International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

Gender Inequalities in Cybersecurity: Exploring the Gender Gap in Opportunities and Progression

Donna Peacock and Alastair Irons

University of Sunderland, UK

ABSTRACT

This paper considers the impact of gender in the global cybersecurity industry. There is currently significant underrepresentation of women in the industry caused by low numbers of women entering the field and compounded by a high rate of women choosing to leave this highly male-dominated work environment.

The findings are based upon a quantitative study conducted by means of an online survey. The research considers the motivations, experiences and progression of those working within cybersecurity roles. The findings from the research indicate that computer security offers an interesting, exciting and challenging work environment, job security, and excellent opportunities for progression and development. Barriers remain for women though; despite the perception that anyone with the 'right skills, knowledge and experience can work in cybersecurity', it is clear that the respondents to this study feel that computer security is viewed as a 'man's job' by wider society and by customers and clients, and that there is perceived gender inequality in recruitment, opportunities and progression.

KEYWORDS

cybersecurity; computer security; gender; women; ICT

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INTRODUCTION

Cybercrime and cyber-attacks are increasing in number, complexity and sophistication. The Crime Survey for England and Wales (CSEW) estimated that there were 1.9 million instances of cybercrime experienced by victims in the 12 months prior to December 2016 in the UK (Office for National Statistics, 2017). The National Crime Agency (2016, p.3) estimates that the cost of cybercrime to the UK economy *"is billions of pounds per annum – and growing."* The cost of cybercrime globally is estimated to be over four hundred billion dollars (McAfee, 2014). One of the ways to tackle cybercrime is through prevention enhanced by robust and resilient cybersecurity; there is currently a significant shortfall in the skills required to address these cybersecurity requirements (see for example reports from the National Audit Office (2013), NCA (2016) and ISACA (2015)). ISACA (2015) report that 86% of respondents to their survey (from a sample of 3,439 global industry professionals) report a skills shortage. Cisco (2015) estimate that there are approximately one million unfilled IT security vacancies worldwide.

The skills shortage could potentially be bridged by addressing the gender imbalance; research carried out by Reed et al. (2017) indicates that only 11% of the global cybersecurity workforce is female and that this figure is as low as 7% in Europe. This is also reflected in the US where according to LeClair, Shih and Abraham (2014) there is a 10-15% representation of women in cybersecurity jobs. This point is emphasised in Bagchi-sen et al. (2009, p.46) who suggest that *"although cybersecurity is a critical IT area, women continue to be underrepresented amongst its ranks".* According to Macdonald (2014, p.6) *"…there is a business case for a more diverse workforce to increase productivity and creativity".* It is further suggested that there is a wide range of opportunities for women in cybersecurity and there is a critical need to embrace the female talent in the cybersecurity field (Divol, 2015).

Macdonald's (2014) contention that women in ICT are bound by dominant cultural conceptions of both gender and technology applies also to those women working in computer security, who are also constrained by notions of security and masculinity (Hudson, 2005; Romaniuk and Wasylciw, 2010), so that the effect is further exacerbated (WSS, 2013). Hegemonic masculinity in society has meant that women do not associate their identities with working in security professions, as their gender is more associated with the private sphere, and indeed some would argue that they are seen as being in need of protection (Romaniuk and Wasylciw, 2010). The result is that the already low numbers of women in ICT are further diminished by the 'security' aspects of cybersecurity work.

This paper considers some factors which have an impact upon entry to the industry, including familial and educational encouragement and recruitment practices, and opportunities and progression for those who have entered computer security roles. The data supports the popular perception of computer security as a 'male' industry,

(BCS, 2016; Reed et al., 2017) and further suggests that the causes of inequality in opportunities and progression lie in the social construction of a gendered labour force (Macdonald, 2014).

This paper is of current relevance as despite a recognised gender disparity within cybersecurity, the subject has received limited attention in the academic literature. The gender imbalance is of special interest beyond its contribution to academic knowledge when considering the skills gap that the sector is attempting to close. It is also a matter of social justice for society to provide equal opportunities and progression within employment.

The proportion of women in information security globally is lower than in other ICT professions at only 11% according to research by Reed et al. (2017) (see also $(ISC)^2$, 2014), compared to approximately 17% in all ICT professions and 47% in the wider UK workforce (BCS, 2016). Whilst there has been a growing literature base with relation to girls into STEM, and girls into ICT, there is limited literature available which considers gender and cybersecurity specifically; this research aims to contribute to addressing this gap.

CONTEXT

In the UK, undergraduate Computer Science, Technology, and Engineering (STEM) is male-dominated, with women making up less than 15% of undergraduates in the academic year 2014-15 (HEFCE, 2016). Women are also under-represented as Higher Education qualifiers in an IT related subject in the UK, currently making up only 17% of graduates, compared to 59% in all subject areas (BCS, 2016).
A number of reasons have been suggested for the gender imbalance in ICT roles. Firstly it has been suggested that despite the fact that girls outnumber and outperform boys in STEM qualifications, girls do not aspire to work within the technology industry as they perceive it to be 'geeky' (WSS, 2013), 'nerdy' (Valenduc, 2011) or 'for boys' (techwomenuk, 2015a) and therefore they do not see it as being in line with their self perceptions (Macdonald, 2014). 'Non-STEM' identities in girls are thought to emerge as early as the age of ten or eleven (techwomenuk, 2015b). Sanders (2005, p.6) suggests that the causes may be located within the ways in which technology has been socially constructed and in particular that:

> *The violent language of technology may be invisible to males but can be a problem for females. Consider hard disc, hard drive, reboot, cold boot, hits, permanent fatal error, and so forth. Recreational or even educational software for children often includes title words such as "attack" or "war".*

Other reasons suggested for girls not aspiring to work in technology are lack of familial encouragement (techwomenuk, 2015b; Denner, 2011), possibly due to a lack of parental knowledge and/or confidence in technology (techwomenuk, 2015a; 2015b), lack of early engagement (techwomenuk, 2015a) lack of encouragement within schools, a lack of appropriate careers education (techwomenuk, 2015a; Macdonald, 2014), and a lack of female role models (LeClair, Shih and Abraham,

2014; techwomenuk, 2015a; 2015b). These factors could impact upon the aspirations of girls, and their awareness of opportunities within the industry.

It has also been suggested that technology as a profession has been more likely to be aspired to by boys because boys were more likely to engage with it for recreational purposes, particularly in gaming (Palmén, 2011). Evidence suggests however that girls do in fact engage with technology recreationally, being much more prolific users of social media than boys (Common Sense Media, 2012) meaning that we cannot therefore point to the extent of recreational use of technology among young people as a cause of gender differences within ICT employment roles.

The proportion of women in information security globally has been found to be lower than is found in other ICT professions, currently at only 11% (Reed et al., 2017) as compared to 26% in all IT professions worldwide (Dallaway, 2016). The security sector as a whole is male dominated, perhaps due to its traditional reliance upon physical strength and the ability to fight, or to protect, which are traditionally masculinised behaviours (Romaniuk and Wasylciw, 2010); many of those working in cybersecurity have previously worked in other areas of security work (WSS, 2013). Gender inequality in ICT more generally is compounded due to the masculinisation of both security (Romaniuk and Wasylciw, 2010) and technology (WSS, 2013), with security being *"based on a hegemonic masculinity"* (Romaniuk and Wasylciw, 2010, p.26) and with technology, and its control, being a *"…fundamental way in which gender is expressed in any society"* (Bray, 2007, 38). Feminist writers have identified the patriarchal development and control of technology as being instrumental in controlling economic, social and labour relations (see for example Cockburn, 1983; 1985; Wajcman, 1991).

There are a number of other potential factors which may also contribute to the gender imbalance in entry to cybersecurity professions. The low numbers of graduates in IT mean that there is overrepresentation of males in teaching roles as there is a much smaller group of people who are able to join the profession (Watt, Richardson and Devos, 2013) leading to a lack of positive female role models in education. The imbalanced gender distribution in technology related roles has also been attributed to a *"…lack of standardisation and formalisation in career paths and qualifications/training required",* and a lack of awareness amongst women of the variety of roles that are available (WSS, 2013: 3).

There are also a wide range of reasons for poor retention of women (Valenduc, 2011) suggested including a 23% pay gap (Macdonald, 2014), discrimination (Weisul, 2014), and lack of advancement due to *"social, institutional and personal challenges"* (Bagchi-Sen et al., 2009, p.47). LeClair, Shih and Abraham (2014, p.2) suggest *"…climate dissatisfaction, pay inequity, pressure from family issues, gender discrimination, lack of social change, lack of support from employers for advancement"*. It is clear that the retention of women is difficult for a number of reasons; these are complex and are both internal and external to organisations in which cybersecurity professionals are employed.

It is desirable for businesses to consider the causes of the gender divide because it has been found that workforce diversity increases productivity (see WGEA, 2016 and Way, Larremore and Clauset, 2016, who make the case for productivity and Bear and Woolley, 2011 who describe a positive impact upon the group process) and creativity (Østergaard, Timmermans and Kristinsson, 2011). Gender diverse organisations significantly outperform male-only organisations, with gender diverse companies found to be outperforming those with male-only workforces by up to 26% (Caldwell, 2013). It has been suggested in previous research that increased gender equality is beneficial to cybersecurity because of the 'different' personal attributes offered by women ($(ISC)^2$, 2013). What is less clear is whether women do actually have these 'different' attributes (according to Wajcman (2004) feminist perspectives on technology are divided on this issue), and if so, what they are, and whether they are biologically determined, or are socially constructed. Cyr, Gefen and Walczuch (2017) suggest that people are in fact psychologically androgynous, and that both men and women can express masculine or feminine values and behaviours in their use of technology. While this discussion is beyond the scope of the current research, it is certainly worthy of further investigation if we are to build a comprehensive picture of the causes and consequences of gender inequality in cybersecurity.

There is a significant skills shortage in the industry (NCA, 2016; CISCO, 2015). This could potentially be met and simultaneously offer some much needed diversity to the workforce by attracting more women into the sector (Divol, 2015, Caldwell, 2013). It is suggested in this paper that it is important that academics, researchers and policy makers consider the gender divide in order to fully understand the causes. It is only by developing an understanding of the generative mechanisms that underlie inequality that solutions may begin to be produced. These solutions must focus upon wider society, parents and education, as well as the industry itself, in order to begin to tackle gender inequality at its roots.

METHODS OF WORKING

This study has utilised a quantitative approach to examine the impact of gender upon perceived opportunities and progression opportunities for those employed within computer security roles. The data in this survey was collected using an online survey, which was completed by 219 individuals working within the sector. Although this is a global sample it is acknowledged that the UK is over-represented in the sample at 73% of the respondents.

The survey was disseminated online, utilising the professional networks of individuals engaged within the sector, making the sample a convenience sample and the results should be considered with this in mind. 33% of the survey respondents were female, which over-represents the distribution of women in the industry, and may be indicative that men were less likely to be interested in completing the survey when invited to do so. 73% were located within the UK, which means that the UK is also over-represented in the sample. As the survey responses were mainly in the form of ordinal and nominal data it was possible to cross-tabulate the responses by gender for the purpose of considering the

differences in responses relating to perceptions from male and female respondents (Wagner, 2015). Cross tabulation is a form of bivariate analysis that allows for statistical analysis of the relationship between variables (Frankfort-Nachmias and Leon-Guerrero, 2015). A chi-square calculation was undertaken in order to test for statistical significance. Data that were calculated to be statistically significant ($p<0.05$), and therefore unlikely to be merely random occurrences in the data (a less than 5% chance), have been included in the discussion that follows. In addition, the discussion is supported by qualitative comments that were made within the survey, where respondents were invited to add any further comments that they felt may be of relevance to the research.

FINDINGS

The findings from the research indicate that computer security offers an interesting and challenging work environment, job security and excellent opportunities for progression and development. Overall, 93% of respondents agreed or strongly agreed that the work is interesting, 89% agreed or strongly agreed that it is challenging, and 73% agreed or strongly agreed that it is exciting. 80% of the respondents were in full-time permanent positions and 59% agreed that they are fairly paid for the work that they do, with no significant difference found here between male and female responses.

86% of the respondents agreed that 'anyone with the right skills and attributes can work on cybersecurity'; it would seem however that being female is not 'the right attribute', only 50% of the respondents agreed or strongly agreed that men and women are equally valued within the industry. Respondents also perceived significant differences in recruitment, opportunities, and progression.

Table 1 and Figure 1 show that there is a significant difference in the perceptions of males and females with regard to whether women and men are equally likely to be recruited; only 25.4% of female respondents (n=16) agreed that men and women are equally likely to be recruited compared to 52.7% of the men (n=69) who agreed ($p=0.00$), showing that male respondents to the study perceive there to be more equality of opportunity than women do. Female respondents were more than four times as likely to strongly disagree that men and women were equally as likely to be recruited as were their male counterparts, who were more than eleven times as likely to agree. Male participants clearly perceive there to be more equality in recruitment opportunities than is perceived by female respondents; it could be suggested that the women were more likely to perceive inequality because they were more likely to have had experience of inequality in their own career although further research is required in this area.

Table 1. 'Men and women are equally likely to be recruited to work in cybersecurity'

	Women (count and percent)	Men (count and percent)
Strongly Disagree	10 (15.9%)	5 (3.8%)
Disagree	26 (41.3%)	30 (22.9%)
Neither Disagree Nor Agree	11 (17.5%)	27 (20.6%)
Agree	15 (23.8%)	45 (34.4%)
Strongly Agree	1 (1.6%)	24 (18.3%)

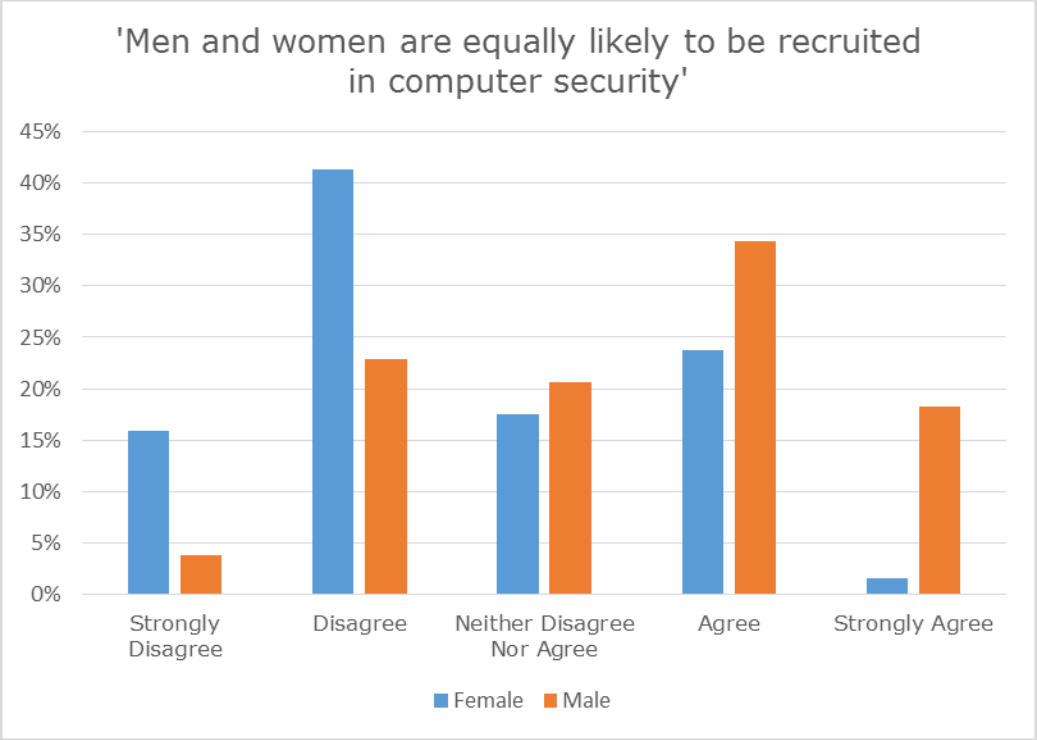

Figure 1. 'Men and women are equally likely to be recruited to work in cybersecurity'

This is partially explained within the qualitative responses as being related to *"the lack of women in IT in general [which] means that there are even fewer entering the IT Security field… for many people IT Security is a progression from a more generalist IT role"* (respondent 218). As respondent 197 goes on to explain further *"…there are feeder roles for entry level security analysts, mainly from technical roles. This makes the pool of available applicants statistically skewed in favour of men, because there just aren't as many women in those roles".* This may suggest that in order to gain a better gender balance in this workforce it is necessary to further consider the different routes by which men and women enter the industry.

Table 2. 'I was encouraged to do cybersecurity work by my family'

	Women (count and percent)	Men (count and percent)
Strongly Disagree	12 (19.7%)	28 (22.6%)
Disagree	23 (37.7%)	45 (36.3%)
Neither Disagree Nor Agree	11 (18%)	39 (31.5%)
Agree	13 (21.3%)	7 (5.6%)
Strongly Agree	2 (3.3%)	5 (4%)

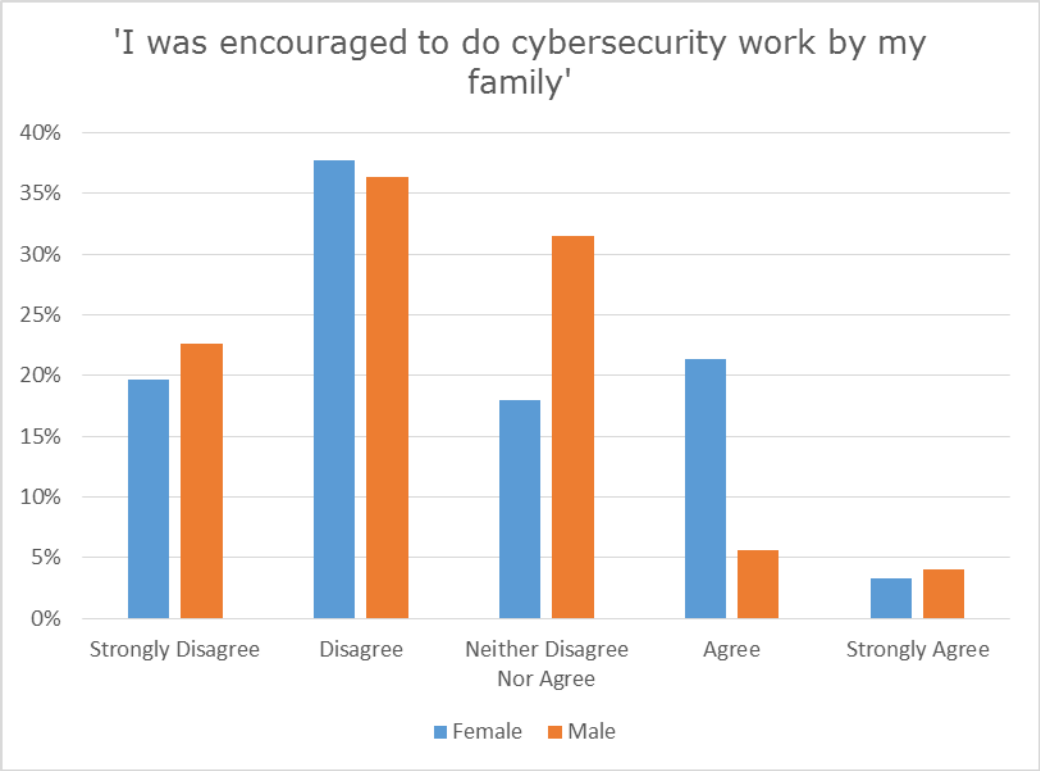

Figure 2. 'I was encouraged to do cybersecurity work by my family'

Table 2 and Figure 2 show that 24.6% (n=15) of female respondents agreed or strongly agreed that they were encouraged by their family to do cybersecurity work; only 9.6% (n=12) of the men agreed or strongly agreed (p=0.016). No difference was found between male and female reporting of encouragement in education where responses indicated low levels of encouragement, as one of the respondents to the study stated *"…women are not encouraged or inspired to enter into the industry"* (respondent 150).

The higher level of perceived familial encouragement among women must be considered within the context of the study; these are participants who have entered the industry. The higher level of encouragement perceived may therefore indicate that women *require more encouragement* than men do in order to enter the industry, rather than that girls and women are actually encouraged more.

Women were more likely to report that they were unable to effectively access information about how to access the industry. As shown in Table 3 (below) 40% of women (n=24) perceived an inability to effectively access information about how to access the industry compared with only 23% (n=28) of men (p=0.011).

This inability to effectively access information about careers in cybersecurity strongly suggests a need to tackle careers advice and guidance for all genders, and specifically to ensure that useful and relevant information is made available to girls who perceived more difficulty in this area. The lack of encouragement in education is perceived by both male and female respondents.

Table 3. 'I was able to effectively access information about how to access the cybersecurity industry'

	Women (count and percent)	Men (count and percent)
Strongly Disagree	2 (3.3%)	10 (8.2%)
Disagree	22 (36.7%)	18 (14.8%)
Neither Disagree Nor Agree	12 (20%)	41 (33.6%)
Agree	22 (36.7%)	50 (41%)
Strongly Agree	2 (3.3%)	3 (2.5%)

Figure 3. 'I was able to effectively access information about how to access the cybersecurity industry'

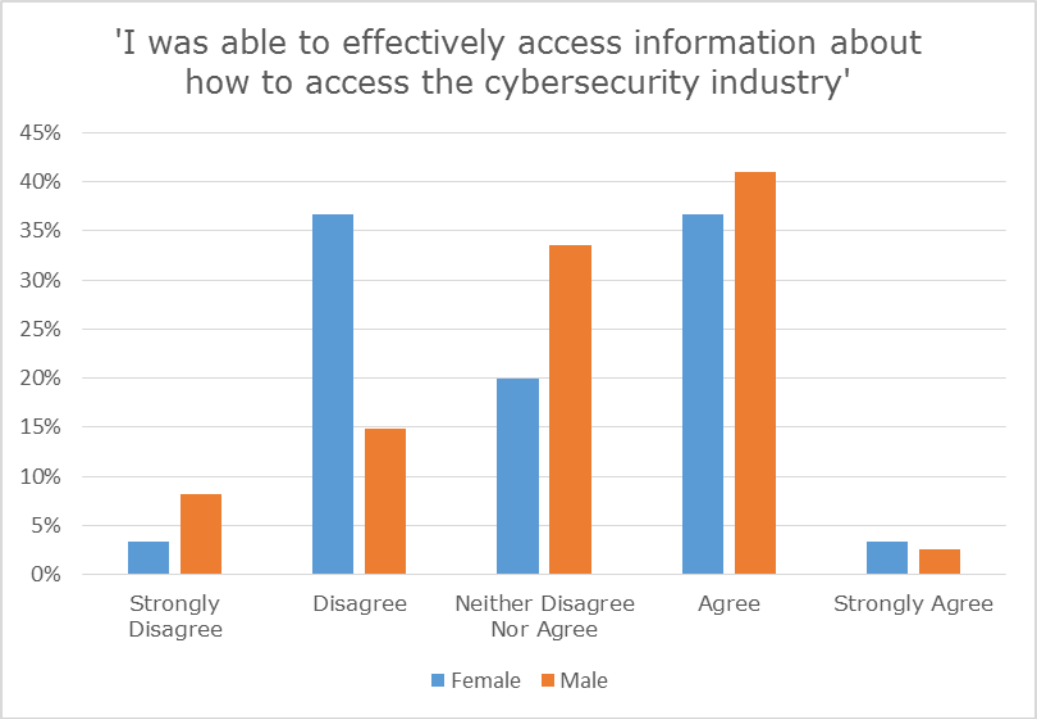

Table 4. 'Men and women are equally valued in my industry'

	Women (count and percent)	Men (count and percent)
Strongly Disagree	7 (11.1%)	4 (3.1%)
Disagree	25 (39.7%)	21 (16%)
Neither Disagree Nor Agree	11 (17.5%)	28 (21.4%)
Agree	16 (25.4%)	53 (40.5%)
Strongly Agree	4 (6.3%)	25 (19.1%)

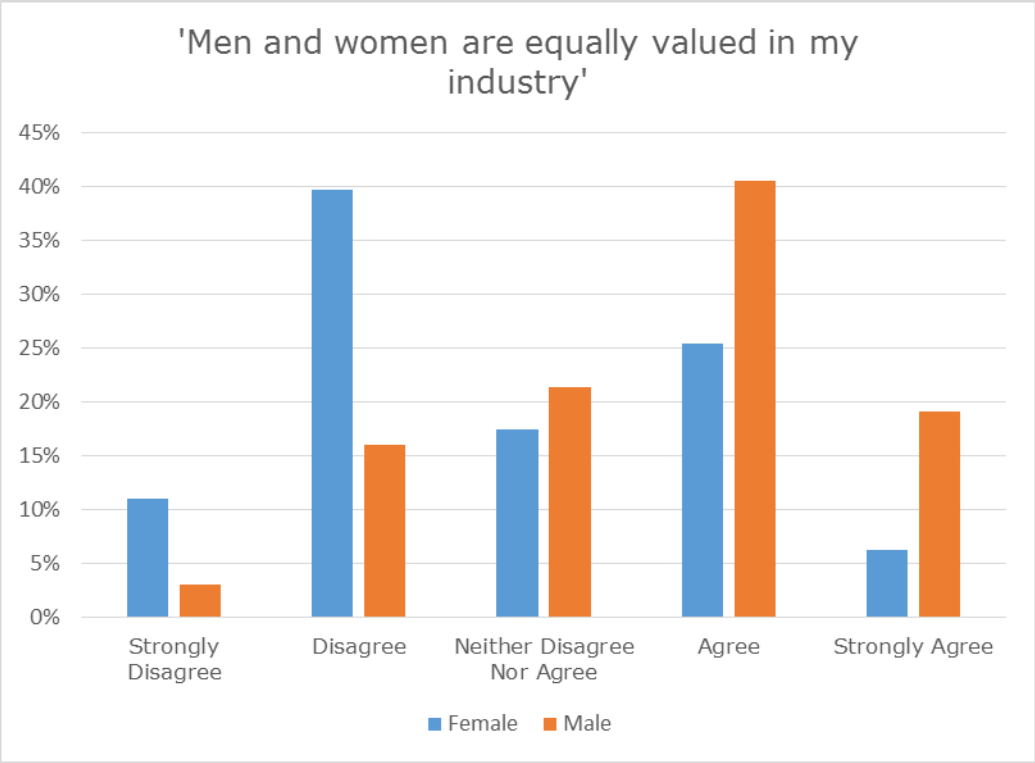

Figure 4. 'Men and women are equally valued in my industry'

Table 4 however shows that there is a clear difference in male and female perceptions of whether both genders are equally valued within the industry. 31.7% of female respondents (n=20) agree that men and women are equally valued within the industry while 59.6% of male respondents (n=78) agreed (p=0.00).

While there is strong agreement that men and women are equally valued in the industry it is important to note that this was stronger among male respondents. The qualitative comments reveal that gender discrimination occurs. One respondent suggests that women in the industry may be subject to practices of positive discrimination whilst simultaneously revealing negative stereotypical assumptions about women's competencies and behaviour. *"The women never attract the blame for security failure, again, because of their gender and they won't be singled out as a 'soft target'; the senior personnel wouldn't dare! Women don't handle high pressure security incidents well and frequently come over as aggressive and point-*

scoring" (respondent 55). Respondent 34 states that she feels that she has *"…to try and be the right kind of woman to get ahead".*

Table 5 shows that only 15.9% (n=10) of female respondents agreed or strongly agreed that men and women are equally likely to be promoted to senior positions; men were more than 3 times as likely to agree or strongly agree (47.7% (n=62) of male respondents (p=0.00)). This reveals that there is the clear perception among respondents that there is inequality in promotion opportunities, and that the problem is perceived to be worse by women than it is by men.

Table 5. 'Men and women are equally likely to be promoted to senior positions in cybersecurity'

	Women (count and percent)	Men (count and percent)
Strongly Disagree	14 (22.2%)	5 (3.8%)
Disagree	24 (38.1%)	25 (19.2%)
Neither Disagree Nor Agree	15 (23.8%)	38 (29.2%)
Agree	7 (11.1%)	42 (32.3%)
Strongly Agree	3 (4.8%)	20 (15.4%)

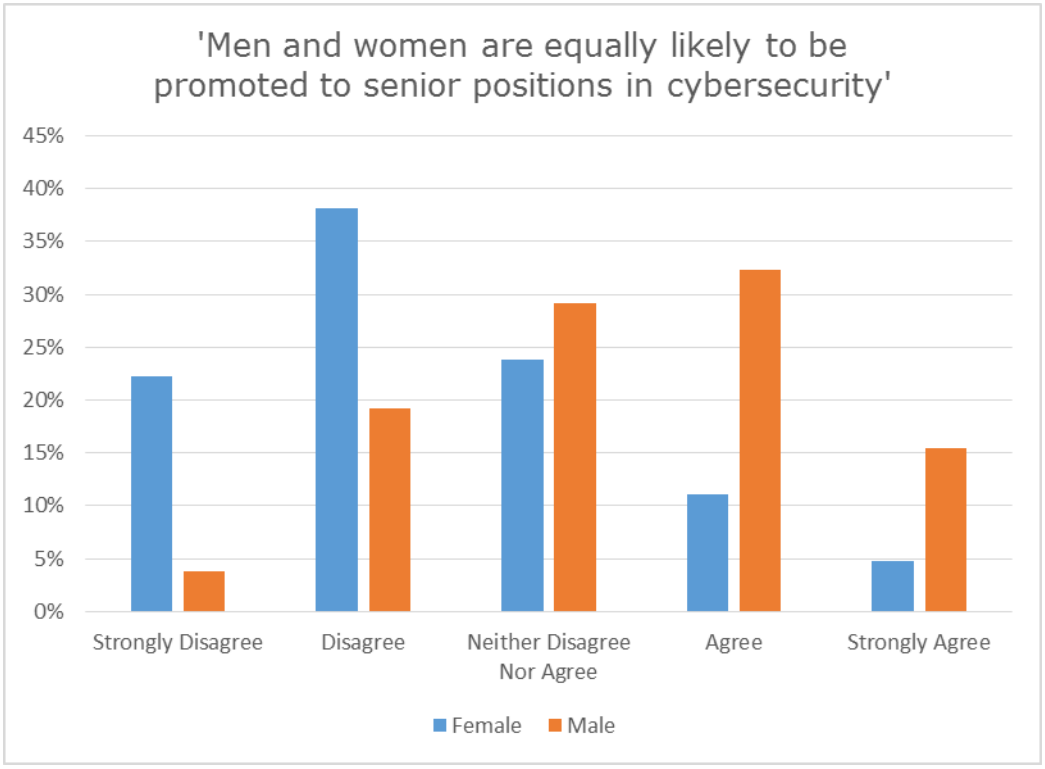

Figure 5. 'Men and women are equally likely to be promoted to senior positions in cybersecurity'

These perceived inequalities and opportunities may be attributed to the perception that cybersecurity roles are seen as 'men's jobs' within the industry, by customers

and clients, and also more widely by society as shown in Tables 6 - 8 below. Customers and clients are believed to display this prejudice, but less strongly than within the industry, with the highest levels of prejudice perceived to be within wider society.

As shown in Table 6 and Figure 6, there is the significant (p=0.00) perception among the respondents that cybersecurity jobs are seen as 'men's jobs' within the industry (a total of 53.9% agree or agree strongly, n=103), although this perception is significantly stronger among women than among men with 74.2% (n=44) of female respondents agreeing or strongly agreeing with the statement compared against 43.9% (n=57) of male respondents.

Table 6. 'Cybersecurity roles are seen as "men's jobs" within the industry'

	Women (count and percent)	Men (count and percent)
Strongly Disagree	0 (0%)	9 (6.9%)
Disagree	8 (12.9%)	36 (27.7%)
Neither Disagree Nor Agree	8 (12.9%)	28 (21.5%)
Agree	33 (53.2%)	50 (38.5%)
Strongly Agree	13 (21%)	7 (5.4%)

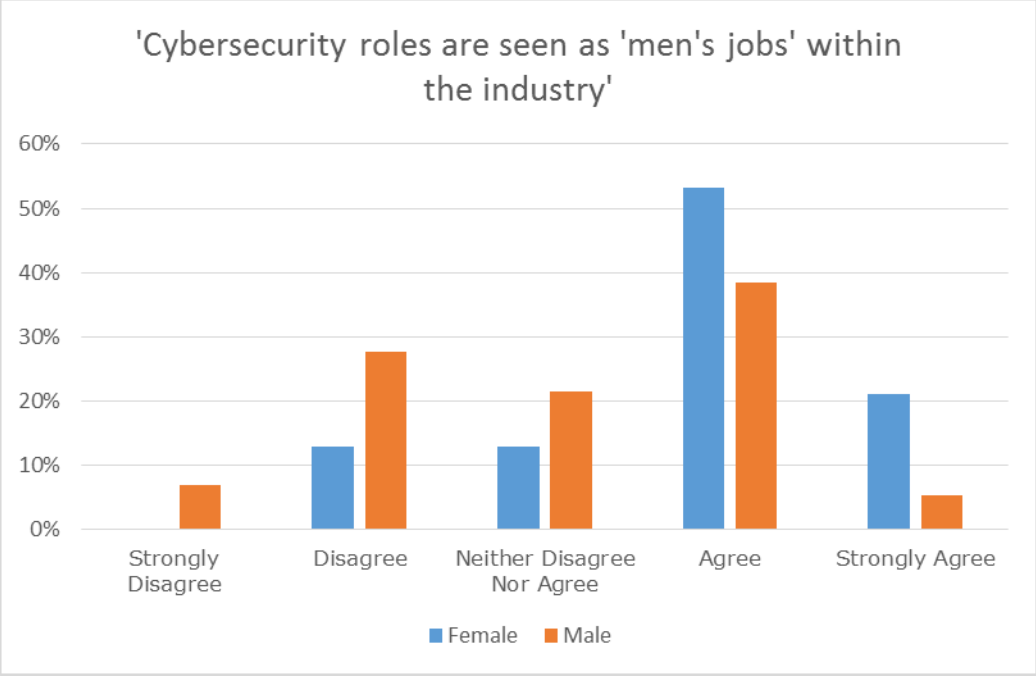

Figure 6. 'Cybersecurity roles are seen as "men's jobs" within the industry'

Table 7 shows that there is the significant (p=0.00) perception that cybersecurity jobs are seen as 'men's jobs' by customers and clients. This perception is stronger among females than among males with 66.2% (n=41) of female respondents agreeing or strongly agreeing with the statement compared against 36.6% (n=48) of the men.

Table 7. 'Cybersecurity roles are seen as "men's jobs" by customers and clients'

	Women (count and percent)	Men (count and percent)
Strongly Disagree	0 (0%)	9 (6.9%)
Disagree	5 (8.1%)	32 (24.4%)
Neither Disagree Nor Agree	16 (25.8%)	42 (32.1%)
Agree	29 (46.8%)	43 (32.8%)
Strongly Agree	12 (19.4%)	5 (3.8%)

Figure 7. 'Cybersecurity roles are seen as "men's jobs" by customers and clients'

As shown in Table 8 there is the significant (p=0.00) perception that cybersecurity jobs are seen as 'men's jobs' in society, again, this perception is significantly stronger among female respondents than among male respondents with 84.1% (n=53) of female respondents agreeing or strongly agreeing with the statement compared with 53.4% (n=70) of male respondents.

Table 8. 'Cybersecurity roles are seen as "men's jobs" in society'

	Women (count and percent)	Men (count and percent)
Strongly Disagree	0 (0%)	7 (5.3%)
Disagree	2 (3.2%)	20 (15.3%)
Neither Disagree Nor Agree	8 (12.7%)	34 (26%)
Agree	41 (65.1%)	59 (45%)
Strongly Agree	12 (19%)	11 (8.4%)

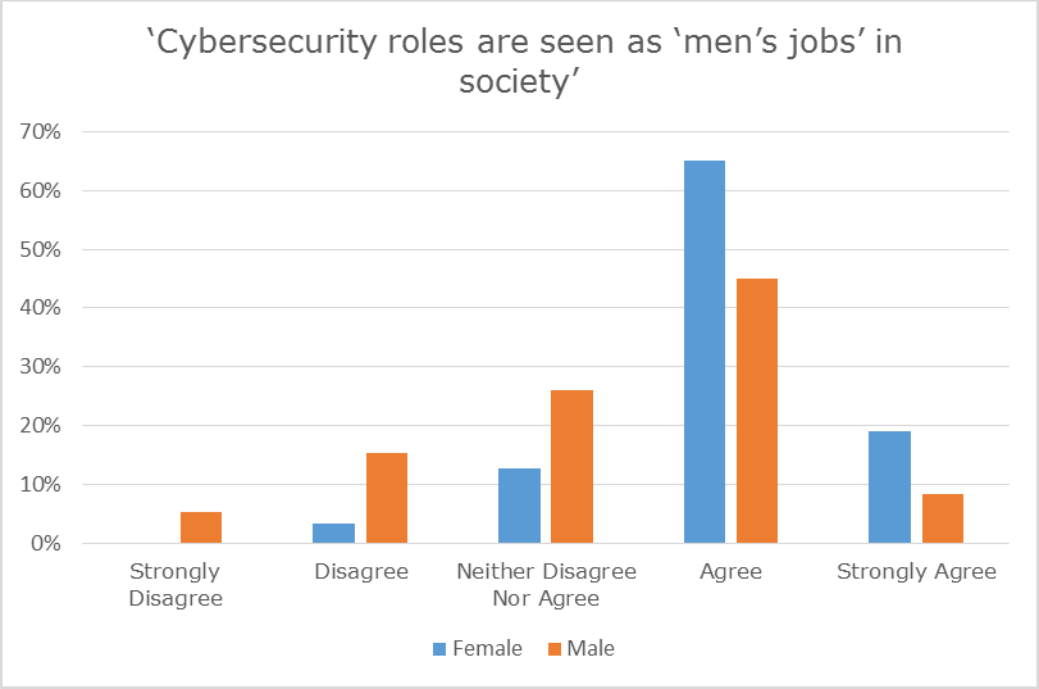

Table 8. 'Cybersecurity roles are seen as "men's jobs" in society'

The perception indicated in Tables 7 and 8 is that there is more gender stereotyping apparent in wider society than within the industry. This would appear to conflict with the demographic data relating to gendered distribution of job roles inside the industry, and may also be a contributory factor to reinforcement of the inequality within the industry; employers may be reluctant to employ people who they perceive not to fit with the customer or clients perceptions regarding who typically conducts these roles.

Overall, there is perceived to be gender difference in careers advice and guidance offered and availability of information and support, there is perceived inequality in recruitment and promotion, and it is also suggested that there is gendered stereotyping in relation to job roles. The inequalities that are perceived in these areas are considered to be greater by the female respondents; women may have a higher level of awareness of inequality within the industry as they are more likely to have experienced it directly.

DISCUSSION

It has been previously suggested that girls do not aspire to employment in technology professions because of wider social constructions of gender impacting on their identity (Macdonald, 2014; techwomenuk, 2015a; 2015b). This is thought to be because security is a male domain (Romaniuk and Wasylciw, 2010) and because *"technology is firmly coded male"* (Bray, 2007, p.38). The masculinisation of both security and technology have led to lower numbers of women in cybersecurity than in other IT professions.

Denner (2011: 56) stated that *"high school girls who express interest in a computing career are more likely to believe their parents support this choice".* Women in this study were more than twice as likely as the men to report that they were encouraged by their family to do computer security work. It must be noted that this is within a sample of respondents who self report working within the industry presently or recently, and therefore indicates that women may need more encouragement from their families than men in order to choose to enter cybersecurity, and not necessarily that women in the wider population are subject to higher levels of familial support than men. It is notable that there was no difference perceived by either gender in levels of encouragement in education, suggesting that familial support may be of more importance in encouraging entry to computer security work than educational support. Despite this perceived parity in encouragement, there is still work to be done within the education system, and by the industry, as the respondents to this study reported significant differences in their ability to access information about how to enter the industry, with women being almost twice as likely to disagree that they were able to do this effectively. This reflects previous suggestions that there is a lack of appropriate careers education relating to technology careers (techwomenuk, 2015a; Macdonald, 2014). It is essential that the perceptions of young women in relation to careers in cybersecurity are challenged. Rather than being 'geeky' (WSS, 2013), or 'nerdy' (Valenduc, 2011) this study has shown that cybersecurity work is perceived by employees within the field to be interesting, exciting, and challenging.

This study has found that there are significant gender differences in perception of equality of opportunity in entering the profession. This finding is of importance due to the male-dominated nature of the industry; if men, who are likely to make up the majority of senior staff and management, do not perceive that there is inequality they are unlikely to take steps to increase equality in this area. According to WSS (2013) the inequality in recruitment opportunities may be due to 'like for like' recruiting patterns, whereby men recruit other men. The lack of perceived equality in access to information and in recruitment revealed by the survey data may also go some way to explaining why such low numbers of women enter the industry.

What is also of concern is that there is the perception that men and women are not equally likely to be promoted to senior positions. This may be suggestive that there is not only an issue around recruitment, but also around retention, as women may feel more inclined to leave an industry where they are unable to advance their career progression and where they suffer pay disparity (LeClair, Shih and Abraham, 2014). Valenduc (2011) describes the situation not as only a 'glass ceiling' but also as a 'sticky floor' pointing out that pay inequality in ICT begins at the recruitment stage, with males being contracted on higher salaries than female counterparts with equal skills, knowledge and experience. There was strong agreement in this study that 'anyone with the right skills and attributes can work in computer security'. Despite this, the respondents showed a clear gendered difference in their perceptions of whether men and women are equally valued within the industry, with men almost twice as likely to report that they perceived equality in this area, and less than one third of women agreeing. This raises questions about what exactly

the 'right skills and attributes' are, and also the suggestion that the 'right skills and attributes' may be those that are perceived to be masculine traits.

There is a clear perception that women are not equally likely to be promoted to senior positions as men. Women perceived heightened inequality in progression opportunities compared to men which is of concern as less than half of the male respondents agreed that they perceived there to be equality in this area. Whilst this may reflect the pattern in the wider ICT industry, the effect is magnified in cybersecurity, possibly because there are so few women in the sector. This may also be in part due to *"the current construction of the male as protector and the woman as dependant"* (Romaniuk and Wasylciw, 2010, p.26) which then precludes women from being valued equally in a predominantly masculinised industry.
The key findings presented here raise particular issues that are suggestive of the need for further research, particularly given the very limited available literature that is specific to cybersecurity. Parents' perceptions, teachers' perceptions, and careers advisors' perceptions of ICT and cybersecurity, and the impact of these perceptions upon young people's career aspirations should be further investigated.

CONCLUSIONS

There is an under-representation of women in cybersecurity jobs worldwide; addressing this issue will contribute to tackling the global skills shortage in the sector. This is of importance to the industry, and to society, in order to deal with the growing threat posed by cybercrime. Perhaps more importantly, it is a matter of social justice that there should be equality of opportunity in access to and progression within a well-paid and intellectually stimulating work environment.

In order to encourage female participation there is a need for an increase in female role models to encourage an increase by reducing the likelihood of 'non-STEM' identity development. Given the importance of familial support towards entering the industry for girls and women, and the early stage at which girls have been found to form STEM or non-STEM identities, possible future solutions may be in educating parents and families about the opportunities that computing and cybersecurity can offer to their daughters in terms of the exciting, interesting, creative, varied, and stimulating nature of the work.

In order to ensure that there is the flow through of female participants in cybersecurity there is a need to encourage girls and young women at school, in further education and in higher education to study the computing disciplines and to further provide the opportunity to focus on cybersecurity opportunities. It is also clear that the industry must work to reduce the impact of, and perception of a "sticky floor" and a "glass ceiling" in terms of opportunities for progression and pay in order to increase the likelihood that women will enter the industry, and that those who do enter the industry will choose to stay.

The causes of gender inequality in cybersecurity are complex. The roots of inequality are found within social constructions of gender, within wider society, within families, within education, and within the ICT, security and cybersecurity industries. Any attempts to reduce the gender gap will take time, and will need to

tackle the problem from all of these angles in order to provide a solution. It is time for the perception that cybersecurity is 'for boys' to be challenged so that the industry can fill its skills shortage, so that girls can access an exciting and stimulating career, and so that society is better equipped to deal with the growing threat posed by cybercrime.

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