of others (see Heilman, 2012).

A substantial body of evidence suggests that most people—men and women—hold implicit biases (Lottero-Purdue, 2013; Moss-Racusin, Dovidio, Bresoll, Graham, & Handelsman, 2012; see also Steinpreis, Anders, & Ritzke, 1999). Further, although the effects of such subtle biases may often appear small, over time and across large populations, such biases toward disadvantaged groups can accumulate into striking differences (Ratcliff et al., 2015). Indeed, in addition to fostering negative attitudes, implicit biases can lead to damaging stereotypical behaviours that may negatively affect the education, hiring, promotion, and retention of women in STEMM (Jackson et al., 2014). These gender biases may play a particularly detrimental role in employment-related decisions, in part because of the generally unstructured nature of those decisions, which allows for biased decisions without accountability (Hoyt, 2012), as well as because of the pervasive nature of such biases. Indeed, implicit association tasks reveal that most people associate men with science more strongly than women with science (Jackson et al., 2014). Thus, weak implicit associations between women and STEMM fields may partly explain why women faculty are paid less, promoted more slowly, receive fewer honours, and are given fewer

leadership positions than men (Jackson et al., 2014). Individuals may espouse egalitarian beliefs on a conscious, explicit level, but if they fail to recognize that they possess discrepant implicit associations, or if they do not understand the effect that these implicit, covert associations can have, they can inadvertently engage in discriminatory behaviours (Jackson et al., 2014; Riffle et al., 2013; see also Latu, Schmid Mast, & Stewart, 2015).

Such implicit forms of prejudice are often referred to as modern forms of prejudice. Accordingly, recent theorists have argued that sexist prejudices have become more subtle since the 1990s, so that few people make openly hostile sexist comments (Yoder, 1999). Whereas “old-fashioned sexism” openly endorsed stereotypic judgements about and differential treatment of women and men, “modern sexism,” or “neo-sexism,” is more subtle—characterized by a denial of continuing discrimination, by antagonism towards women’s demands, and by a lack of support for policies designed to improve women’s status (Lips, 2001, p. 13). Further, these more subtle forms of discrimination are difficult to notice, and thus can have substantial adverse effects because they often remain unaddressed. For example, academic women may be assigned heavier teaching and service responsibilities, may be interrupted more, and may be marginalized in meetings, due to such biases (see Riffle et al., 2013). In turn, in such a work climate, women may believe that their opinions are less valued, and that their influence and opportunities are more limited, compared to men (Riffle et al., 2013).

But for women, the effects of gender biases may be experienced many years before entering STEM fields, or may dissuade them from even considering entering such a career. From early childhood to adulthood, women and girls encounter overt messages, as well as more subtle, even unconscious, influences (e.g., from teachers or parents) that may lead them to believe that men are naturally more talented in STEM fields, and that identifying oneself as feminine is at odds with identifying as a professional in a STEM field. Given the pervasiveness of the stereotype that women are less capable of math and science, for instance, it is unsurprising that researchers have found evidence of this stereotype at an implicit level, among both boys and girls (Saucerman & Vasquez, 2014). Once again, even though these beliefs may be held outside of conscious awareness, they can predict real and important outcomes. Such outcomes include female students’ academic self-concept, performance on math exams, enrollment in future math courses, and desire to pursue a math-related career (Eccles, 2005, 2007; Tiedemann, 2000). Indeed, gender stereotypes may decrease girls’ or women’s identification with and career aspirations in science (Jackson et al., 2014), as well as affect performance, for instance, through stereotype threat (i.e., when gender stereotypes are made salient to girls/women, with negative impacts on performance; Saucerman & Vasquez, 2014). Likewise, as will be detailed in this report, there is ample evidence in the literature that women are subjected to gender-biased evaluations, in which their performance on male gender-typed tasks is devalued and their competence is denied (see Heilman, 2012). Furthermore, even when they are successful, women may be subject to biased judgments (Heilman, 2012).

1.5 Gender and diversity issues in the Canadian Public Service

At DRDC, the possible influence or effects of gender biases have not been examined systematically to date. However, results from the Public Service Employee Survey (PSES) may shed some light on gender and diversity-related issues. Thus, the 2011 PSES indicated that 92%

of ADM S&T employees believed that every member within their work unit, regardless of race, colour, gender or disability, would be/is accepted as an equal member of the team—an encouraging result. Some positive results were also found for the 2014 PSES, in that the majority of ADM S&T respondents (72%) strongly or somewhat agreed with the statement that “my department or agency implements activities and practices that support a diverse workplace.” However, among the 5% of employees who indicated (in 2014) that they were a victim of discrimination in the past two years, 30% reported that they had experienced sex discrimination—which remains one of the most frequently-cited types of discrimination by employees in all occupational categories in the public service. Further, among the 13% of ADM S&T respondents who reported in 2014 that they were a victim of harassment on the job in the past two years, 11% indicated that the nature of the harassment was specifically sexual in nature.⁷

1.6 Working group on women in STEMM at DRDC

As previously discussed, evidence suggests that relatively few women currently occupy S&T management roles at DRDC centres, and that women are generally under-represented in STEMM occupations at DRDC. In addition to that evidence, previous informal inquiries⁸ at DRDC have suggested that women in DRDC perceive that there may be barriers, both specific and systemic, to their advancement, and that there may be a lack of awareness of gender issues among DRDC employees and managers (Genik & Wood, 2014). According to Genik and Wood’s (2014) assessment of the relevant literature, such “second-generation gender bias” (or secondary bias) refers to powerful yet subtle and often invisible barriers that arise from cultural assumptions and organizational structures, practices and patterns of interaction that inadvertently benefit men while disadvantaging women; such barriers may include a paucity of role models for women, gendered career paths and gendered work, women’s lack of access to networks and sponsors, and double binds regarding leadership and gender.

In response to such issues, in November 2013, the ADM S&T, as Champion of Employment Equity (EE) within DRDC, endorsed the creation of a Working Group (WG) on Women in Science, Technology, Engineering, Mathematics and Management (STEMM) at DRDC, with national participation and Co-Chaired by Lynne Genik, Centre for Security Science (CSS) and Donna Wood, Centre for Operational Research and Analysis (CORA). In addressing one of the four groups targeted under the Employment Equity Act (women, persons with disabilities, members of visible minorities, and Aboriginal peoples), the WG on Women in STEMM at DRDC is responsible for supporting the EE Champion and for developing and implementing an action plan in accordance with the vision and objectives of the WG. These objectives include:

- a. contributing to the achievement of EE obligations in the DRDC Human Resources Strategic Plan;
- b. acting as a cornerstone for a supportive network for women in STEMM at DRDC;

⁷ These PSES results were not broken down by gender. However, gender biases can affect both women and men. That is, both women and men can experience sexist discrimination, or harassment that is specifically sexual in nature.

⁸ These inquiries of DRDC employees were conducted by Genik and Wood as part of a grassroots engagement to begin to determine whether perceptions of barriers were shared by women at DRDC.

- c. enabling the creation of a supporting environment for women in STEMM at DRDC;
- d. communicating to DRDC employees about challenges faced by women in STEMM at DRDC; and
- e. developing and implementing an annual action plan to achieve these objectives.

Accordingly, among the aims of this WG is to develop an action plan for achieving a balanced representation of women in non-traditional roles within DRDC. In addition to this aim, the WG proposed to write a scientific report on the factors impeding the advancement of women in non-traditional roles, focusing specifically on unconscious and personal biases and how these might impact hiring processes. The present report fulfills that aim.

1.7 This report

Gaining insight into implicit or unconscious biases is an important first step in finding effective interventions and approaches that foster positive attitude and cultural change, as well as in identifying policy changes or organizational practices that can increase gender diversity (Lalonde, 2011). Thus, the primary purpose of this report is to illuminate such implicit or unconscious biases, drawing on empirical research evidence that demonstrates the conditions under which such biases may exist. As will be discussed, such research suggests that, although implicit biases are widely shared within a culture among both women and men, and although such biases may be unconscious, habitual, or even automatic, they can also be modified with experience, and with various forms of counter-stereotypic, bias literacy, and unconscious bias training.

This report is divided into four main sections. The first section, this Introduction, sets the context and identifies the main issues related to women in STEMM, particularly with respect to unconscious or implicit bias, and outlines the mandate of the WG on Women in STEMM at DRDC, including the aim of this report. The second section details the findings of empirical research on unconscious/implicit bias, including research on gender stereotypes and implicit associations, specifically with respect to women in STEMM/non-traditional fields. Also noted in this section are implications of such biases for employment decisions, such as hiring or selection decisions. The third section focuses on potential interventions for addressing or minimizing such biases, including various training approaches and workshops, at both individual and organizational levels. The fourth and final section contains a concluding summary and offers recommendations for next steps and future work.

2 Empirical research on implicit gender bias

As noted in the Introduction, a substantial body of research has established that most people—men and women—hold implicit biases—that is, biases that are held by the subconscious mind and thus are not normally available to conscious awareness. Such biases are learned and shaped by societal stereotypes that often contradict explicit, socially acceptable beliefs about gender equality (Saucerman & Vasquez, 2014). Researchers have also found strong evidence to indicate that implicit biases can have profound effects on behaviour (Saucerman & Vasquez, 2014). Indeed, a growing body of research indicates that the effects of bias, not simply a “leaky pipeline” or “personal choice,” may push women out of, or away from, science (see Lottero-Perdue, 2013; J. C. Williams, 2015).

In this section, we highlight some of the recent scientific evidence regarding implicit gender bias, with a particular focus on the implications for women in STEMM, as well as for employment-related decision making, such as hiring decisions. We examine the roots of implicit gender bias in gender stereotypes, both descriptive and prescriptive, as well as the concept of stereotype threat. We take a closer look at women in managerial and leadership roles, exploring whether such women face a “glass ceiling,” a “labyrinth,” or a “glass cliff.” And finally, we examine the implications of implicit bias for individual health and well-being, as well as for organizational outcomes. But first, we begin with a look at the early development and influence of implicit bias within an individual’s life trajectory—for instance, at the influence of teachers, parents, peers, and media on bias formation. We do this in order to emphasize the early origins of such bias in individual development—to highlight the fact that such bias begins to exert its influence on an individual years before they enter the workplace, within a social and cultural context, and with potential implications for their future career. But we also seek to suggest possible strategies or opportunities for stakeholders or other actors to influence the decisions of girls or women to pursue STEMM studies or careers—potentially in a more positive direction.

2.1 Early development of implicit bias

2.1.1 The role of teachers

Research suggests that the effects of implicit bias begin early in human development (Saucerman & Vasquez, 2014). Young children perceive messages about social roles, their own competence, and possibilities for their future, from both overt instruction and subtle, unconscious, influences. For instance, teachers can convey messages or attitudes regarding science and math without being aware they are doing so, with potentially powerful effects on students. Thus, female teachers’ math-related anxiety has been associated with lower mathematical achievement among female students, and with increased likelihood of students endorsing traditional gender-based notions of academic ability (Beilock, Gunderson, Ramirez, & Levine, 2010). Such associations may develop over the course of a school year. For instance, in a study of 17 Grades 1 and 2 classrooms (Beilock et al., 2010), there was no relationship between the teachers’ math anxiety and students’ initial math proficiency at the beginning of the school year. But by the end of the school year, there was a significant relationship between teachers’ math anxiety and female students’ achievement. The more math anxiety a teacher reported, the lower the girls’ scores (this pattern

was not found for male students). High teacher math anxiety was also positively related to female students' reported beliefs in traditional gender abilities (the idea that boys are good at math, and girls are good at reading). Further, the more girls expressed this gender-typed thinking, the lower their math scores at the end of the school year. None of this research implies that teachers intend to communicate messages about gender stereotypes or math anxiety to the students, or that they are even aware that they are doing so. Rather, the teachers may, in many cases, be reflecting implicit attitudes that they developed themselves during their own childhoods. Nevertheless, implicit attitudes can cause the teachers' behaviour to differ in subtle but powerful ways, as they interact with female and male students (Saucerman & Vasquez, 2014).

2.1.2 The role of parents

The effects of teacher expectations can be increased by parental beliefs. For instance, Tiedemann (2000) found that mothers and fathers, on average, believed that boys were more competent in mathematics than were girls. The children's teachers also shared this belief, despite the fact that there were no significant differences between the boys' and girls' previous or current grades. For instance, in Tiedemann's (2000) study, mothers' and teachers' beliefs about the children's ability were strongly correlated, and had a strong influence on the child's own ability perceptions. Thus, a girl's perceptions about her mathematical ability were influenced by factors outside her own ability, with potential implications for a future career in mathematics. Much like teachers, in most cases, the messages that parents conveyed were a product of their own socialization experiences, transmitted unconsciously, rather than directly or explicitly (Saucerman & Vasquez, 2014). Similar patterns have been shown for parental expectations about science. Several studies have investigated parental attitudes about their elementary-school-age children and have found that parents believe that sons are more interested in science than daughters, have higher expectations of boys' performance than girls' performance, believe that science is more difficult and less important for girls than for boys, and engage in more complex dialogue about scientific concepts with boys than with girls (Andre, Whigham, Hendrickson, & Chambers, 1999; Tenenbaum & Leaper, 2003). Such beliefs have been found in parents despite a lack of gender difference in their children's reported interest in or liking of science (Andre et al., 1999; Tenenbaum & Leaper, 2003).

Parental beliefs continue to play a role during adolescence. For example, Chhin, Bleeker, and Jacobs (2008) found that parental expectations about whether their sons and daughters should have gender-traditional careers were significantly correlated with their children's gendered career expectations. Likewise, such parental beliefs and the corresponding expectations they have for their adolescent children strongly predicted those children's careers in young adulthood (Chhin et al., 2008). Specifically, mothers' and fathers' career expectations for their daughters at age 17 significantly predicted their daughters' actual gender-type career at age 28 (Chhin et al., 2008).

One particularly salient finding relates to self-efficacy, or the belief in one's ability to succeed in a particular situation or field. Bleeker and Jacobs (2004) found that mothers directly and indirectly affected the self-efficacy of girls in STEM fields.⁹ For example, adolescent girls' STEM career self-efficacy was significantly related to mothers' expectations for their children's success. Overall, the mothers of girls in Grade 7 reported lower expectations of their daughters' capacity for success in STEM fields than did the mothers of boys, and these effects persisted

⁹ Fathers were not included in this study.

beyond adolescence. Thus, mothers' predictions of their Grade 7 children's success in STEM fields were correlated with their adult children's STEM career self-efficacy. Further, female adolescents whose mothers did not predict high success in STEM fields were 66% more likely to select a non-STEM field than a physical science field, compared with those whose mothers had more optimistic attitudes. However, mothers' perceptions had only a small effect on male adolescents' selection of non-STEM careers (Bleeker & Jacobs, 2004). By the end of adolescence, the differences in self-efficacy may be substantial between young men and women, just at the time that they are making career choices. Accordingly, Chhin et al. (2008) found that men's STEM self-efficacy at the age of 19–20 years old was significantly higher than that of women at that age.

2.1.3 The role of the media

In addition to teacher and parental influences, portrayals of science and math in the media have the potential to influence girls' attitudes and performance in such fields through the representation of science as a masculine endeavour. For example, scientists as characters in popular media (e.g., television) are most often male (see Saucerman & Vasquez, 2014). Further, although scientists in programs targeted at children may behave in ways that do not conform to gender stereotypes more often than is true in the general media, male scientists still far outnumber female scientists in these children's programs as well (Long, Steinke, Applegate, Lapinski, Johnson, & Ghosh, 2010). Even programs specifically designed to reduce gender stereotypes and increase interest in science (some of which have shown promising results, e.g., Mares, Cantor, & Steinbach, 1999) may contain gender stereotypes (Long, Boiarsky, & Thayer, 2001). For instance, Mares et al. (1999) found that the television show *Get Real!* enhanced girls' view that science is appropriate for women, but showed the opposite effect for boys' attitudes. Long et al.'s (2001) analysis of television shows, such as *Beakman's World*, *Bill Nye The Science Guy*, *Magic School Bus*, and *Newton's Apple*, found that males and females in these shows were equally likely to be scientists, and that male and female scientists did not differ in screen time or status (e.g., in terms of likelihood of answering questions). However, Long et al. (2001) also found that in two of the programs (*Newton's Apple* and *Bill Nye The Science Guy*), the male characters in general were more likely than the female characters in general to be adults, and that males had much greater screen time than females overall. The researchers suggested that such findings reinforce the stereotype that science is a masculine activity (Long et al., 2001).

2.1.4 The role of peers

Along with media portrayals and adults' implicit attitudes, implicit peer attitudes can also play a role in children's feelings toward STEM fields, particularly in the development from childhood to adolescence. For instance, Leaper, Farkas, and Brown (2012) found that girls whose friends conveyed support for math and science pursuits, along with girls with gender-egalitarian beliefs, were more motivated to pursue STEM topics than were girls whose friends endorsed gender-typical roles. Overall, as girls and boys move through childhood and into adolescence, they may receive numerous unintentional or implicit messages about the appropriateness of STEM as an area of interest (Saucerman & Vasquez, 2014). For instance, children in elementary school have been found to identify science-related jobs as masculine (Andre et al., 1999). Muzzatti and Agnoli (2007) found that boys as young as seven years old reported the belief that male students are better at math than female students, whereas girls expressed the belief that male

and female students are equally good at math until the girls were about 10 years old, when they started reporting that male students are superior. Muzzatti and Agnoli (2007) also found that, during adolescence, boys adopted a more egalitarian stance, at least in their explicit statements, agreeing with the idea that boys and girls are equally good at math, whereas girls continued to endorse the belief of male superiority in math, possibly due to the internalization of gender stereotypes.

2.1.5 Opportunities for positive influence

The research discussed above indicates the potentially early and pervasive influence of teachers, parents, peers, and media on the development of implicit gender bias within a social and cultural context (see also T. Williams, 2014). Moreover, such influence has the potential to negatively impact the motivations of individual girls and young women to pursue STEM studies or careers, as well as to adversely affect their self-efficacy, ability perceptions, aspirations, expectations, and performance in relation to such fields. Yet, the research may also suggest possible opportunities for stakeholders, such as parents or teachers, or other actors, to influence, in a more positive direction, the decisions of girls or young women in relation to such fields. Although a detailed discussion of such strategies involving parents or educators, for instance, is beyond the scope of this report, the first step in such an effort would include an awareness of the pervasiveness of such implicit bias and its implications, as well as a better understanding of the nature of such bias, including the conditions in which it is more or less likely to occur. Likewise, as will be discussed in later sections of this report, strategies for minimizing implicit bias in the workplace context, such as through diversity training with workplace stakeholders, including managers, will also require an awareness of the nature and pervasiveness of implicit bias, as a first step. Thus, we turn next to a closer examination of the nature of implicit gender bias, including some of the conditions in which it occurs.

2.2 The roots of implicit gender bias: gender stereotypes

As mentioned in the Introduction of this report, implicit gender bias is rooted in gender stereotypes, both descriptive and prescriptive. Descriptive gender stereotypes designate what women and men are assumed to be like, whereas prescriptive gender stereotypes designate what women and men ought to be like. Heilman (2012) discusses how descriptive gender stereotypes, for instance, promote gender bias through the negative performance expectations that result from the perception that there is a “poor fit” between what women are like and the attributes believed necessary for successful performance in male gender-typed positions and roles, including STEM positions and roles. Similarly, Heilman (2012) discusses how prescriptive gender stereotypes promote gender bias by creating normative standards for behaviour that induce devaluation and derogation of women who directly or indirectly violate gender norms (e.g., by being successful in traditionally masculine positions and roles). Heilman (2012) reviews an extensive body of psychological research, for instance, that tests these ideas, considers career consequences that may result from stereotype-based bias, and identifies conditions that tend to exaggerate or minimize the probability of its occurrence. Below is a more detailed description of this body of research.

2.2.1 Descriptive gender stereotypes

The content of descriptive gender stereotypes, or beliefs about how men and women typically are, has been studied extensively. Beginning with early studies in the 1960s and 1970s, researchers have identified the attributes that are thought to characterize men and women (e.g., Bakan, 1966; Broverman, Vogel, Broverman, Clarkson, & Rosenkrantz, 1972). Thus, *agency* is often considered the defining characteristic of the male stereotype, and *communality* the defining characteristic of the female stereotype (Bakan, 1966). Agency has come to denote achievement orientation (e.g., competent, ambitious, task-focused), inclination to take charge (e.g., assertive, dominant, forceful), autonomy (e.g., independent, self-reliant, decisive) and rationality (e.g., analytical, logical, objective). Communality, on the other hand, has come to denote concern for others (e.g., kind, caring, considerate), affiliative tendencies (e.g., warm, friendly, collaborative), deference (e.g., obedient, respectful, self-effacing) and emotional sensitivity (e.g., perceptive, intuitive, understanding). Such gendered conceptions tend not only to be different between the two genders, but also oppositional. That is, women are seen as lacking what is thought to be most typical of men, and men are seen as lacking what is thought to be most typical of women. Further, such gender stereotypes have been remarkably consistent across culture, time, and context, such as across diverse employment settings (Heilman, Block, Martell, & Simon, 1989; Schein, 2001; see J. C. Williams, 2015).

As Heilman (2012) explains, these widely shared beliefs about men and women have significant consequences. Descriptive stereotypes serve as heuristics or shortcuts for forming impressions about people, that is, “energy-saving devices” that allow perceivers to form impressions quickly, and thus to respond easily to or predict the highly complex social world in which they live. Moreover, descriptive stereotypes can exert influence without the awareness of the perceiver, and are often activated automatically, although they are not always acted upon. Further, evidence suggests that people are often not cognizant of the impact of these automatically activated gender stereotypes on their impressions and judgments. Thus, such stereotypes may be problematic for women in work settings if they negatively affect expectations about their performance, as may occur if there is a perceived “lack of fit” between a woman’s attributes and those characteristics believed necessary for success in traditionally male positions, including positions within STEM fields (Moss-Racusin et al., 2012), as well as top management and executive positions (J. C. Williams, 2015). Such gender stereotypes may help to explain why women are under-represented in academic fields where raw, innate talent is believed to underlie success (e.g., physics), as women are stereotyped not to possess such innate talent (Leslie et al., 2015).

As noted, such gender stereotypes seem highly resistant to change. Although there are some indications that communal attributes, such as interpersonal skills, are increasingly becoming valued leadership and managerial characteristics (Heilman, 2012), the perception of “what it takes” to be successful in these positions remains largely tied to agentic qualities (Schein, 2001). Accordingly, research has found a perceived lack of fit between the demands of high-level organizational positions and characterizations of women. In early work on this topic, it was found that when respondents, both male and female, were asked to identify the attributes of men in general, of women in general, and of successful managers, the characterization of successful managers were more congruent with the characterization of men than of women (Schein, 1973, 1975). Heilman et al. (1989) later showed that this result held when respondents were asked specifically about the attributes of male and female managers; male managers were described as more similar to successful managers than were female managers. More recently, Ryan, Haslam,

Hersby, and Bongiorno (2011) replicated the “think manager, think male” association, in that stereotypically masculine traits (forceful, decisive) were almost twice as likely as stereotypically feminine traits (neat, sophisticated) to be selected as characteristic of managers of successful companies. Ryan et al. (2011) also found that this association was stronger for male participants than for female participants. Thus, although there is evidence that such stereotypes may be slowly changing over time, the general idea that we “think manager, think male” seems to persist, and the perceived lack of fit between female stereotypic attributes and male gender-typed job requirements may lead to the conclusion that women are not equipped to handle these jobs (Ryan et al., 2011).

2.2.1.1 Cognitive distortions as a basis for implicit gender bias in evaluations

According to Heilman (2012), stereotype-based negative performance expectations may have a profound effect on information processing, and may result in cognitive distortions that form the basis of gender bias in performance evaluation. As Heilman (2012) describes, cognitive distortions are self-perpetuating, in that they tend to bias information in ways that allow such distortions to be maintained and to withstand disconfirming evidence. More specifically, cognitive distortions can affect what information is attended to, its interpretation, and its recall—all of which can have distinct consequences for employment evaluations and decisions. Expectations can affect what information is focused upon, by acting as a perceptual filter, directing attention away from disconfirming information and toward confirming information. If expectation-inconsistent information is either ignored, discounted or attributed to something outside of the individual, for instance, the original expectation can be maintained, reflecting a confirmation bias.¹⁰ Research has provided support for these ideas, indicating that evaluators spend less time attending to the work behaviours of individuals about whom there are stereotype-based expectations than individuals for whom such expectations do not exist (Favero & Ilgen, 1989). Even if expectation-inconsistent information is attended to, its interpretation can perpetuate initial expectations. Thus, behaviours performed by individuals about whom there are different expectations have been shown to be interpreted very differently. For example, changing a course of action may be seen as flexible when performed by a man, but as weak or indecisive when performed by a woman. Memory can also be biased by expectations, in that people have been found to recall more expectation-consistent than inconsistent information. In fact, expectations can be more powerful than memories of actual behavioural events in making behavioural ratings (Baltes & Parker, 2000). Thus, a woman’s behaviour that is consistent with expectations about women is more likely to be recalled by evaluators, whereas behaviour that is inconsistent with expectations is more likely to be forgotten. Biased expectations can lead to biased evaluations, and these in turn become the basis of organizational decision making (Heilman, 2012).

Indeed, the tenaciousness of performance expectations, and their powerful influence on the ways in which information is processed, suggests that expectations can have important consequences

¹⁰ In addition to the “confirmation bias,” researchers have identified other human decision making or cognitive biases that may be relevant to the gender-evaluative context, including the “anchoring bias” (the tendency to over rely on one trait or piece of information); the “bias blind spot” effect (the tendency to see oneself as less biased than other people, or able to identify more cognitive biases in others); and the “availability heuristic” (the tendency to rely on information that is readily available in our minds). See also Adams, Rehak, Brown, and Hall (2009), and Pronin, Lin, and Ross (2002).

for the workplace. For instance, there may be consequences for hiring and job placement decisions, as well as for opportunities for skill development, pay raises and promotions. Also, because of selective attention, interpretation, and recall, assessments of women's performance and competence may be negatively affected and, accordingly, their opportunities for advancement and attainment of organizational rewards frustrated. Such implicit cognitive biases may also explain, in part, why women in non-traditional roles, such as STEMM roles, often feel that their expertise is questioned, or that their success is discounted—in short, that they must prove themselves over and over again (see, e.g., J. C. Williams, 2015, regarding the “prove-it-again” bias pushing women out of STEM).

There is also strong experimental evidence demonstrating that the greater the perceived lack of fit between women's characteristics (descriptive gender stereotypes) and the characteristics required for a position, the more negative the evaluative outcomes for women (see Heilman, 2012). In these experiments, the degree to which stereotypes about women are activated, or the degree to which the position in question is seen as male gender-typed, is varied. In fact, negative evaluations in selection decisions for women have repeatedly been found to occur more often for male gender-typed jobs than other types of jobs, that is, for jobs in which the work responsibilities are ones typically associated with men, in which men constitute the majority, or in which the occupation, profession, or academic field is perceived as “male” (for a meta-analysis¹¹, see Davison & Burke, 2000; Hoyt, 2012; see also J. C. Williams, 2015). Similar patterns have been found concerning competence assessments and performance evaluations of women. Lyness and Heilman (2006), for example, found that in a large financial services company, women were evaluated less favourably than men in line jobs, which tend to be male gender-typed, but not in staff (non-line) jobs. Similarly, female military officers were rated as less competent than male officers in male-dominated military units, but not in military units where men were less prevalent (Pazy & Oron, 2001).

Further, research has shown that women with personal attributes that increase the saliency of their gender, such as physical attractiveness or motherhood status, are evaluated more negatively than men, compared to women who do not share these gender-salient personal attributes. Organizational factors also can contribute to the salience of a woman's gender. For example, token or minority status can lead to more stereotyped characterizations of women (Kanter, 1977), as well as to a lesser chance of being selected or promoted (Heilman, 2012). Thus, both personal and organizational factors can accentuate a woman's gender, exacerbating perceptions of lack of fit with a male gender-typed job and the negative evaluative consequences of these perceptions, which in turn give can rise to gender bias in evaluations (Heilman, 2012).

2.2.1.2 The role of ambiguity in implicit gender bias

The biasing effects described above may also be facilitated by certain situational factors that organizations may be able to control, or reduce, comparatively easily, such as ambiguity in evaluative contexts, including in hiring or promotion decisions. Indeed, ambiguity may allow biased expectations to flourish: the more ambiguity, the more opportunity there is for inference,

¹¹ Meta-analysis is a statistical technique used to determine whether a relationship between variables exists, and if so, the magnitude of the relationship. This is done through an exhaustive search for studies that have been undertaken on the topic of interest, and a comparison of study results to see if a pattern exists among the findings.

subjectivity, and cognitive distortion, and thus the greater the chance for gender bias to occur. Further, as Heilman (2012) describes, ambiguity is heightened under the following conditions:

- a. when the information available about an individual is limited, inconsistent or irrelevant;
- b. when there is poor definition of the evaluation criteria;
- c. when there is a lack of specificity concerning the evaluation process; and
- d. when there is confusion about the source of performance outcomes.

For example, the quantity of information that is available to evaluators has consistently been found to be related to bias in evaluations (Heilman, Wallen, Fuchs, & Tamkins, 2004), with limited information facilitating the use of stereotype-based expectations. Accordingly, a meta-analysis of “Joan versus John” studies, in which the gender of equally qualified fictitious targets is experimentally manipulated via the target name, demonstrated that women tended to be evaluated by respondents less favourably than men, particularly when there was little information about the target individuals (Swim, Borgida, Maruyama, & Myers, 1989; see also Moss-Racusin et al., 2012).

However, the quality of the information, not simply the quantity, also matters. Research has demonstrated that information must be job-relevant and diagnostic of performance success if it is to reduce, rather than reinforce, gender bias.¹² Moreover, the relevant information has to be highly specific and unequivocal in its implications if it is to prevent biased evaluation. For example, in a study where all targets were rated in the highest category possible for past performance in a male gender-typed job, it was only when the category was labeled, “top 2% of employees” (not “top 25% of employees”) that women were rated as favourably as men (Heilman & Haynes, 2005). The consistency of information also plays a role in whether expectations influence the evaluation process. For instance, when information is inconsistent (e.g., not uniformly positive), and discretion will be needed to weigh pieces of information against each other, expectations are likely to exert influence by helping to “tip the scales” regarding what information is given most attention, often to the detriment of women (Uhlmann & Cohen, 2005). Research has generally found that judgment criteria that are poorly defined or vague (i.e., abstract or not amenable to objective evaluation) tend to more easily allow information to be distorted to fit expectations (Fiske & Taylor, 1991; as cited in Heilman, 2012). Similarly, impressions of personal characteristics, such as whether an individual is a “team player” or a “charismatic leader,” tend to be more susceptible to distortion than impressions based on explicit accomplishments and work outcomes.

Importantly, unclear evaluative criteria also allow people to *shift* their standards regarding the extent to which particular criteria are considered indicators of high potential or good performance. By redefining what it means to perform well, individuals can shift their standards to fit expectations and justify their biased decisions. Accordingly, research has found that evaluators may overstate or understate the importance of the same performance criterion depending on

¹² Job-relevant selection or performance criteria (bona fide occupational requirements) are also more legally defensible than are criteria that are not specifically job-relevant.

whether it is attributed to a man or a woman (Uhlmann & Cohen, 2005). Similarly, in studies comparing the qualifications of a male and female candidate for a traditionally masculine job (e.g., manager of a construction company, police chief), reviewers assigned importance to a qualification (such as education or professional experience) only when the male candidate had more of the qualification than the female candidate. Whatever assets the female candidates possessed became irrelevant to the reviewers. However, none of the participants in these studies were aware that they were influenced by gender, and those who discriminated the most were the ones most convinced of their own objectivity (Uhlmann & Cohen, 2005).

Lack of specificity about how evaluative criteria are to be combined may also encourage expectation-based distortion. For instance, if evaluators are allowed to devise their own individual systems for combining information (e.g., previous employment history; job interview performance) into an overall evaluation, then they will not be constrained to abide by a predetermined set of criteria. If, in contrast, the evaluation process is structured, then particular elements of performance should be assessed consistently for everyone, and these elements weighted in a specified way, regardless of the particular person being evaluated, or the evaluator (Baltes & Parker, 2000).

Further, even the specificity with which performance is measured can make a difference. Research has found that where explicit and unequivocal information about performance excellence is lacking, a structured procedure using specific observed behaviours, rather than an overall, general judgment of an employee, is more effective in mitigating the biasing effects of gender stereotypes on performance evaluation (see Bauer & Baltes, 2002, on evaluations of female professors). Similarly, research also indicates that lack of structure in the evaluation process allows for existing expectations to affect the ongoing evaluation process, with managers sometimes unwilling to give up their current views when given new information (Heslin, Latham, & VandeWalle, 2005). Moreover, there is evidence that gender stereotypes affect how women's evaluations are updated over time. In a series of studies, Manzi, Caleo, and Heilman (2012; as cited in Heilman, 2012) found that evaluators' changes in performance assessments (as a result of changes in performance history) differed as a function of the target's sex, in that a decrease in performance was found to have a more damaging effect on the competence perceptions of previously successful women than previously successful men. Likewise, an improvement in performance was found to have a less beneficial effect on the competence perceptions of previously unsuccessful women than unsuccessful men (Heilman, 2012).

Lack of clarity about individual contributions to a performance outcome also requires an inferential process, or subjectivity, in determining, for instance, credit for a successful outcome or blame for an unsuccessful outcome, especially in the context of joint achievements. Thus, research has shown that when a woman works together with a man on a joint task that is male in gender-type, she is given less credit for a successful joint outcome, and is viewed as having made a smaller contribution to it, than her male counterpart; she is also rated as less competent than when she achieves the same outcome on her own (Caleo & Heilman, 2010; as cited in Heilman, 2012). However, these effects were not found when the task was structured so that the woman's individual contribution was unquestionable, or there was explicit evidence that the woman's task competence was very high (Heilman & Haynes, 2005). Research also indicates that women working with men on male gender-typed tasks are not only credited less than their male counterpart for joint successes, but are also blamed more for joint failures (Caleo & Heilman, 2010; as cited in Heilman, 2012). Source ambiguity is particularly problematic because

of the prevalence of teams in organizational settings and the rarity of work being accomplished in isolation. Mentoring or coaching relationships also have the potential to produce ambiguity regarding performance outcomes. For example, if a woman has been mentored by a man, her subsequent success may be attributed to his wisdom and guidance, rather than to her skills and expertise (Heilman, 2012).

2.2.1.3 A new hiring preference for women?

Although a large body of evidence has demonstrated the persistence of implicit gender bias, and the potential impact of such bias on real-world employment decisions, recent research suggests that the situation may be changing, and that there may now be a hiring *preference* for women in STEM (W. M. Williams & Ceci, 2015). In a series of five experiments conducted in the United States, STEM faculty members in the fields of biology, engineering, psychology, and economics evaluated narrative summaries (or curriculum vitae) describing hypothetical, equally and exceptionally qualified female and male applicants for tenure-track assistant professor positions who shared the same “lifestyle” (family status) (e.g., single with children, married with children). Evaluative information on each applicant was extensive, and included the search committee chair’s notes reflecting the hiring committee’s evaluation of each candidate’s scholarly record, excerpts from reference letters and average faculty ratings of the candidate’s job talk and interview, and the chair’s comments about the candidate’s “fit with the department.” Applicant gender was indicated solely by the pronouns used in the applicant file. Results of the main experiment showed a 2:1 preference for women by faculty of both genders, with the single exception of male economists, who showed no gender preference.

Such research findings may be encouraging in some respects. For instance, they may indicate that the hiring situation for women in STEM is in fact changing in a positive direction. In particular, the results may provide evidence of the positive impact of having extensive, and unambiguously positive, evaluative information on the hiring of women (see also Heilman & Haynes, 2005). However, there is also reason to be cautious about the interpretation of the findings. In addition to the need to replicate the results (e.g., with larger samples,¹³ cross-nationally, and in different evaluative contexts beyond academic hiring), and in addition to the need to rule out the potential influence of social desirability on evaluations, some of the findings, if taken at face value, are themselves somewhat concerning. Apart from any potential concern about a bias against male applicants,¹⁴ the findings also suggest that gender-related biases based on lifestyle or family status may persist. For instance, female faculty preferred divorced mothers to married fathers, whereas male faculty preferred mothers who took maternity leave during graduate school to mothers who did not take such leave. In addition, the applicant information used in the research (e.g., to

¹³ The sample size for the main experiment was 363 and, for the four follow-up experiments, 144, 204, 35, and 127, respectively. In addition, effect sizes were reported only for the fifth experiment ($n = 127$), and were small in the two cases reported. In the first case, a main effect, the female applicant was rated one scale point higher (on a scale of 1 to 10) than the male applicant (8.20 vs. 7.14, $\eta = 0.12$). In the second case, there was a marginal interaction reflecting a larger down-rating of male applicants by male than by female faculty members, $F(1,123) = 3.36$, $p = 0.07$, $\eta = 0.03$. However, this interaction was not significant after a Bonferroni correction.

¹⁴ It should be noted, however, that within employment equity (or affirmative action) programs, where there are two equally qualified applicants, one female and one male, preference *should* be given to the female applicant. Given that women continue to be under-represented in many STEM fields, such programs and policies are intended to “even the playing field,” and to promote fairness and diversity.

describe strong candidates), specifically the chair's notes about department fit, focused on agentic (masculine) characteristics, such as independence, ambition, and competitive skills, rather than on more communal attributes. This focus on agentic characteristics in demonstrating department fit could mean that candidates who are more communal (e.g., more collegial or cooperative), rather than competitive, may fare less well in hiring decisions; and ultimately, such evaluations may negatively impact women more than men. In addition, the research focused on hiring decisions only; it did not address women's experiences after being hired into STEM positions, such as whether they received appropriate supports and mentoring, whether they continued to advance in their careers, or whether they remained in STEM. And once again, the research focused on unambiguous hiring decisions, in which female and male candidates were both equally and exceptionally highly qualified. Such situations may not reflect realistic hiring contexts, which tend to involve more ambiguity (Moss-Racusin et al., 2012). The findings may also suggest that women may be advantaged in hiring only if they are deemed to be highly exceptional candidates, rather than simply excellent or competent. Alternatively, the findings may also reflect an underlying gender bias against women akin to the "talking platypus phenomenon," in which women's achievements are magnified simply because they are unexpected (Abramson, Goldberg, Greenberg, & Abramson, 1977). Thus, it may be too soon to conclude that "it is a propitious time for women launching careers in academic science" (W. M. Williams & Ceci, 2015, p. 5360). Indeed, the overall body of evidence—including other recent findings showing subtle gender biases among science faculty favouring male students—suggests that implicit gender bias may still be a concern in STEM fields (see Moss-Racusin et al., 2012).

2.2.1.4 Impacts of gender stereotypes on women's self-evaluations

Gender stereotypes not only affect how women are evaluated by others, but also how women evaluate themselves. Research indicates that women's characterizations of themselves largely parallel characterizations of women in general, in that their self-characterizations are more communal and less agentic than are men's (see Heilman, 2012). Such self-perceptions may lead to performance expectations for women about themselves, which may in turn influence women's career choices, their pursuit of opportunities for advancement, their willingness to put themselves forward for positions, and their willingness to take risks (Heilman, 2012). Indeed, lack of confidence in one's own competence can have very damaging effects. Research has shown that women approach male gender-typed tasks with less confidence and more trepidation than do men, and that without being given reason to think otherwise, their sense of competence on such tasks is low. In one study, for instance, women's self-ratings of expected task competence were the same as the self-ratings of individuals who had actually received negative feedback about their task ability. Importantly, the only situation in which women's self-ratings equaled men's was when women had received direct and credible positive feedback about their ability (Heilman, Lucas, & Kaplow, 1990). Research also has demonstrated that such negative self-expectations can give rise to bias that is self-directed. For example, a series of studies showed that when working collaboratively with men, women were unwilling to take an equal amount of credit for successful joint outcomes, and were likely to see themselves as less competent than their male co-workers (see Heilman, 2012).

2.2.2 Prescriptive gender stereotypes

While descriptive gender stereotypes refer to beliefs about what women and men are like, prescriptive stereotypes refer to beliefs about what women and men should be like. Thus, prescriptive gender stereotypes function as social norms, dictating what attributes and behaviours are considered appropriate and inappropriate for men and women. There is a great deal of overlap in the content of prescriptive and descriptive gender stereotypes, with the characteristics that are seen as descriptive of men and women also the ones that are prescribed for them. Thus, for women, communality is prescribed; not only is it thought that women *are* communal, it is thought that they *should be* communal. Further, prescriptive gender stereotypes also designate “should not” for women and men (Heilman et al., 2004). For women, these include the agentic characteristics associated with men but not women, such as self-assertion, dominance and achievement orientation.

Since gender prescriptions function as norms, violating them produces social disapproval and negativity, sometimes called “backlash” (Heilman, 2012). For instance, women who do not exhibit stereotypically feminine prescribed attributes have been regarded as less psychologically healthy than more traditionally feminine women (Heilman, 2012). Likewise, women thought to be non-traditional have been shown to suffer in their evaluations, with “feminists” evaluated less favourably than more traditional women, specifically “housewives” (Haddock & Zanna, 1994). Repeatedly, women who do not fulfill gender prescriptions have been shown to be derogated; they are considered cold, interpersonally hostile, and are disliked (Heilman, 2012; see also J. C. Williams, 2015).

In work contexts, breaking gender-related prescriptions has additionally been shown to result in more tangible penalties, including lower pay, less intention to hire and promote, and fewer recommendations for organizational rewards for women compared to men (e.g., Brett & Stroh, 1997; Heilman & Chen, 2005; Rudman, 1998). Prescriptive gender stereotypes also present double binds, or “catch-22s,” for women (Saucerman & Vasquez, 2014; see also J. C. Williams, 2015). That is, if women are to succeed in senior-level work settings, they must violate gender stereotypic prescriptions. They must be able to compete for positions, to act independently and decisively, and to take charge when required. The unfortunate consequence for women who exhibit these stereotypically male characteristics is that they often experience disapproval and penalties for acting in ways that are reserved for men. Therefore, even when women seek to distinguish themselves from descriptive gender stereotypes, and demonstrate that they have the qualities to fulfill traditionally male positions, they are likely to suffer negative consequences. Research has consistently documented the negative reactions that can occur when women violate gender norms. For instance, when women communicate directly and assertively, they have been found to achieve less influence on male listeners than when communicating in a tentative and hesitant style (Carli, 2001). Similarly, men have been found to be less influenced by a competent woman than by either a competent man or an incompetent woman (see Carli, LaFleur, & Loeber, 1995). It thus appears that the communication behaviours that are successful for men may be disadvantageous for women, and that competence in women may not have the same positive impact as competence in men.

Regarding gender and leadership, research has shown that different leadership styles are viewed as appropriate for men and women. In their meta-analysis, Eagly, Makhijani, and Klonsky (1992) found that women were evaluated more negatively than men when they adopted autocratic or

directive leadership styles that deviate from communal prescriptions for women. However, when women adopted a more stereotype-consistent democratic or consultative style of leadership, gender differences in evaluations were not found. Similarly, although self-promotion has been found to enhance assessments of competence for both men and women, when women engage in self-promotional behaviour by explicitly drawing attention to their skills, talents and accomplishments, they are viewed as less socially appealing. However, the same is not true for men, as self-promotional behaviour violates gender prescriptions for women, but not men, to be modest and uncompetitive (Rudman, 1998). Thus, a good impression management strategy for men may not necessarily be a good impression management strategy for women. Along the same lines, research indicates that women are hesitant to initiate negotiations about salaries, likely because the self-confident demeanor and demanding behaviour entailed in salary negotiation is considered inappropriate for women (Heilman, 2012). Bowles, Babcock, and Lai (2007) demonstrated that women who engaged in negotiation for higher pay incurred greater penalties than men who engaged in exactly the same behaviour, with evaluators less likely to hire and to express an interest in working with the women. Likewise, angry women have been found to be conferred less status at work than angry men, suggesting that anger in women is not well received (Brescoll & Uhlmann, 2008).

Women can also be penalized for not engaging in behaviours that are prescribed by gender stereotypes, such as being kind, considerate, collaborative, or altruistic. In one study, women who refrained from engaging in altruistic behaviour to help a colleague were judged negatively, although men who behaved in the same manner were not penalized (Heilman & Chen, 2005). The researchers also found that women who did behave altruistically were not rewarded, although men were rewarded for the same behaviour. Similarly, Allen (2006) found that performing organizational citizenship behaviours, such as altruism, had a greater positive effect on the salary and promotions of men than of women. Research has also shown that women who choose not to collaborate with coworkers when given the opportunity are regarded more negatively and are rewarded less than men who make the same decision not to collaborate (Chen, 2008). Further, women are punished to a greater extent than men for behaving in an interpersonally unfair manner (Caleo & Heilman, 2010; as cited in Heilman, 2012).

Overall, the research cited above indicates that prescriptive gender stereotypes can be highly constraining for women, as violating such prescriptions can lead to penalties in the workplace. But women can also be penalized for simply exhibiting competence and success in male gender-typed positions. Research tracking the advancement of 30,000 managers, controlling for age, organizational tenure, and education, indicates that promotion becomes increasingly difficult for women as they move up the organizational ladder, and that they increasingly experience disapproval and negativity (Lyness & Judiesch, 1999). Highly successful men, however, do not suffer the same consequences; rather, they are celebrated for their successes. It is also important to note that negative reactions to successful women have been shown to be limited to situations in which the success is in a male gender-typed role and is perceived to require agentic qualities (Heilman et al., 2004). When the position is believed to require communal qualities consistent with female prescriptive gender stereotypes, women are neither derogated nor disliked. These findings indicate that it is not success, per se, that is problematic for women, but rather success in an area that implies violation of gender stereotypic prescriptions. Further, the negativity directed at successful women can have significant consequences. Not being liked is disadvantageous for people seeking upward mobility in organizations, can limit one's influence and access to social

networks, and may reduce career opportunities and salary recommendations (Casciaro & Lobo, 2005; Heilman et al., 2004).

What about men? Do they, like women, also experience penalties for violating prescriptive gender stereotypes? Although most studies have examined the effects of prescriptive stereotypes for women, several investigations have demonstrated that men may also experience penalties for violating gender prescriptions. For example, when men request a family leave, they may suffer negativity in perceptions of their work ethic and in recommended rewards to a greater extent than women (Wayne & Cordeiro, 2003). Men may also be penalized for pursuing careers that are considered female in gender type. A study of the evaluations of men who succeed at female gender-typed jobs, for instance, found that men who were clearly successful at a job typically held by women were also seen as “wimpy” and passive (Heilman & Wallen, 2010). These findings appear to contradict research indicating that men ride the “glass elevator” in traditionally female occupations, that is, that they receive greater organizational rewards and make quicker career progress than similarly qualified women (C. L. Williams, 1992). But research also indicates that men’s comparative advantage over women in pay and promotions is maintained regardless of the gender composition of the job, although the advantage for men in traditionally female gender-typed jobs is comparatively smaller than in gender-neutral or male-dominated jobs (Budig, 2002). Thus, questions remain regarding the conditions under which men may continue to benefit from being men, even in predominantly female work settings, as well as regarding the barriers they may face in non-traditional occupations.

2.2.3 Stereotype threat

As noted earlier, gender stereotypes may affect not only how women are evaluated by others, but also how women evaluate themselves. Although the effects of such gender stereotypes, or implicit biases, on self-evaluations often occur on an unconscious level, gender stereotypes can also be made explicit or salient, with similar negative effects on self-evaluations and, ultimately, performance. Stereotype threat refers to the decrease in performance that occurs when stereotypes about the group to which an individual belongs are made salient (Steele, 1997). Stereotype threat has been studied extensively with regard to women in STEM fields. In general, research on stereotype threat has shown that when women with equally strong backgrounds and ability in a STEM domain as men are put into a testing situation and told that the test is an indicator of women’s ability and potential in the field—which implies a negative gender stereotype about women’s performance in a non-traditional field—the women perform worse than the men, and worse than expected given their training. However, when the stereotype is removed (e.g., by telling the women that the test is gender-neutral), the gender difference in performance disappears. In other words, it is not only the *content* of the test that influences women’s performance, but also the *idea* that they are a member of a group that is expected to do poorly on the test. Ironically, the more motivated a person is to do well on the test, the more interference they experience from stereotype threat (Saucerman & Vasquez, 2014).

Notably, stereotype threat can worsen the effects of negative implicit attitudes. Women with the strongest implicit stereotypes about women’s inability to do math, for instance, were affected the least by situational cues designed to *reduce* the stereotype threat. Women who held relatively egalitarian beliefs about math ability were found to be more influenced by beliefs about the gender-fairness of the test; their test scores were more reactive to the situational cues than were the scores of those who already believed, at an unconscious level, that others expected them to

fail. Further, stereotype threat can be elicited by very subtle cues that are common in the environment. Steele (1997) found that checking a box that indicated one's gender on a standardized test induced the stereotype threat and reduced the test scores of the most motivated, most hopeful female math students. However, even cues further removed from an academic context can induce the stereotype threat. In one study, ads that showed women contemplating some cosmetic solution to "flaws" in their appearance reduced women's aspirations for technical occupations, their willingness to take on leadership roles, and the number of math problems they would attempt in a mock testing situation. In contrast, the gender-typed ads did not have any effect on male viewers (Davies, Spencer, & Steele, 2005).

2.3 A closer look at the management aspect of STEM: women in leadership roles

As discussed earlier regarding implicit gender stereotypes, people in general tend to view leadership as being incongruous with the traditional female gender role ("think manager, think male"; Schein, 1973, 1975; Ryan et al., 2011). Individuals who act in ways that are incongruent with their gender role tend to be evaluated negatively (Eagly & Karau, 2002; Elssesser & Lever, 2011). Eagly, Karau, and Makhijani (1995) have offered role congruity theory as an explanation for the gender stereotyping of leadership positions and its effects. According to this theory, perceived gender roles may conflict with expectations regarding leadership roles, especially when an occupation is held predominantly by one sex. Thus, consistent with role congruity theory, female candidates for leadership roles tend to be viewed less favourably than male candidates (Diekmann & Eagly, 2008; Eagly & Karau, 2002). Further, if a leadership role requires a particular behaviour (e.g., giving direction or selecting team members), the same behaviour may be viewed less favourably when performed by a woman than when performed by a man. These implicit attitudes can be even more pronounced when women are assessed in non-traditional or numerically male-dominated fields, including leadership or STEM fields.

As we have seen, people can shift standards to favour male over female employees, without consciously being aware that they are doing so. For instance, in one study (Phelan, Moss-Racusin, & Rudman, 2008), participants were asked to evaluate videotaped interviews of a male or female applicant for the position of computer laboratory manager. The applicants were actors working from a script; both the male and female actors taped one interview in which they represented an agentic, take-charge, top-down management style, and another in which they exhibited a communal, cooperative, management style. The study participants watched one of the four interviews and rated the competence and social skills of the applicant, as well as how important competence and social skills were to the job. Results showed that the agentic male manager was viewed as the most desirable candidate for the job of laboratory manager, more so than the female who had said exactly the same things in the interview. Also, for three of the four candidates, competence was rated as more important than social skills. The only candidate for whom this pattern was reversed was the agentic and highly competent female manager. She was found to be faulty for not having social skills that were considered unimportant for the agentic male or the communal male or female. Given that women who apply for jobs in many subfields of STEM are working against the social stereotype that these are traditionally male jobs, such studies suggest that subtle and unconscious bias may limit the entry of qualified women into these fields, or inhibit their career progress. Likewise, as discussed earlier, both descriptive and prescriptive gender stereotypes leave women who are seeking leadership roles in a double bind. If they

conform to their traditional gender role, women may not be seen as having potential for leadership. But if they adopt the agentic characteristics associated with successful leaders, then they may be evaluated negatively for behaving in an “unfeminine” manner (Elsesser & Lever, 2011).

As we have seen, there exists an extensive body of research on the lack of gender equality in certain STEM fields. In particular, more covert forms of bias, and its resulting discrimination, still persist. Such resulting discrimination is reflected, for instance, in the smaller research spaces, start-up packages and salaries, but higher teaching loads, for academic women (McCullough, 2011). Not surprisingly, women are more likely than men to consider leaving STEM academic environments because of fewer resources and lack of support (Xu, 2008). Similarly, there is a large body of literature on gender inequity in leadership roles. Experimental laboratory studies have shown, for instance, that both men and women exhibit biases against women leaders (Eagly & Carli, 2007). Such biases have also been found in experimental studies of the relinquishment of power, in that both men and women leaders were more likely to relinquish power to male co-workers than female co-workers, possibly because they perceived the male co-workers to be more competent than the female co-workers (Ratcliff et al., 2015). Surprisingly, however, there currently exists little research on the intersection of these two areas: that is, on women’s leadership in STEM fields. To begin to address this gap, McCullough (2011) reviewed some of the literature on the primary barriers to women’s participation in STEM areas and leadership arenas. Her review suggests that women in STEM fields are particularly susceptible to the barriers and biases facing women who wish to move into leadership positions. In fact, the similarity in the barriers in these two areas could lead to an effective “double jeopardy” for women entering STEM leadership (McCullough, 2011).

2.3.1 A glass ceiling, or a labyrinth of leadership for women?

In 1986 the *Wall Street Journal*’s Carol Hymowitz and Timothy Schellhardt used the term “glass ceiling” to capture the frustration that many women experience as they strive for top leadership positions in the corporate world. As the glass ceiling metaphor suggests, such top leadership goals are within sight, but are somehow unattainable, due to invisible, yet unbreachable, barriers. Eagly and Carli (2007) have argued, however, that the glass ceiling metaphor fails to incorporate the complexity and variety of the challenges that women can face in their paths to leadership. Accordingly, women are not turned away from leadership positions only as they reach the latter stage of a career, but rather may disappear at various points leading up to that stage. This conception of women’s leadership experiences is in some respects similar to the “leaky pipeline” metaphor that has been used to describe women’s departure from STEMM careers. That is, a certain number of women who are interested in STEM careers are lost at every educational transition and career stage (see Lottero-Purdue, 2013).

According to Eagly and Carli (2007), an alternative to the glass ceiling concept, and a more useful metaphor for describing what confronts women in their professional endeavours, is the labyrinth. Such a concept conveys the idea of a complex journey toward a goal worth striving for, a journey that is not simple or direct, but rather requires persistence, awareness of one’s progress, and a careful analysis of the puzzles that lie ahead. Using the labyrinth metaphor, for women who aspire to top leadership positions, pathways exist but are full of twists and turns, both unexpected and expected. But because all labyrinths have a viable route to the centre, it is understood that goals are attainable. Thus, in contrast to the glass ceiling, the labyrinth metaphor acknowledges

obstacles, but is ultimately encouraging for women aspiring to leadership roles (Eagly & Carli, 2007).

Along with offering a more optimistic view of women and leadership, however, Eagly and Carli (2007) also elucidate some of the many challenges that women may face as they strive to attain leadership roles. Although more encouraging than the concept of the glass ceiling, the labyrinth still involves challenges to attaining leadership for women, not only near the latter stages of a career but throughout a career. In support of their labyrinth concept, for instance, Eagly and Carli (2007) cite research suggesting that, rather than women's promotions becoming progressively less likely than men's at higher levels within organizations, a general bias against women appears to operate with approximately equal strength at all organizational levels. The scarcity of female corporate officers, thus, is the sum total of gender bias, and resulting discrimination, that has operated at all ranks, not simply evidence of a particular obstacle to advancement as women approach the top (Eagly & Carli, 2007; see also Heilman, 2012).

In line with research on implicit bias previously discussed, Eagly and Carli (2007) also suggest that resistance to women's leadership stems from a set of widely shared conscious and unconscious mental associations about women, men, and leaders. As the researchers point out, for instance, studies have consistently shown that engaging in nonverbal dominance, such as staring at others while speaking to them, or pointing at people, is a more damaging behaviour for women than for men; that verbally intimidating others can undermine a woman's (but not a man's) influence; and that assertive behaviour on the part of a woman (but not a man) can undermine the chances of getting a job or advancing in a career. Indeed, simply disagreeing can sometimes get women into trouble, whereas men who disagree or otherwise act in dominant ways can get away with it more often than women do (Eagly & Carli, 2007; see also Heilman, 2012).

In response to the challenges presented by the double bind, female leaders may struggle to develop an effective leadership style, one that somehow reconciles the communal qualities people prefer in women, with the agentic qualities people think that leaders need in order to succeed. In spite of such challenges, the scientific literature has demonstrated women's leadership effectiveness in many settings, when using objective ratings (Boldry, Wood, & Kashy, 2001; Eagly et al., 1995). In addition, research has shown that women and men tend to adopt similar leadership styles, but with some small differences. Eagly and Johnson's (1990) meta-analysis of 370 gender comparisons, for instance, found very small gender differences in leadership style. Such studies have found, for example, that women may be slightly more likely than men to adopt a participative and collaborative style of leadership. Similarly, a meta-analysis integrating the results of 45 studies found that women were more likely than men to adopt the leadership style that is generally considered optimal for modern organizations: that is, a transformational leadership style, characterized by being supportive and encouraging of subordinates (Eagly, Johannesen-Schmidt, & van Engen, 2003). Thus, as women navigate their way through the double bind, they may, in some instances, seek ways to project authority without relying on an autocratic leadership style that people may find jarring in women. Women leaders may do this by bringing others into the decision making process (adopting a participative, collaborative leadership style), or by being an encouraging and positive role model (adopting a transformational leadership style) (Eagly & Carli, 2007). Once again, however, such gender differences in leadership style or effectiveness tend to be small, overall.

For many women, the labyrinth of leadership, or the paths they choose as they navigate this labyrinth, may also be influenced by family responsibilities or other social dynamics (Eagly &

Carli, 2007; see also J. C. Williams, 2015). Although men have become more involved in housework and child care in recent years, the bulk of such work still falls largely on women's shoulders. Even women who share child care and domestic work with partners, other family members, or paid workers, may not enjoy the full advantages of such arrangements, as employers often assume that mothers, in particular, have domestic responsibilities that make it inappropriate to promote them to demanding leadership positions. As indicated earlier, such assumptions can often be made implicitly, without conscious awareness. Further, attempting to juggle work and family life may also leave little time to women for socializing with colleagues outside of work hours, or for building professional networks. This lack of social interaction can have a negative impact on a career, given that the social capital that accrues from such "nonessential" parts of work can be even more critical for managerial advancement than the skillful performance of traditional managerial tasks. Even given sufficient time, women can find it difficult to engage in and benefit from informal networking, if they are a small minority. Indeed, breaking into predominantly male networks can be challenging, especially if the focus of these networks is on traditionally masculine activities, such as sports (Eagly & Carli, 2007).

2.3.2 Think crisis, think female: the glass cliff

Along with the labyrinth and glass ceiling metaphors, an additional concept, that of the glass cliff, has also been used to describe the experiences of women as they pursue leadership roles. Bruckmüller, Ryan, Rink, and Haslam (2014), for instance, contend that the contexts in which women and men achieve leadership positions tend to differ markedly—that women who manage to break through the glass ceiling are more often appointed to positions that are more precarious, and are at a higher risk of failure, than are men. This phenomenon is reflected in the metaphor of the glass cliff. Bruckmüller et al. (2014) suggest that such a phenomenon may be due to perceptions held by both women and men that women are more communal, and therefore are more competent in times of crises involving other people, than are men (see also Ryan et al., 2011). The ability to "smooth things over" with other people, or to encourage others during times of organizational crisis or instability, also fits with the more transformational leadership style sometimes associated with women (e.g., Eagly et al., 2003).

Bruckmüller et al. (2014) summarized a series of experiments that they conducted on the glass cliff and concluded that, although leaders in general were still seen as stereotypically male, and although ideal leaders in both successful and unsuccessful companies were seen as combining stereotypically female and stereotypically male characteristics, the characteristics that were seen to be desirable for a leader in times of crisis were more strongly associated with the female gender stereotype than the male stereotype. In other words, study participants were not only "thinking manager—thinking male," they were also "thinking crisis—thinking female." Further, the evidence reviewed by Bruckmüller et al. (2014) suggested that women were appointed to glass cliff positions in such studies not because they were perceived as able to turn things around or to represent a company effectively in times of crisis, but rather mainly because women were perceived as possessing the right "people skills" to manage staffing during times of crisis (e.g., "redundancies").

The limited evidence on the glass cliff that currently exists suggests that, although explicit gender bias might provide a partial explanation for the phenomenon, implicit or more subtle bias may also play an important role. For example, in addition to the role of implicit gender stereotypes discussed above, some of the experimental work summarized by Bruckmüller et al. (2014) found

that stereotypically female leaders were judged to be more desirable than stereotypical male leaders when a manager's main task was to take responsibility, or to act as a scapegoat, for continuing failure. Moreover, Haslam and Ryan (2008) found that participants preferred a female over a male candidate in times of crisis, despite an expectation that taking on this leadership position would be more stressful for a woman than for a man.

Further analyses of the study data in Bruckmüller et al. (2014) revealed that this expectation of comparatively higher stressfulness for the woman was a reason why study participants perceived the female candidate as more suitable for the position. According to Bruckmüller et al. (2014), the willingness to expose a woman to the higher stresses associated with leading in a context of declining performance can certainly be interpreted as a form of sexism, one that is more implicit than explicit. Consistent with this, research by Brown, Diekmann, and Schneider (2011) found that participants who endorsed ideologies that legitimize the gender status quo are particularly likely to favour women under conditions of crisis or threat. Such participants may be implicitly seeking to protect men from precarious glass cliff positions, or even to set women up to fail. In support of this interpretation, Bruckmüller et al. (2014) point out that people may unwittingly (unconsciously) adjust their perception of what is required in a position to justify the selection of a man over a woman for a desirable position, as discussed earlier regarding shifting evaluation criteria. In the case of the glass cliff, Bruckmüller et al. (2014) suggest that “[s]uddenly seeing stereotypically male characteristics as less important and highlighting the importance of stereotypically female qualities when the position that needs to be filled is particularly risky and precarious might be one instantiation of this effect” (p. 13). In sum, Bruckmüller et al. (2014) contend that the empirical evidence to date “speaks against explicitly held sexist attitudes, especially blatant sexism, as a key factor, but suggests that more subtle and implicit sexist dynamics are likely to play an important role” (p. 13).

2.3.3 Gender and leadership in experimental vs. real-world contexts

Along with the experimental evidence for the glass cliff discussed above, the preference for women leaders in times of crisis is also reflected in archival research in real-world settings, such as stock market-listed corporations in the United Kingdom and Germany, as well as in politics in the United Kingdom (Bruckmüller et al., 2014). More broadly, other researchers have also examined preferences for male and female managers in real-world settings. For example, in their study of whether gender bias still persists, Elsesser and Lever (2011) investigated preferences for male and female managers in general, as well as evaluations of one's current manager, in a sample of 60,470 women and men working in a variety of occupations, including male-dominated (e.g., architecture, engineering) and female-dominated (e.g., personal care, social services) occupations, in the United States. In particular, Elsesser and Lever (2011) were interested in comparing attitudes towards female managers in real-world contexts to attitudes toward hypothetical female leaders, given that experimental studies using student samples and vignettes of hypothetical or ideal leaders in laboratory settings—studies which have generated much of the evidence for gender stereotypes—may not be generalizable to the real world (see also Heilman et al., 2004). For instance, increased exposure to a particular person (e.g., in a real-world setting) has been found to result in less stereotyping of that person (Fiske, 1998; as cited in Elsesser & Lever, 2011). Further, although a meta-analysis of studies using vignettes of hypothetical leaders and laboratory confederates found that male leaders were evaluated more favourably than female leaders, particularly when the female leaders adopted a masculine management style (Eagly et al.,

1992), another meta-analysis of studies of leaders in actual organizations found that the military was the only setting where male leaders were rated as more effective than female leaders; in all other settings examined, the genders were rated as equally effective (Eagly et al., 1995). Similarly, although several studies have found that competence and success can be detrimental to female leaders in terms of how much these leaders are liked interpersonally, such studies have not examined interpersonal relationships with actual leaders (Catalyst, 2007; Heilman, Block, & Martell, 1995; Heilman et al., 2004). On the other hand, some researchers have shown substantial external validity (real-world generalizability) of experimental results in organizational settings (Stone-Romero, 2002; see also Heilman et al., 2004), as well as academia (see J. C. Williams, 2015).

In their study, Elsesser and Lever (2011) found mixed results in response to the question of whether gender bias still persists. For instance, consistent with the researchers' predictions, participants were less likely to show gender bias when evaluating their own manager than they were when imagining an ideal or hypothetical manager in general. However, and importantly with respect to STEMM, participants in the most male-dominated profession of architecture/engineering preferred male managers in general more than did participants in the female-dominated profession of personal care and social services. Furthermore, participants who currently reported to a male manager were *also* more likely to prefer male managers than those who currently reported to a female manager. Those participants who had never reported to a female manager were more likely to prefer male managers (in general) than those who had never reported to a male manager.

Elsesser and Lever (2011) also found that general preferences for male or female managers reflected the content of gender stereotypes. Thus, the most prevalent rationale for preferring female managers was their perceived compassion and understanding; for example, participants viewed female managers as more supportive, nurturing, personable, and empathetic than male managers. Other reasons for preferring female managers included their perceived competence (e.g., organizational and communication skills), intelligence, decision-making skills, hard work, and ability to create collaborative work teams and environments. However, the most common justifications for preferring male managers focused on the perceived *negative* attributes of female leaders. For instance, many participants indicated that their preference for male leaders stemmed from a dislike of the perceived personality of female managers (e.g., their perceived moodiness). Other justifications for preferring male managers focused on the perceived competence of male leaders; for instance, men were described as more professional, objective, decisive, open-minded, consistent, and fair than women. In general, the justifications for preferring male or female managers tended to coincide with gender stereotypes.

Further, although participants in Elsesser and Lever's (2011) study, overall, tended to exhibit less bias in relation to actual managers compared to hypothetical managers, the researchers also found evidence of gender bias in relation to actual managers, in that female leaders who were "direct" received slightly lower relationship ratings from their subordinates than direct male leaders. Although this was a small effect, Elsesser and Lever (2011) acknowledged that women may still be penalized in real-world settings for adopting a style that is incongruent with the traditional feminine gender role. Further, although a small majority (54%) of participants claimed to have no preference for the gender of their manager, the remaining participants reported preferring male over female managers by more than a 2:1 ratio. Indeed, there was no category of participants where a significant majority preferred female managers over male managers.

Importantly, although Elsesser and Lever's (2011) findings suggest that gender bias may be less likely to occur in real-world organizations compared to laboratory or hypothetical contexts, such biases may nevertheless be prevalent in real-world settings that involve employment decisions about hypothetical or potential performance, such as hiring decisions. Indeed, in many instances, those making hiring or other employment-related decisions have distinct, often implicit impressions of others with whom they have never worked or even met—impressions based on inference or word of mouth but not direct experience. Also, even when impressions in organizations are based on information, the information available is often not particularly detailed or elaborated (i.e., there is a lack of “individuating information;” Elsesser & Lever, 2011; Heilman et al., 2004; Ratcliff et al., 2015). In comparison, when making evaluations of current employee performance, or when making assessments in situations where there are ample opportunities to interact with the employee, bias may be minimized (see also Heilman et al., 2004). Consistent with the importance of direct experience or interaction in mitigating bias, some research has found that women are more likely to be *promoted* into management roles than to be *hired* into them (Lyness & Judiesch, 1999). Nevertheless, Elsesser and Lever's (2011) findings regarding actual managers in male-dominated professions (e.g., that male managers tend to be preferred by participants currently working in male-dominated professions, and by participants currently reporting to male managers) is of particular concern for the issue of women in STEM.

2.3.4 Implications of implicit bias for management's role in women's career progression

As the research findings cited in this report suggest, there is a need for managers, both male and female, to be aware of the fact that subtle gender-based cognitive biases may impact on women's progression into managerial positions, and that such managers, too, may share these implicit biases. This is also evidenced by findings stemming from research conducted by Hoobler, Lemmon, and Wayne (2011). The main objective of this research was to better understand why women may not aspire to managerial roles (i.e., the “opt out” phenomenon). In particular, Hoobler et al. (2011) assessed day-to-day managerial decisions involving the allocation of organizational developmental opportunities and the extent to which these decisions were impacted by managers' stereotypes that women are less career motivated than men. This research question was addressed in the context of a real-world global Fortune 500 transportation organization. Subordinate and manager dyads ($N = 112$) were used as the unit of analysis. On average, each manager-subordinate dyad was in place for approximately one year, and managers rated three subordinates who were one level below the manager in the organization's hierarchical structure.

The results of this research indicated that subordinate gender was strongly and significantly associated with decreased manager ratings of career aspirations, even after factoring in the impact of six control variables¹⁵ (Hoobler et al., 2011). In particular, women were perceived as having lower career motivation compared to men. This gender bias occurred regardless of the gender of the manager. Further, managers' assessments of subordinates' career motivation was related to subordinates' reports of having received opportunities for challenging work assignments, training and development opportunities, and career encouragement from their manager (Hoobler et al.,

¹⁵ The control variables were education level, selection into the organization's self-sponsored management development program, performance (manager ratings of subordinates' work performance), number of promotions, dyad tenure (manager-subordinate tenure), and organizational tenure.

2011). In addition, when subordinates received such opportunities and encouragement from their managers, they reported having higher managerial aspirations (Hoobler et al., 2011). The researchers contend that these findings are particularly relevant to women's career progression, in that women have been found to be more reliant than men on formal organizational career management processes (see Lyness & Thompson, 2000), and to benefit more from encouragement, for instance, with respect to moving from middle management to upper management (Tharenou, 2001). Overall, these findings suggest that managers have a significant role to play in providing women with opportunities for development and growth in the workplace. Such opportunities set the groundwork for women to obtain the experience and skill sets necessary to compete successfully for positions in upper management. Ultimately, managers must have an increased self-awareness of the ways in which their cognitive biases may limit women's career progression—and of the positive role they can play in furthering women's careers and managerial aspirations, for instance, through the provision of relevant opportunities and encouragement.

2.4 Implications of subtle bias and discrimination for individual health and well-being and organizational outcomes

In addition to implications of implicit gender bias for women's career progress, one may also consider the implications of such bias on individual health and well-being, as well as on organizational outcomes. What is the potential link between subtle gender bias, and resulting discrimination, and the health or well-being of individuals in the workplace and organizational outcomes? How might such a link compare to the link between more overt forms of bias or discrimination and such individual or organizational outcomes? These are questions that Jones, Peddie, Gilrane, King, and Gray (2013) sought to address through the use of meta-analysis.

The rationale for the research was threefold. First, the researchers theorized that harmful actions with ambiguous intent (e.g., more subtle forms of discrimination or bias, including unintentional interpersonal discrimination, such as sexist jokes, benevolent sexism, as well as unconscious cognitive expectations of inferior performance based on gender) have the potential to be more confusing and stressful than more overt or intentional forms of bias or discrimination, such as old-fashioned sexism or discrimination in hiring (Jones et al., 2013). This is due to the fact that actions stemming from more overt bias or discrimination can more easily be identified as being discriminatory and thus externalized (i.e., the action can be attributed to another person's prejudice). However, in the case of actions stemming from more subtle forms of bias or discrimination, trying to understand what brought about the behaviour may be more confusing and thus more stressful (Jones et al., 2013). Second, the researchers hypothesized that there may be more negative repercussions for individuals who have experienced more subtle forms of discrimination, compared to more overt forms (Jones et al., 2013). This is due to the fact that many organizations have formal policies in place regarding overt discrimination, so that when an incident does occur, there is a mechanism by which it can be remedied. In comparison, it is not as clear how to effectively remedy a situation where the discrimination is more subtle in nature, as it is harder for an individual to prove that they have been a target of subtle discrimination (Jones et al., 2013). Third, subtle discrimination may have more negative consequences for the individual targeted than overt discrimination, due to the greater frequency, and thus more chronic nature, of these types of experiences (Utsey, Chae, Brown, & Kelly, 2002; Utsey & Ponterotto, 1999; Yoo,

Steger, & Lee, 2010). The potential for subtle discrimination to be more chronic in nature is important, as there is ample research indicating that chronic stress, as opposed to stress that is more acute in nature, is a stronger predictor of depression (McGonagle & Kessler, 1990; as cited in Jones et al., 2013).

The meta-analysis was based on published and non-published research (i.e., 44 samples, including 26 journal publications, 11 dissertations, one conference presentation, and one unpublished study). The results of the meta-analysis, which examined both sex- and race-based discrimination and bias,¹⁶ revealed that there was no significant difference in the strength of the relationship between discrimination/bias, whether overt or subtle, and the outcome of interest (i.e., individual psychological and physical health; individual work correlates such as stress, satisfaction, and attachment; or organizationally relevant correlates, such as employee performance, organizational performance, and employee turnover intentions). More specifically, the mean sample-size-weighted corrected correlation between overt discrimination and psychological health was .28, while the comparable correlation between subtle discrimination and psychological health was .31. Similar results were obtained for the relationships between individual work correlates and overt and subtle discrimination (i.e., corrected correlations of .28 and .31, respectively). The mean sample-size-weighted corrected correlation between overt discrimination and organizational work correlates was .22. This compares to the correlation of .25 between subtle discrimination and organizational work correlates. Similar but weaker mean sample-size-weighted corrected correlations were obtained between overt discrimination and physical health and subtle discrimination and physical health (i.e., .16 and .17, respectively). Thus, discrimination, either overt or subtle, was most strongly related to psychological health and to individual work correlates such as stress, satisfaction, and attachment.

One final set of analyses was conducted to determine whether sex and race differentially affected the relationship between overall discrimination (i.e., both overt and subtle) and the outcomes of interest. With respect to race-based discrimination, discrimination was found to be correlated with psychological health (.30), individual work correlates (.18), physical health (.19), and organizationally relevant correlates (.22). In the case of sex-based discrimination, discrimination was correlated with psychological health (.33), individual work correlates (.29), and physical health (.15). There were insufficient cases for a mean sample-size-weighted corrected correlation to be calculated for the relationship between sex-based discrimination and organizationally relevant correlates.

Overall, the findings from this meta-analysis indicate that *both* overt and subtle forms of discrimination and bias are related to the experience of a variety of individual and organizationally relevant outcomes. In addition, and of equal importance, there was no significant difference in the *extent* to which discrimination and bias, either overt or subtle, was related to the outcomes of interest. More detailed analyses suggest that both sex-based and race-based discrimination and bias are related to psychological and physical health outcomes, along with individual work correlates, including job stress, satisfaction, and organizational commitment. Race-based discrimination was also related to organizationally relevant correlates, such as employee performance, organizational performance (e.g., productivity, business success) and

¹⁶ Discrimination and bias were undifferentiated in this meta-analysis, and were both subsumed under the label “discrimination.” Thus, the results for discrimination (e.g., interpersonal behaviours, such as sexist jokes) and bias (e.g., unconscious cognitive expectations) could not be assessed separately.

employee turnover intentions. In light of these findings, and the fact that organizations typically have formal policies in place to manage overt discrimination, Jones et al. (2013) suggest that more needs to be done to address the issue of more subtle forms of discrimination in the workplace. However, it should also be noted that this meta-analysis did not differentiate between subtle or unconscious cognitive bias on the one hand, and subtle interpersonal discrimination, such as sexist jokes or interpersonal avoidance, on the other hand. Thus, more research is needed to compare the possible links between subtle and overt cognitive bias, in particular, and individual and organizationally relevant outcomes.

2.5 Research on cultural diversity and gender integration at the Canadian Department of National Defence

Research related to implicit bias has also been conducted at Canada's Department of National Defence (DND). Specifically, Lalonde (2011) measured the attitudes and perceptions of DND employees toward cultural diversity and gender integration in the workplace, in order to determine the prevalence of implicit prejudiced attitudes in this context. Thus, the DND Diversity Climate Survey (DCS), which was designed to capture both direct and subtle attitudes towards diversity, was administered to a random sample of 1,067 DND employees in 2009. Results indicated that employees generally held favourable attitudes towards diversity and employment equity; for example, 65% of respondents rated the diversity climate from "about average" to "good." However, 27% of designated group members (DGMs; visible minorities, aboriginal peoples, and persons with disabilities) compared to 11% of non-DGMs, rated the diversity climate in DND as "very poor" or "poor." Gender analyses did not show any significant differences in this regard. According to Lalonde (2011), such findings indicate that DGMs are more likely than non-DGMs to recognize that improvements are required in order to achieve a genuinely inclusive workforce.

In addition, responses to the Neo-Racism and Neo-Sexism scales contained within the DCS indicated some evidence of implicit prejudiced attitudes ("modern" sexism or racism) in the DND sample. For instance, there was a moderate level of agreement, for both DGMs and non-DGMs, with the statement, "*In order not to appear racist, many people are inclined to be more accommodating to visible minorities and Aboriginals.*" On the Neo-Sexism Scale, there was a moderate level of agreement, for both men and women, with the statement, "*With fair employment policies and practices, all employees would be considered equal.*" Further, men showed a significantly higher level of agreement than women with the statement that "*Discrimination against women in the labour force is no longer a problem in Canada.*" Lalonde (2011) suggests that these findings indicate that individuals are not necessarily aware of their implicit biases. Accordingly, if employees truly feel that with fair employment practices, all employees would be considered equal, then they lack the awareness that an inclusive workplace cannot be achieved simply by implementing employment equity initiatives and policies. Or, if employees truly feel that sexist discrimination is no longer a problem in the workplace, then they may also be exhibiting a form of modern sexism.

Although survey respondents generally did not show a high level of implicit racist or sexist attitudes, women showed slightly less implicit sexist attitudes on the Neo-Sexism scale as compared to men. (No significant gender differences were found on the Neo-Racism scale, and no significant differences were found between DGMs and non-DGMs on the Neo-Racism and the

Neo-Sexism scales.) Survey respondents also showed greater support for programs and policies that promote fair and equal treatment of *all* employees, compared to those that appear to favour one particular group over another. This attitude could also indicate an implicit bias against particular groups (i.e., those targeted by employment equity programs and policies) (cf. Lalonde, 2011). Indeed, the attitudes of DGMs, as well as women, were significantly more positive than those of non-DGMs, and men, respectively, towards such employment equity initiatives and policies (i.e., targeted staffing, commemorative events). In general, the results from Lalonde's (2011) study indicate that attitudes and perceptions toward diversity and employment equity are moderately favourable at DND, but that implicit bias—modern forms of sexism and racism—may also be present.

3 Interventions for reducing implicit bias

As we have seen in earlier sections of this report, an extensive body of research indicates that gender stereotypes and unconscious, implicit biases may be prevalent in a variety of settings, including workplace contexts. The unconscious nature of such biases renders them particularly difficult to change or mitigate. However, research has also identified some of the conditions under which gender stereotypes or implicit biases are more, or less, likely to occur. Moreover, research has demonstrated that such stereotypes or biases are modifiable and can be reduced, with appropriate training and intervention. This section focuses on research that illuminates the conditions under which gender stereotypes or implicit biases tend to occur, or tend to be minimized. In addition, it describes specific training programs that have been successful in modifying or reducing such biases, as well as other interventions that may reduce gender bias.

3.1 Factors that influence gender stereotypes and implicit bias

As discussed in earlier parts of this report, various factors can influence the occurrence of gender stereotypes and implicit biases. For instance, empirical studies have shown that implicit biases may be particularly likely to arise, and to undermine the ability to process information in a non-biased manner, in situations of ambiguity. But there are other factors to consider. Distraction and time pressure, for instance, can also increase the influence of implicit bias on decision-making, and the role of attention as a moderator for implicit attitudes has also been demonstrated empirically (see Lalonde, 2011). Further, employment-related gender biases are particularly likely to occur, and exert their influence, where employment decisions are unstructured, as previously discussed, and there is little accountability (Hoyt, 2012).

3.1.1 Minimizing descriptive gender stereotypes

Heilman (2012) has identified several conditions that can exaggerate or minimize the likelihood of stereotyped-based gender bias. For instance, given that bias often results from a perceived lack of fit between what women are believed to be like and the attributes perceived to be necessary for performance in male gender-typed positions and roles (i.e., from descriptive gender stereotypes), efforts to narrow the perceived gap can alleviate the negative effects of such stereotypes. According to Heilman (2012), the perceived lack of fit can be weakened if gender stereotypes are not activated in a given situation. For instance, organizations can ensure that structural or contextual features of the workplace do not activate such stereotypes. Contextual features that downplay the distinctiveness of an individual's gender, for instance, can limit its salience and thus its influence in impression formation. In particular, as Heilman (2012) suggests, and as Kanter (1977) pointed out several decades ago, the proportional representation of women in work settings is one such contextual feature. Thus, gender is made salient by numerical scarcity, but recedes in importance when a "critical mass" of women exists in an organization. As Heilman (2012) notes, this approach reduces the uniqueness of gender and also makes it difficult for others to see all women in the same stereotypic terms. Further, research has shown that an increased proportional representation of qualified women in an applicant pool can positively affect perceptions of women's career opportunities; likewise, an increased proportional representation

of women in work groups can positively affect women's performance evaluations (Heilman, 2012; see also Jackson et al., 2014).

Efforts to broaden conceptions of what it takes to perform male gender-typed jobs can also alleviate the negative consequences of descriptive gender stereotypes. Broadening the conception of what it takes to perform traditionally male jobs may occur naturally, as women increasingly take on such positions, and in fact there is evidence that exposure to biographical information about famous women leaders, for instance, as well as direct exposure to women in leadership positions, may reduce bias against such leaders (Cagnassola, 2015; Elsesser & Lever, 2011; Jackson et al., 2014). There is also evidence that communal traits and behaviours are becoming valued leadership characteristics (Heilman, 2012). However, organizations can also facilitate this process, not only by placing women in traditionally male roles, including leadership roles, but also by accurately characterizing these positions and their job-relevant requirements, including, potentially, communal attributes such as collaboration (Heilman, 2012). In a similar vein, European research on the effects of using gender-fair language in descriptions and advertisements of traditionally male jobs suggests that such language can curtail bias (Horvath & Sczesny, 2011; as cited in Heilman, 2012).

Heilman (2012) also offers suggestions for how organizations can lessen or even eliminate ambiguity in evaluation processes, in order to reduce the likelihood of gender bias. For instance, collecting and providing comprehensive job-relevant information about candidates to evaluators can prevent the tendency to use expectations to "fill in the blanks." Similarly, ensuring that evaluation criteria are concrete, and that they are used consistently no matter who is being evaluated (or who is doing the evaluating), can avoid the possibility of using different criteria for different people. Additionally, obtaining individual performance information for collective work can prevent evaluators from making attributions that deny women credit for their successes. Each one of these suggestions involves removing unnecessary ambiguity from the evaluation process, which can often be done with minimal cost or effort (Heilman, 2012).

Implicit gender bias can also be reduced when people are motivated to be accurate in their evaluative judgments. As Heilman (2012) explains, reliance on gender stereotypes or schemas is a "default" processing strategy; people generally operate using a least-effort principle and expend as little cognitive resources as possible to perform a task, whether it involves forming an impression or making a decision. But when motivated to be accurate, people expend the energy to systematically process information. Heilman (2012) further explains that people can be motivated to be accurate for a number of reasons. These reasons include anticipated interdependence, the desire to do the "right thing," and accountability. Each of these is elaborated below.

3.1.1.1 Anticipated interdependence

Evaluators are motivated to be accurate when they are in an interdependent relationship with the target of evaluation (i.e., when the evaluator's outcomes are linked with the evaluated person's performance, such as occurs when organizational performance requires teamwork and collaboration). In other words, when a target's success or failure has implications for an evaluator's well-being, self-interest will encourage the evaluator to identify the target's strengths and weaknesses and to systematically assess the likelihood of competence (Heilman, 2012). Thus, the evaluator will be motivated to be accurate because such accuracy will further their own interests.

3.1.1.2 The desire to do the right thing

Given people's desire to be fair towards others, whether due to increasing societal pressure against prejudice or their own personal values, a concern about potentially being sexist can promote a desire to do what is right in evaluating women, which may in turn lead to more careful processing of information and less gender bias. However, given that stereotypes are activated automatically, and often without the awareness of the evaluator, gender stereotypes can often sneak into the evaluation process, despite the evaluator's best intentions. Further, if the concern about doing the right thing is not motivated by personal values, but rather by a concern about doing what is socially desirable, the concern may not motivate accuracy but rather a desire to avoid the use of stereotypes, especially when the resulting bias will be obvious to disapproving others. As mentioned earlier, such "modern" sexism has been distinguished from "old fashioned" prejudice.¹⁷

3.1.1.3 Accountability

People can be motivated to be accurate when they are accountable, that is, answerable to others for the evaluative judgments they make. As Heilman (2012) points out, managers may be required to justify decisions based on these judgments to supervisors, subordinates or upper management, all of whom they may wish to impress favourably. Thus, when accountability motivates people to be accurate in order to appear competent, it can inhibit the use of expectations in evaluative judgments and encourage more complex judgment strategies. When held accountable, individuals are likely to exert more effort to search out information and to process it more deeply. Consistent with this, there is evidence that people who are held accountable act in ways that prepare them to justify their judgments, such as being more attentive when observing performance, or taking more extensive notes when gathering information, ultimately increasing their accuracy (Mero, Motowidlo, & Anna, 2003). However, as Heilman (2012) warns, bias is precluded only if organizational norms work against gender bias, rather than support it.

3.1.2 Deterring prescriptive gender stereotypes

Heilman (2012) also considers the unique challenges involved in attempting to deter prescriptive gender bias (i.e., bias that arises when women prove themselves to be successful in traditionally male domains). Such bias is value-based and results from beliefs about how things *should* be. Thus, prescription-based bias is less responsive to contextual intervention, or to organizational efforts to reduce its effects (Heilman, 2012). As Heilman (2012) explains, the problem is not inattention to individuating information, or a tendency to discount disconfirming evidence; likewise, solutions do not involve creating conditions that encourage more careful and thoughtful information processing. This is because of the value component to prescriptive-based bias. Even motivating people to be accurate so that they can further their own self-interests does not appear to provide a viable deterrent against prescriptive-based bias. Thus, the effects of such stereotypes present a difficult problem for those trying to minimize gender bias in the work setting.

¹⁷ The avoidance of stereotypes for reasons of social desirability is sometimes described or experienced as a social expectation for "political correctness."

Nevertheless, Heilman (2012) has identified several moderators of the negative reactions that may occur when successful women are seen as violating prescriptive gender stereotypes. As with descriptive stereotypes, the gender-type of the domain in which the prescriptive violation takes place can be important, in that the perceived level of a violation is determined not only by the woman's behaviour, but also by the degree to which male attributes are thought to be necessary for performance. For instance, the masculine ethos of certain work domains (e.g., law enforcement) or positions (e.g., engineer) increases the extent to which agentic attributes are thought to be necessary for success, and thus will increase the degree of perceived violation when women are successful in these roles. Attempts to feminize these jobs and occupations by broadening conceptions of the attributes actually needed to perform them successfully, as discussed earlier with respect to descriptive gender stereotypes, should, according to Heilman (2012), also help to reduce the perceived violation. This may involve highlighting those communal attributes that are relevant to job success, alongside agentic attributes. However, lessening disapproval for engaging in the behaviours that are directly associated with success is especially difficult. For instance, the gender-typing of agentic behaviours is culturally influenced and highly resistant to change. Until the content of prescriptive gender stereotypes changes, the behaviours believed necessary for success will conflict with prescriptions for women's behaviour.

Still, there are some circumstances that can lessen these effects—not by altering the perceived violation itself, but by counteracting the negative perceptions of the prescription-violating woman that result. Given that the disapproval of successful women is due to them being seen as not sufficiently feminine, providing information verifying a woman's femininity can guard against this deficiency-based disapproval (Heilman, 2012). Thus, information that contains references to a successful woman's communality (e.g., volunteering to help the sick or to work with children), may help to protect her against perceptions of femininity deficiencies (Heilman 2012). The downside of such a strategy, however, is that it may inadvertently reinforce descriptive and prescriptive gender stereotypes about women.

In short, Heilman (2012) suggests that we can mitigate the effects of prescriptive gender stereotypes by broadening our conceptions of the attributes needed to perform successfully in STEMM fields, and by changing our perceptions of women who are successful in such fields. Such changes in conceptions and perceptions will be difficult, given the role of values in maintaining prescriptive gender stereotypes. Nevertheless, such changes may be possible, with the appropriate interventions.

3.2 Training interventions that work: how to minimize biases through institutional change

Research suggests that raising awareness of gender-based and other forms of cultural diversity, and educating employees on recognizing their own potential biases, can indeed be effective, and that diversity training, when designed and delivered efficiently and effectively, can significantly improve employee attitudes toward diversity (see Lalonde, 2011). Such improvements, in turn, may reduce prejudiced attitudes and discriminatory behaviours, increase employee well-being, and promote overall job satisfaction (Lalonde, 2011). To minimize explicit and implicit prejudiced attitudes, for instance, Greenwald and Banaji (1995) propose three strategies. These include: (a) "blinding," a process used in personnel selection that involves the employer being blind to the name of the candidate; (b) "consciousness raising," which involves increasing

awareness of the source and nature of implicit bias (e.g., through mental imagery or counter-stereotypic association training, such as thinking of individual women leaders in one's organization); and (c) setting employment equity goals to increase the proportion of under-represented groups, such as women. As Lalonde (2011) suggests, achieving a truly inclusive work environment involves promoting inclusivity in the workplace, rather than focusing all efforts on initiatives that treat diversity as a social problem.

In a similar vein, the National Science Foundation (NSF) in the United States, and others, have concluded that institutional transformation is required to ensure equal opportunities for the participation and advancement of both genders in science, technology, engineering, mathematics, and medicine (Carnes et al., 2012). Towards this end, for example, the NSF has funded the "ADVANCE" program, which, along with increasing the participation and advancement of women in academic science and engineering careers, seeks to develop best practices for transforming STEM departments and overall institutional workplace climate (see Riffle et al., 2013).¹⁸ Such ADVANCE-funded programs have created, for instance, a system of equity advisors (e.g., senior faculty members) who raise awareness about equity in hiring, retaining, and promoting faculty members in the institution, and who promote a supportive environment by serving as a resource, confidant, and consultant on matters relating to equitable assessment, resources, teaching, research, and work/life balance (Riffle et al., 2013). Further, as Riffle et al. (2013) point out, another way to address sexism in STEMM institutions is to confront implicit bias, that is, indirect or unintentional bias. Thus, several ADVANCE institutions (e.g., the University of Michigan and the University of Wisconsin) have developed workshops on implicit bias in order to address workplace climate issues.

3.2.1 Promoting institutional change through bias literacy

One such approach to promoting institutional change, and addressing implicit bias, is through the development of bias literacy.¹⁹ Thus, Carnes et al. (2012) describe the theoretical basis of an educational intervention designed to promote bias literacy—a Bias Literacy Workshop that the researchers conducted at the University of Wisconsin-Madison—as well as its development, implementation, and early results. According to the theory underlying this intervention, institutional or organizational change requires changing the habitual attitudes and behaviours of organizational members through a multistep process; thus, implicit bias is viewed as a remediable, or changeable, habit. The aims of the workshop included: assisting faculty to achieve bias literacy; encouraging faculty to use their new knowledge by engaging in intentional behavioural change to reduce the activation and application of gender bias; and ultimately, achieving a change in the cultural norms of departments.

As Carnes et al. (2012) point out, the literature on prejudice has shown that the motivation to reduce one's prejudiced behaviour is a prerequisite for attempting the change process. Further, research has identified two independent motivators: internal motivation to respond without prejudice that is part of a personal belief system, and external motivation to respond without prejudice that stems from a desire not to appear prejudiced to others (see also Heilman, 2012, regarding the desire to do the right thing). However, although being motivated to change is

¹⁸ For more information on ADVANCE, see http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383.

¹⁹ In 2007, the American Association for the Advancement of Science (AAAS) coined the term "bias literacy," noting that achieving literacy in a given topic area is a prerequisite to action.

necessary, motivation is not sufficient for individuals to stop undesirable, habitual behaviours and to adopt new desirable behaviours. To produce actual changes in behaviour, individuals must believe they can change their behaviours (they must possess “self-efficacy”), and they must believe that their actions will produce a desirable effect (they must have “outcome expectations”). For example, positive outcome expectations for academic gender equity might include reducing faculty turnover, while negative outcome expectations might include needing to dedicate additional time to personnel decisions. Further, internal and external motivators can influence the “decisional balance” that individuals engage in to determine if the positive outcomes of change outweigh the negative outcomes. Once an individual makes a commitment to behavioural change, deliberate practice is required to effect a new habitual behavioural change (Carnes et al., 2012).

Based on the work of Prochaska and DiClemente in the 1980s, Carnes et al. (2012) describe a trans-theoretical model of change that includes five stages which individuals and/or organizations go through (not necessarily in a linear fashion) as they move from negative to positive behaviours. These five stages include pre-contemplation, contemplation, preparation, action, and maintenance—stages that also coincide, in part, with models of adult learning. For example, as Carnes et al. describe, Howell’s 1982 adult learning model posits that when acquiring a new skill, learners move from being unconsciously incompetent (analogous to pre-contemplation) to consciously incompetent (realizing they need to learn something new), to consciously competent (deliberately practicing) until they reach the ultimate goal of being unconsciously competent. Self-efficacy, decisional balance, and outcome expectations also feature in these models. Thus, Carnes et al. designed a unique educational intervention that incorporated practices from adult learning and continuing professional development, as well as providing participants with experimentally tested strategies from social psychology, in order to promote effective self-regulation of implicit bias.

As Carnes et al. describe, the resulting Bias Literacy Workshop acknowledged workshop participants as experts, engaged them in self-reflection and problem solving, and provided opportunities for practice with immediate feedback. The workshop also elicited a written “Commitment to Change” from each participant as a way to encourage retention of information and application of strategies provided during the workshop. Further, to increase awareness of implicit bias and help motivate participants, prior to the workshop, participants were invited to take the Implicit Association Test (IAT) (Greenwald, McGhee, & Schwartz, 1998; see also Dasgupta & Asgari, 2004). This test assessed the strength of association between male or female gendered names and words categorized as leader or supporter.²⁰

Carnes et al.’s (2012) workshop also involved targeted recruitment, strategies for optimizing workshop attendance, and a workshop evaluation plan. For instance, the workshop was presented to departments or units that function like departments, as opposed to holding open workshops attended by members of multiple departments, in order to capitalize on the potential for diffusion within social units (i.e., the possibility for workshop participants from the same department to reinforce and remind each other about what they learned during the workshop, and to introduce the concepts and strategies to those who did not attend the workshop). In addition, to encourage attendance and convey a more positive message, Carnes et al. modified the title of the workshop from “Breaking the Prejudice Habit Through Bias Literacy” to “Retaining and Advancing Excellent Faculty Through Bias Literacy.” The email invitations indicated that although

²⁰ The IAT is available online at <https://implicit.harvard.edu/implicit/takeatest.html>.

attendance was voluntary, the workshop would be an important use of faculty time, and multiple workshops were offered for large departments. Carnes et al. also worked closely with department chairs and administrators to find times most convenient for their faculty, and encouraged department administrators to attend.

To evaluate the workshop, Carnes et al. used a mixed-methods approach; data were collected from attendance records, institutional databases, participants' written evaluations of the workshop, and follow-up interviews with selected attendees. The post-workshop evaluation assessed changes in knowledge regarding the concepts taught, if the workshop was useful, and if participants would recommend the workshop to colleagues. The written Commitment to Change document, completed at the end of the workshop, asked participants to complete two sentences: "I commit to overcoming gender bias in my department or division in the following way..." and "I commit to overcoming gender bias in my personal life in the following way..." Follow-up interviews were conducted to further assess faculty perceptions of the workshop and its subsequent impact.

Results showed that among the 220 attendees from the initial 17 departments/divisions offered the workshop, all 180 who completed a written evaluation found the workshop at least "somewhat useful" and 74% found it "very useful." Over 68% indicated increased knowledge of the workshop material. Of the 186 participants who wrote a commitment to engage in new activities to promote gender equity, 87% incorporated specific workshop content. The most frequently cited actions included individuating, stereotype replacement (e.g., not assuming that the authors of research papers are male), counter-stereotype imaging (e.g., thinking of individual women leaders in departments), and perspective-taking (e.g., focusing on results, rather than making attributions about work commitment if women, for instance, need to adjust their work hours due to family commitments). In addition, of the 24 participants who were interviewed 4-6 months after attending the workshop, 75% not only demonstrated increased bias awareness, they described plans to change, or had actually changed behaviours because of the workshop. Interview results also reflected the other stages of behavioural change, supporting the underlying theoretical basis for the intervention. For instance, eight faculty (seven male, one female) expressed comments consistent with the pre-contemplation stage of change (e.g., denied that personal bias and departmental bias could exist); 23 of the 24 faculty made contemplation statements (e.g., acknowledged that the workshop increased their awareness of personal bias, as well as recognition of bias in others); and six interviews communicated maintenance statements (e.g., reflected efforts to actively work with women to provide them with strategies for success, through mentoring).

Based on these results, Carnes et al. (2012) concluded that at least one third of faculty who are invited will attend a 2.5-hour Bias Literacy Workshop,²¹ that nearly all will find it useful, and that most will complete a written commitment to promoting gender equity. According to Carnes et al. (2012), the findings suggest that this type of educational intervention may be effective in promoting institutional change regarding gender equity. Importantly, the findings also suggest that the effects of such interventions can endure beyond the training, as even after several months post-training, individuals who had participated in the diversity training workshop reported reduced bias and described plans to change their behaviour.

²¹ Of the 510 faculty members invited to the workshop, 167 (33%) participated.

3.2.2 Reducing implicit and explicit bias through gender diversity training

Similar to Carnes et al. (2012), Jackson et al. (2014) recently conducted a study to evaluate the effects of gender diversity training on implicit and explicit gender bias. Their sample included 234 STEM faculty members at four diverse mid-western universities in the United States. Faculty members came from a variety of STEM-related departments, including physical science, social science, technology, engineering, and mathematics. As Jackson et al. (2014) point out, gender diversity training has been widely used in public, private, and educational settings, but the effectiveness of such training has seldom been evaluated. Indeed, it is possible for diversity training to be ineffective. As Jackson et al.'s (2014) review of the literature indicates, some studies have shown increased contact through immersion not to be effective; that training people to suppress their stereotypical thinking can actually increase stereotype activation and target group avoidance; and that forced diversity training can result in backlash due to reactance. In contrast, effective interventions include those that help participants appreciate differences rather than trying to eliminate or ignore them. Diversity education that focuses on bias education and fear reduction has also been successful. Rather than trying to suppress thoughts about a target group, activities that make use of sub-grouping, and other methods to encourage *more* thinking about the underlying reasons for stereotypes, can be effective in reducing stereotypes. According to Jackson et al. (2014), these forms of deeper cognitive elaboration may be more likely to change personal attitudes rather than surface-level extra-personal associations. In addition, although immersion has generally been found to be ineffective, automatic bias can be reduced through exposure to exemplars, especially those in leadership positions or those who have attributes that are deemed desirable by society (see Jackson et al., 2014; and Ratcliff et al., 2015).

Given the above, Jackson et al. (2014) incorporated certain specific features into their diversity training. For example, the training included data on the representation of women in STEM nationally and locally, highlighted research on the effects of implicit bias on hiring, promotion, and retention, and featured ways to overcome bias. The training content was informed by research on diversity training, persuasion research, and teaching methods aimed at reducing threat and increasing interest and efficacy. Specific evidence-based recommendations included non-confrontational, research-based content, the use of inclusive language, and the introduction of practical remedies for overcoming bias.

In addition, Jackson et al. (2014) incorporated two types of assessment measures into their evaluation study: explicit and implicit. As they point out, with some exceptions (such as Carnes et al., 2012), the few evaluation studies that have been conducted on diversity training have tended to use explicit attitude measures of bias, or self-reports, which are easy to administer but vulnerable to threats to validity, such as social desirability and experimenter demand effects. In contrast, implicit attitude measures, such as the Implicit Association Task or the Go/No-Go Association Task, assess attitudes while reducing issues of response distortion. Implicit attitude measures are thought to reflect automatic activation of unconscious knowledge. Participants are not informed of what is being assessed, and conscious introspection is not required, thereby minimizing reactivity and reducing threats to validity. Thus, Jackson et al. (2014) sought to examine changes in both explicit and implicit attitudes in response to gender diversity training for faculty members in academic STEM disciplines. Further, Jackson et al. (2014) used a personalized version of the implicit attitudes test, which asks about one's own personal attitudes, in order to reduce any effects of normative or extra-personal associations. Thus, their paper-based

Go/No-Go Association Task (GNAT) and personalized GNAT (PGNAT) used a single target category (female scientist/engineer) and a single attribute category (GNAT: *pleasant* or *unpleasant*; PGNAT: *I like* or *I don't like*) at the top of the test.

In addition to completing these attitudinal measures of implicit and explicit bias, individuals completed a trait survey (assessing personality), prior to being assigned to one of two conditions: an experimental condition, in which individuals were exposed to a half-hour diversity training presentation; or a control condition, which consisted of attending a regularly scheduled departmental faculty meeting. Random matched assignment of participants to the various conditions was done to ensure that an even number of experimental and control groups were assigned to each university, and to ensure that an even number of departments from each of the STEM departments was assigned to each group. The matching procedure also helped to ensure that the two groups of participants differed only in what they were exposed to (diversity training vs. departmental faculty meeting), to the extent possible in a real-world (applied) setting.

Jackson et al.'s (2014) results showed that, after diversity training, *personal* implicit associations about women in STEM (as measured by the PGNAT) improved for men, but not for women, in the experimental group. The attitudes of women, who had already tended toward more positive implicit associations prior to training, did not change after training. On the other hand, the GNAT did not provide evidence of change for men or women. This finding suggests that personalized measures of implicit associations may in fact be more sensitive to changes in personal associations than traditional (general) implicit measures. Jackson et al. (2014) suggested that one possible explanation for the greater sensitivity of the personalized measure is that the cognitive elaboration elicited by effective diversity training is more likely to result in personal attitude change. In addition, Jackson et al. (2014) identified several components that their diversity training shared with the workshop implemented by Carnes et al. (2012). These included the goals of increasing awareness of implicit bias and motivation to change, providing strategies that increase self-efficacy, and setting expectations for positive outcomes.

Regarding explicit attitudes, Jackson et al. (2014) found that; overall, both men and women expressed generally positive attitudes towards women in STEM. However, the men reported significantly less favourable attitudes toward women in STEM than the women did, and were more likely to endorse gender stereotypes than women. These gender differences were found both prior to and after the diversity training. In addition, explicit attitudes did not change significantly following training, for either men or women, compared to the control group. The researchers suggested that the short time span between the pre- and post-training measures (30 minutes) may be a reason for the lack of change in explicit attitudes (after training, participants may have recalled their pre-training responses). Alternatively, ceiling effects in the explicit measures, or demand characteristics (a motivation to produce socially desirable, non-prejudiced responses), may have worked against finding attitude change in the explicit measures. However, given the significant gender differences in explicit attitudes that were found in this study (e.g., men reporting less positive attitudes and more endorsement of stereotypes toward women in STEM, compared to women), the researchers suggested that gender diversity training is still needed in this area.

Importantly, Jackson et al. (2014) found no significant correlation between explicit and implicit measures. This finding suggests that implicit measures may provide unique information about people's attitudes that is not captured by explicit measures, particularly where social norms might

result in socially desirable responding on explicit measures. The findings also suggest that men in STEM, in particular, might benefit from training on implicit bias. However, Jackson et al. (2014) emphasize that gender diversity training should be provided to both men and women, because everyone is susceptible to the influence of implicit bias (e.g., Devine, 1989; Moss-Racusin et al., 2012).

Overall, Jackson et al.'s (2014) findings suggest that participation in a brief diversity training intervention can improve implicit associations about women in STEM, as reflected in personalized implicit bias measures. Jackson et al. (2014) also recommend that, to be effective, training presentations should include a number of features. These include the incorporation of numerical information about women's representation in STEM, as well as local climate indicators; the training should be research-driven (e.g., should include stereotype-disconfirming information rather than emotional or moral appeals); and the training should provide steps to address bias. For example, workshop presenters can discuss the importance of awareness of bias as a first step to avoid implicit bias,²² or describe perspective taking as a method to reduce bias (see also Carnes et al., 2012). Further, to reduce reactance in diversity training participants, Jackson et al. (2014) recommend that presenters use non-confrontational language; both the use of a non-confrontational message and avoiding the negative evaluation of bias may be equally effective. To reduce threat and increase group cohesion, Jackson et al. (2014) recommend that presenters use inclusive language (e.g., *we*, *our*, *men and women*), that presenters explicitly acknowledge that everyone holds or is subject to biases, and that presenters maintain a research focus. Finally, Jackson et al. (2014) suggest that making diversity training optional rather than mandatory, as was the case in their evaluation and in Carnes et al.'s (2012) study, may reduce reactance and increase personal buy-in.

3.2.3 Creation of an implementation intention plan

An implementation intention plan can be included as a part of a workshop on reducing subtle/unconscious bias. As we have seen from Carnes et al. (2012), such a plan could take the form of a written commitment to change included at the end of the workshop whereby participants are asked to complete a few sentences in the form of, "I commit to overcoming sex-based bias in my organization in the following way(s)..." (Carnes et al., 2012). Implementation intention plans can train individuals to recognize particular situations that tend to encourage the emergence of unconscious biases, and to consciously respond differently to such situations (Oxford Learning Institute, 2013–14). By creating an implementation intention plan, an individual is consciously telling themselves what they would like to achieve (e.g., making a fair and unbiased decision in times of high pressure when it might be easier to use a stereotype regarding a group of individuals to make a key decision).

The benefits of using an implementation intention plan are clearly exemplified in findings from a validated experiment using three groups of volunteers (see Oxford Learning Institute, 2013–14). All three groups were asked to associate a number of "hire and fire" words with dark or light-toned faces. All other facial attributes were the same. The three groups received different

²² One means of making individuals aware of their own implicit bias is to ask them to complete an anonymous measure of implicit bias during the course of the diversity intervention, such as the Implicit Association Test. A general discussion of the ways in which implicit bias can negatively affect the workplace could then ensue.

sets of instructions regarding the completion of the task. One group of volunteers received goal intention instructions ("don't be prejudiced"). Another group was given the implementation instruction, "if I see a dark face, then I'll ignore colour."²³ The control group received no additional instructions regarding the completion of the task. Findings indicated that individuals in the control group showed a preference for hiring light-skinned people, individuals in the goal-intentioned group had half the race bias of the control group, while individuals in the implementation instruction group demonstrated no prejudice (see Oxford Learning Institute, 2013–14).

Another study also demonstrates that the effects of an implementation intention plan can persist beyond the initial training. This particular study addressed the use of an implementation intention plan in the context of gender-based bias. This research, which looked at the effect of the stereotype associating management with maleness, found similar results as those obtained in the previous study on race-based bias (see Oxford Learning Institute, 2013–14). However, what is important to note in this study is that the research participants were re-tested three weeks following the initial study and the positive effects obtained for the implementation intention group remained (see Oxford Learning Institute, 2013–14). In sum, the findings from both of these studies indicate that individuals can actively re-train themselves to lessen their use of biases in a variety of important decision-making situations.

3.2.4 The use of perspective taking

Another means of reducing bias is through the use of perspective taking (Todd, Bodenhausen, Richeson, & Galinsky, 2011). Being open to alternative perspectives and opposing viewpoints may contribute to individuals becoming more aware of the unconscious biases driving their opinions of others (Grewal, Ku, Girod, & Valantine, 2013). The benefits of perspective taking are exemplified by Proctor and Gamble's approach to mentoring, which involves junior/middle women managers sharing their perspectives with upper management. The purpose of this mentoring program was threefold: (a) to reduce the departure of up-and-coming female managers (i.e., middle managers); (b) to provide these women with increased exposure to key decision makers in upper management; and (c) to open new lines of cross-gender communication (Brady & McLean, 2002). This unique mentoring program, called "Mentor Up," was designed to create awareness of issues facing women at earlier career stages, and to build positive relationships between males and females in upper management and junior women mentors (i.e., reverse mentoring). Since the inception of this reverse mentoring program, there has been a significant reduction in the percentage of women managers leaving the company (i.e., "regretted loss") (Zielinski, 2000). In addition, as a consequence of such initiatives, Proctor and Gamble has received a number of awards for their efforts, including the 2015 Catalyst award which recognizes "success in creating workplaces where women and men have equal opportunity to advance and lead" (see Catalyst website at <http://www.catalyst.org>).

²³ Such an instruction is not "race-blind," in that colour is perceived, but is thereafter ignored when making the hiring decision.

3.2.5 Organizational-level approaches to reducing unconscious bias

The previous discussion focused on approaches to reducing implicit bias in the workplace that are targeted primarily at individuals. However, initiatives at the organizational level are equally important for reducing gender-based subtle or implicit bias in the workplace. Some of these, which focus on institutional change, were described previously in the context of diversity and implicit bias training. Several other organizational-level approaches to reducing unconscious bias are highlighted briefly below:

- a. The creation of an annual published report card on the status of women. This report could include information with respect to the rate at which females in an organization are being promoted compared to their male counterparts and tracking women currently in leadership positions (Morahan, Rosen, Richman, & Gleason, 2011). A product of this report should be a plan to address any inequities identified. A similar report could be created for all DGMs.
- b. Substantial representation of women on all major committees (Morahan et al., 2011), including hiring committees. This is especially important in the context of hiring committees, as research on law firms has shown that the odds of a female being hired increases when women are included in evaluative and decision-making processes, such as hiring a partner (Grewal et al., 2013).
- c. Educating members of hiring or selection boards on the issue of unconscious bias. A part of this initiative could include conducting hiring workshops for members of hiring boards. These workshops would include information on unconscious biases, on how such biases can impact the decision-making process, and on ways in which individuals can actively work to lessen the effects of such biases. Evidence of the utility of hiring workshops is reflected in findings from the University of Wisconsin. Researchers found that departments where faculty members participated in hiring workshops had significantly greater odds of increasing their percentages of women faculty compared to departments where faculty members did not attend such workshops (Grewal et al., 2013).
- d. Ensuring criteria used to evaluate prospective job candidates are set prior to the actual selection process to ensure that the criteria do not change to fit the favoured job candidate, thus reducing the possibility of gender- or race-based biases influencing the decision-making process (Grewal et al., 2013).
- e. Instituting a senior women's group (in the case of DRDC, the Women in STEMM Working Group) to play a role with respect to advising management on relevant gender-based policies and practices (Morahan et al., 2011). Similar groups could be created to address issues for other diversity groups.²⁴

²⁴ In fact, DRDC has created working groups for the four employment equity designated groups (Aboriginal, Visible Minorities, Persons with a disability, and Women).

3.3 Other interventions for addressing gender inequities in STEMM

As we have seen, an effective approach to addressing gender inequities in STEMM is for organizations to understand the subtlety and complexity of implicit biases and gender stereotypes, and to provide training programs and opportunities to minimize or reduce such biases or stereotypes. Nevertheless, although biases and stereotypes may be significant causes of gender inequity, the roots of such inequity are multi-faceted, and must be attacked on various fronts simultaneously. Thus, Eagly and Carli (2007) recommend that, in order to increase the number of women in executive or leadership positions, for instance, organizations must intervene in several ways. Some of these interventions have already been discussed, with respect to implicit bias. But other interventions seek to address other sources of gender inequities in organizations. These interventions, which may address inequities in STEMM positions in general, in addition to leadership positions, may include:

- a. increasing people's awareness of the psychological drivers of prejudice toward female leaders, and working to dispel those perceptions (e.g., through diversity-training initiatives that are not only formally endorsed by management, but whose lessons are reflected in daily management practices);
- b. changing the long-hours (or "face time") norm, and focusing instead on objective measures of productivity;
- c. reducing the subjectivity of performance evaluation, by including explicit evaluation criteria that can limit the influence of conscious and unconscious biases;
- d. using transparent, open-recruitment tools, such as advertising and employment agencies, which have been shown to increase the numbers of women in leadership roles, rather than relying on informal social networks and referrals to fill positions;
- e. ensuring a critical mass of women in executive/leadership positions (not just one or two women) to prevent the problems that often accompany tokenism, and to ensure that women's individual competencies are recognized;
- f. avoiding having a sole female member of any team, to ensure that women's contributions are not overlooked;
- g. helping to shore up social capital, by highlighting the importance of social networking and encouraging women to establish mentoring relationships;
- h. establishing family-friendly human resources practices (e.g., flextime, job sharing, telecommuting, elder care provisions, adoption benefits, dependent child care options, and employee-sponsored on-site child care), which have been shown to increase the proportion of women in senior management, as well as organizational performance in general; and

- i. encouraging male participation in family-friendly benefits, to dispel the idea that such benefits are appropriate for women only, and to demonstrate that men can benefit from such programs as well as women.

Like Eagly and Carli (2007), Bruckmüller et al. (2014) suggest the need for organizational initiatives, such as women-focused leadership training initiatives, women's networks, and specialized mentoring programs, to promote gender diversity. Likewise, McCullough (2011) suggests that preparing women for leadership roles, adopting equitable selection processes, and establishing mentoring networks (including peer-mentoring groups) can promote women's advancement in STEM fields.

In a similar vein, Lottero-Perdue (2013) offers 16 strategies to support female STEM faculty, based on qualitative interviews with 19 female faculty members at a major research university in the United States, in the fields of science, mathematics, and engineering. The strategies responded to initiatives and policies already in place at the university to support female STEM faculty, were specifically mentioned by at least one participant, or attended to issues common to female faculty such as work-life balance. The 16 strategies were organized into four categories:

- a. The first category, *changing culture*, involved fostering an appreciation of the strengths of a diverse faculty; valuing service that builds community; raising awareness of subtle messages toward female STEM faculty; and emphasizing data-driven decision making.
- b. The second category, *building networks of support and information*, included continuing and enhancing the faculty mentoring program; encouraging informal networking among female STEM faculty; and providing workshops for female STEM faculty.
- c. The third category, *supporting work-life balance*, involved continuing, clarifying, and enhancing family-friendly policies; improving and expanding child care resources (including the addition of lactation rooms); and considering creative solutions to dual-career situations.
- d. Finally, the fourth category outlined other strategies to support female STEM faculty, as well as all STEM faculty, as by doing so female STEM faculty will be supported: increasing opportunities for female STEM faculty to be officially recognized for their work; providing personnel support to STEM faculty who are new parents; listening to female STEM faculty, both those who stay and those who leave; and continuing recruitment efforts to increase the number of female STEM faculty.

Although many of the recommendations offered by Lottero-Perdue (2013), and by McCullough (2011), focus on the academic context, such recommendations echo those offered Eagly and Carli (2007) for organizations in general. Thus, such recommendations (along with certain private-sector programs, such as Proctor and Gamble's mentoring program) may also apply to STEM organizations such as government science laboratories, including, potentially, DRDC.

3.4 Additional considerations regarding interventions

As the interventions described above suggest, gender equality is not simply about increasing the quantity of women in STEMM or leadership positions. It is also about the quality of those positions, and about women's experiences within those roles. The research on the glass cliff, in particular, suggests that the expectations surrounding women's leadership appointments, and women's experiences in those roles, can be critical (Bruckmüller et al., 2014). Thus, in addition to recommending that organizations use objective performance evaluations, Bruckmüller et al. (2014) propose that organizations ensure that senior management is made aware of subtle forms of gender discrimination such as the glass cliff, and that employees are trained to reduce not only the gendered association of "think manager, think male" but also the gendered association of "think crisis, think female." Further, organizations could address the potential problems of the glass cliff by giving leaders in precarious positions greater access to social resources. Indeed, as discussed earlier, social networks, mentors, and support programs may help leaders to build and maintain relationships and provide career planning assistance (Bruckmüller et al., 2014).

However, Bruckmüller et al. (2014) caution against focusing interventions exclusively on women and stereotypes about women, as a focus on women as "the odd ones out" may implicitly reinforce the normative status of men in leadership roles. In general, singling female leaders out as "special" by focusing policies and interventions exclusively on them (e.g., through selective training or networking programs) might subtly reinforce gendered leadership associations, and thereby undermine the very purpose of these policies. Thus, rather than framing such programs as "extra help" for women, mentoring or networking programs should instead be presented as a necessary way of countering structural inequality. Similarly, training programs could be promoted in a gender-neutral fashion, with a focus on the acquisition of specific job-relevant skills, rather than on gender demographics, especially when the skills are traditionally linked with gender stereotypes (Bruckmüller et al., 2014).

Further, Bruckmüller et al. (2014) also provide recommendations on how organizations can ensure that they benefit from gender diversity. As Bruckmüller et al. (2014) point out, all diversity programs aim to create awareness about the value of diversity, but they may use different approaches to accomplish this goal. Many programs, for example, encourage people to make use of diverse talents and professional backgrounds in order to meet organizational goals, and thus seek to create a diversity climate where group differences are acknowledged and celebrated. However, with gender diversity, there is a need to counteract existing gendered stereotypes. By emphasizing perceived gender differences (e.g., in styles of leadership), organizations may inadvertently convey the message that they endorse gender stereotypes rather than challenge them. For instance, beliefs that women bring a communal, interpersonal leadership style to crisis situations may inadvertently reinforce the "think crisis, think female" gender stereotype (cf. Saucerman & Vasquez, 2014). Rather, Bruckmüller et al. (2014) suggest that in the case of gender diversity, organizations should try to create a diversity climate that acknowledges *individual* or non-gendered group differences (e.g., in professional background; see also Jackson et al., 2014). The goal of such programs should be to create awareness that both women and men, as individuals, can hold very different professional identities, display very different leadership styles, differ in their task strategies, differ in the career aspirations, or differ in many other respects. Bruckmüller et al. (2014) believe that such a diversity climate will enable organizations to benefit from gender diversity, because it minimizes the likelihood that women and men will be

constrained by a particular set of gender-based expectations, such as women being deemed particularly good “people managers” in times of crisis.

On the other hand, such an approach, which emphasizes individual differences rather than gender-based group differences, may be contrasted with approaches that have sought to increase the representation of women in STEM by focusing on communal rather than agentic attributes. According to proponents of these more gender-based approaches, if women view communal goals as important and do not perceive that STEM careers will provide the opportunity to meet those goals (see Eccles, 2005, 2007), then the interventions that focus on agentic goals may have limited success (Saucerman & Vasquez, 2014). Some research has supported this reasoning. For example, a study by Diekmann, Clark, Johnston, Brown, and Steinberg (2011) showed that reading a description of a scientist’s day when the activities clearly mentioned collaboration increased the participants’ belief that a science career would fulfill communal goals, and increased women’s positivity toward science careers. However, proponents of invoking communality to attract women to STEM careers have also emphasized the importance of recognizing the substantial overlap that exists between men and women, and caution strongly against framing the issue of agency versus communion as a direct function of gender (Saucerman & Vasquez, 2014). Further, according to such proponents, effective strategies for attracting women to STEM careers may involve simple or subtle changes, such as changing the physical environment of a computer science laboratory so that objects and posters in the laboratory are gender neutral (e.g., depict nature landscapes, rather than Star Trek images). In fact, such strategies have been found to increase women’s sense of belonging and interest in STEM (Cheryan, Plaut, Davies, & Steele, 2009). Similarly, using gender-balanced images in an advertisement for a STEM conference resulted in greater interest in attendance from women and men (Murphy, Steele, & Gross, 2007). Thus, in addition to advocating for emphasizing communal goals in some cases in order to attract women to STEM fields, proponents of such an approach have also argued against framing the issue of communion versus agency in strictly gender terms, and moreover, have pointed to gender-neutral strategies that have worked to attract women to STEM.

4 Concluding summary and recommendations

4.1 Summary of findings

Taken as a whole, the research findings cited in this report suggest that women in STEM, including women leaders, may face significant hurdles in the workplace (McCullough, 2011). This may also hold true for women in STEM occupations at DRDC, where women are particularly under-represented in S&T managerial roles, overall. In addition to a lack of role models and mentors, and other challenges identified in this report, the issue of unconscious or implicit bias, in particular, may be a significant obstacle for women striving to succeed in their chosen STEM area. As we have seen, implicit biases are subtle cognitive processes that can inadvertently hinder girls' and women's aspirations in STEM fields, and ultimately lead to unfair employment practices, including inequitable hiring, performance assessment, and promotion decisions (Lalonde, 2011). Such unconscious biases may partly explain women's under-representation in terms of entering STEM fields, as well as their exit from such fields through a "leaky pipeline." The primary purpose of this report, therefore, was to illuminate such implicit or unconscious biases. As such, the report also contributes to a major objective of the Women in STEM Working Group at DRDC, namely to communicate to DRDC employees about the challenges faced by women in STEM, generally speaking, and to promote awareness of such potential challenges. Towards this objective, the report highlighted findings of empirical research on unconscious/implicit bias, and identified some of the potential impacts of such bias for real-world employment decisions that may affect women, including hiring, selection, and promotion decisions.

Although implicit bias represents a difficult, potential challenge, research also suggests that there is reason for optimism. Despite the fact that implicit biases may be highly prevalent, and resistant to change, evidence suggests that such biases can be modified, reduced, or even eliminated, with the appropriate training or education (see Carnes et al., 2012; Jackson et al., 2014). Thus, this report also identified potential interventions for addressing or minimizing such biases, including various training approaches and workshops, at both individual and organizational levels. Importantly, gaining insights into implicit biases is a key first step in identifying effective ways to teach individuals to recognize and reduce their own personal biases, to increase awareness of the importance of diversity in the workplace, and ultimately, to foster positive attitude and cultural change within organizations (Lalonde, 2011). In short, there is growing evidence that efforts, through training and education, to narrow the gap between how women are perceived and how STEM jobs are perceived, can alleviate the negative effects of gender stereotypes (Heilman, 2012). Further, as previously noted, such training and education should be made available to all organizational members, regardless of gender—given that everyone is susceptible to the influence of implicit bias (see Jackson et al., 2014).

4.2 Recommendations for reducing implicit bias in the short or near term

As discussed earlier, researchers have identified a variety of recommendations and interventions for mitigating implicit gender bias, and for addressing the gender prejudice or discrimination that

may result from such bias. These recommendations and interventions were detailed in Section 3 of this report, and encompass a broad range of possible organizational practices, policies, and programs. Below, we present an integrated list of such recommendations for consideration. In some cases, the recommendations focus specifically or directly on reducing cognitive bias (e.g., ensuring evaluative criteria are as objective as possible; instituting implicit bias literacy training). In other cases, the effects on implicit bias may be less direct (e.g., introducing refinements to existing mentoring programs; changing the “face time” norm). In each case, however, the recommendation could be achieved in the relative short or near term, as implementation would require relatively little organizational effort, or may already be in place to a degree within an organization. These interventions may include, for instance, strategies for reducing ambiguity in employment evaluations, or refinements to already existing programs, such as mentoring programs. In each case, however, the recommendation must be considered in light of the specific organizational context, and must take into account organizational costs and benefits, organizational constraints, organizational structures, and organizational culture. The recommendations are as follows:

1. In job advertisements, strive to use gender-balanced images and gender-fair language in descriptions of traditionally male jobs, and to accurately characterize these positions and their job-relevant requirements. Use open/transparent recruitment tools.
2. Educate members of selection/hiring boards on the issue of unconscious bias. This could include conducting hiring workshops for members of hiring boards.
3. To the extent possible, strive to ensure sufficient time for employment evaluations and decisions to be made, so that such evaluations and decisions are not made under excessive time pressure and are given sufficient attention.
4. Ensure that evaluation criteria are as objective as possible—that is, job-relevant, unambiguous, concrete, specific, explicit, and structured, and that evaluation processes are structured, to ensure that they are followed consistently. Strive to use multiple sources of information when making evaluations of individuals, with clear instructions on how to combine or weight diverse pieces of information, and strive to obtain individual performance information for collective work. Ensure that the criteria used to evaluate job candidates are set prior to the actual selection process, so that such criteria do not shift based on gender stereotypes, or to fit a favoured job candidate.
5. Whenever feasible use a “blind” process for personnel selection (e.g., by having members of a job selection board be blind to the name of a candidate), so as to minimize explicit and implicit prejudiced attitudes.
6. Ensure accountability in the evaluation process, so that evaluators and decision makers are motivated to make accurate assessments.
7. Given that exposure to women in leadership positions can broaden conceptions of leadership, and may alleviate the negative consequences of gender stereotypes, strive to provide opportunities to expose organizational members to women leaders. Such exposure may be provided, for instance, through publications such as “Breaking Down the Barricades: Women in the Defence World,” or through “brown bag lunches” or a speaker series focusing on

women leaders in STEMM organizations. In general, strive to provide opportunities for women to be officially and publicly recognized for their work.

8. In addition to formal or public recognition, ensure that good performance is acknowledged more informally as well. This may be especially important for women in STEMM, given the importance of receiving direct and credible positive feedback on their ability or performance (e.g., Heilman et al., 1990). In addition, women have been found to benefit more from encouragement with respect to moving from middle to upper management (Tharenou, 2001). Overall, there is a need for managers to provide direct, credible, and timely feedback on good performance, in order to better support organizational members, including women, in STEMM.
9. Consider instituting a mentoring program, such as the “Mentor Up” program, which is designed to create awareness of issues facing women, by building positive relationships between men and women in upper management and junior women mentors.²⁵ In addition, encourage informal networking among women, and consider providing career-related workshops for women. But note: rather than framing such programs as “extra help” for women, mentoring or networking programs should be presented as one way of countering structural inequality. Alternatively, depending on the organizational context, such training programs or workshops could be promoted in a gender-neutral fashion, with a focus on the acquisition of specific job-relevant skills, rather than on gender demographics.
10. Institute some form of diversity training (or “promoting excellence through bias literacy training”) for all organizational members. Such training should be research-based; emphasize the strengths of diversity; include data on the representation of women in STEMM (nationally and within the local region/organization); underscore the prevalence of implicit bias among both women and men, and the fact that everyone holds or is subject to such biases; highlight the effects of implicit bias on hiring, promotion, and retention; use non-confrontational, inclusive language; include practical remedies for overcoming bias (e.g., in evaluations); and be available to all members of the organization, regardless of gender. Such training may also include a “commitment to change” or implementation intention plan, or provide participants with an opportunity to learn about their own potential biases (e.g., by taking the Implicit Associations Test). Such training may also include measures of implicit and explicit bias, both pre- and post-training, so that training efficacy (attitude changes) may be assessed.²⁶
11. Create an annual published report card on the status of women in the organization that includes information on women’s career progression and tracks women in leadership positions.

²⁵ Such a program could be a refinement to any current mentoring program.

²⁶ Whether such training should be voluntary or mandatory for organizational members must be examined within the context of organizational constraints (e.g., Treasury Board requirements within federal government S&T laboratories). Also, as research has shown that mandatory diversity training can result in backlash due to reactance (see Jackson et al., 2014), “strongly encouraging” attendance for employees, rather requiring it as mandatory, might be a preferable approach. Attendance at such training may be mandatory for managers (i.e., those with sections 32 or 34 delegation, or those with the authority to hire civilian employees). In addition, the length of the training may be brief (e.g., 30 minutes), or longer (e.g., 2.5 hours), especially if assessing explicit attitudes (see Jackson et al., 2014).

12. Ensure that there is substantial representation of women on all major committees, including selection/hiring/promotion committees.
13. Institute a senior women's group (in the case of DRDC, the Women in STEMM Working Group) to advise management on relevant gender-based policies and practices.
14. Change the long-hours or "face time" norm, and instead focus on objective measures of performance.
15. Support the use of family-friendly or flexible work arrangements—for both women and men.

Given that DRDC is a STEMM organization, it is not immune from any of the issues identified in this report. Thus, it may be worth taking a closer look at whether any of the elements listed above may be relevant to the DRDC situation, and whether they may contribute towards efforts to identify solutions, as appropriate.

4.3 Recommendations for the longer term

While the recommendations listed above may be addressed in the relative short or near term, other interventions may require a longer-term horizon, but are also worth considering. In particular, broadening conceptions of leadership—and challenging notions of what is gender-appropriate in the workplace more generally—will require cultural shifts, not just changes in individual attitudes, whether implicit or explicit. Thus, some of the narrowing of the gap in perceived fit between how women are perceived and how STEMM jobs are perceived may also occur as perceptions shift regarding, for instance, what it takes to be a good manager or leader. As noted earlier in this report, research indicates that communal attributes and behaviours traditionally associated with women—such as sharing responsibility, developing others' skills, building relationships, and reducing hierarchy—are increasingly becoming valued characteristics for leadership roles (Eagly & Carli, 2003; Heilman, 2012). Similarly, research on transformational leadership has shown the benefits of taking a communal approach to leading, with individualized consideration and inspirational motivation becoming increasingly associated with effective leadership (Eagly et al., 2003). If, over time, such a change in the conceptualization of effective leadership does become culturally normative, then there should also be a reduction in descriptive gender stereotypes, or the perceived lack of fit between the attributes associated with women and the attributes thought necessary for success (Heilman, 2012). Moreover, if such a reconceptualization should occur, it would also mitigate against the effects of prescriptive gender stereotypes, diminishing the perceived normative violation and resulting disapproval that may occur when women take on traditionally male roles and perform them successfully (Heilman, 2012). But whether through diversity training and education offered in the workplace, or through shifting cultural perceptions in the broader society, or both, the reduction of implicit bias will help to ensure that human talents are applied most effectively in the workplace and that organizations and society will gain the most from such diverse talents. Such a new organizational cultural norm could result in increased experiences of collegiality, equal treatment, and ultimately greater job satisfaction and productivity for all STEMM workers, regardless of gender (see Riffle et al., 2013).

4.4 Future research directions

This report has identified several areas in need of future research. Although there is general agreement that bias, prejudice and discrimination can be explicit and implicit, relatively little is known about strategies for reducing implicit bias or prejudiced attitudes, or about which strategies may be the most effective at sustaining immediate and permanent attitude or behavioural change. For instance, there are still questions about whether interventions should emphasize individual differences, or whether they should emphasize gender-based group differences. Likewise, questions persist about whether interventions should focus on women or whether they should be presented in a more gender-neutral fashion. Thus, further research is needed to determine the effectiveness of such strategies within an organizational setting (Jackson et al., 2014; Lalonde, 2011). Future research should also compare the validity of different measures of bias, both implicit and explicit. For example, research could compare the precision of computer-based personalized implicit association measures, paper-based personalized implicit measures, and various explicit measures of bias (see Jackson et al., 2014). Future research should also investigate whether attitude change is produced most effectively by majority group members or by minority group members. Research has indicated, for instance, that a majority group member challenging stereotypes can be as effective in producing attitude change as a minority group member, but also produces more positive evaluations of the messenger, compared to when the message comes from a minority group member (Jackson et al., 2014). Other avenues of future research should include investigations into women's leadership within STEMM fields. As we have seen, the lack of research on women's leadership in STEMM has itself been a barrier to women's equitable participation in such fields, and warrants further research (McCullough, 2011).

There is also a need for additional research on the topic of subtle bias and its impact at both the individual and the organizational level. Areas of future research could include determining the mechanisms through which subtle forms of discrimination have their effects (Hoobler, Wayne, Lemmon, 2009) and the conditions under which subtle forms of bias and discrimination are most likely to occur (Jones et al., 2013). For example, obtaining a better understanding of which individuals are more likely to be influenced by subtle bias, and under what conditions, can contribute to initiatives being implemented to reduce the likelihood of bias or to lessening its impact. In addition, research focused on understanding the effect that various organizational policies or climates have on the rates of subtle bias would be extremely beneficial. Understanding how these policies or climates are related to relevant work-related outcomes, including the retention of women and other minorities within STEMM, or the progression of these groups to more senior managerial positions, is also of importance.

To conclude, this report sought to illuminate some of the challenges that women may face in entering and advancing in STEMM fields, including within managerial or other non-traditional roles. The particular focus of this report was on the challenge of unconscious or implicit gender bias. In addition, the report identified several recommendations for countering such biases. If implemented, such interventions could help to bring about a more inclusive workplace environment, to ensure that human talents are applied most effectively and that the potential gains from diversity are maximized.

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List of symbols/abbreviations/acronyms/initialisms

AAAS	American Association for the Advancement of Science
CORA	Centre for Operational Research and Analysis
CSS	Centre for Security Science
DCS	Diversity Climate Survey
DGM	Designated Group Member
DGMPRA	Director General Military Personnel Research and Analysis
DND	Department of National Defence
DRDC	Defence Research and Development Canada
DSTKIM	Director Science and Technology Knowledge and Information Management
EE	Employment Equity
IAT	Implicit Association Test
NSERC	Natural Sciences and Engineering Research Council
NSF	National Science Foundation
PSES	Public Service Employee Survey
R&D	Research & Development
STEM	Science, Technology, Engineering, and Mathematics
STEMM	Science Technology, Engineering, Mathematics, and Management
WG	Working Group

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This scientific report focuses on factors that can impede the participation and advancement of women in Science, Technology, Engineering, Mathematics, and Management (STEMM). In particular, attention is paid to unconscious, implicit gender biases and how these may impact the hiring, selection, or promotion of women in STEMM fields/non-traditional roles. This report satisfies one of the objectives of the Working Group on Women in STEMM at Defence Research and Development Canada (DRDC), namely, to create awareness within DRDC about challenges faced by women in STEMM, and contributes to the aim of developing an action plan for achieving a balanced representation of women in non-traditional roles. The report also provides insight into an issue of importance to the ADM S&T, as champion of Employment Equity within DRDC. Specifically, this report provides statistics on women's representation in STEMM, nationally, internationally, and within DRDC; discusses the particular role of implicit or unconscious bias, rooted in gender stereotypes, as one possible explanation for the under-representation of women in STEMM, and, based on a review of empirical research, identifies the potential impacts of such biases on employment-related evaluations and decisions, including those pertaining to hiring, selection, and promotion. Women and leadership within the STEMM context is given specific consideration, as are implications of implicit bias and discrimination for individual health and well-being, as well as organizational outcomes. Possible interventions for reducing implicit bias, for instance through bias literacy training, are reviewed, and recommendations, along with suggestions for future research in this area, are offered.

Le présent rapport scientifique porte essentiellement sur les facteurs pouvant nuire à la présence et à l'avancement des femmes dans les domaines des sciences, de la technologie, de l'ingénierie, des mathématiques et de la gestion (STIMG). On s'intéresse tout particulièrement aux préjugés sexistes implicites ou inconscients, ainsi qu'à leurs répercussions éventuelles sur l'embauche, la sélection ou l'avancement des femmes dans les domaines STIMG et les rôles non traditionnels. Ce rapport a atteint l'un des objectifs du groupe de travail sur les femmes en STIMG à Recherche et développement pour la défense Canada (RDDC). Il a permis, entre autres, de sensibiliser l'Agence aux obstacles que doivent surmonter les femmes en STIMG et de contribuer à l'élaboration d'un plan d'action dans le but d'arriver à une représentation équilibrée des femmes dans les rôles non traditionnels. Le rapport présente également un aperçu d'une question d'importance pour le SMA S&T, en tant que champion de l'équité en matière d'emploi au sein de RDDC. Plus précisément, ce rapport contient des données statistiques sur la représentation des femmes en STIMG à l'échelle nationale et internationale, et au sein de RDDC. On aborde le rôle particulier que joue la partialité implicite ou inconsciente, bien ancrée dans les stéréotypes sexistes, qui pourrait expliquer la sous-représentation féminine en STIMG. Également, sur la base d'une revue de recherche empirique, on détermine les répercussions possibles de tels préjugés sur l'évaluation et les décisions relatives à l'emploi, notamment celles ayant trait à l'embauche, à la sélection et à l'avancement. On accorde une attention particulière aux femmes et au leadership en STIMG, de même qu'aux implications de la partialité implicite et de la discrimination fondée sur la santé et le bien-être personnel, ainsi qu'aux résultats de l'organisation. On énonce des moyens possibles de diminuer la partialité implicite, entre autres

par une formation contre les préjugés, on formule certaines recommandations et on propose des suggestions de recherches futures dans ce domaine.

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women in STEMM; women in STEM; unconscious bias; implicit bias; gender stereotypes;
gender bias