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A STUDY OF ATTITUDES RELATED TO THE USE OF CYBER-WARFARE

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ABSTRACT

Cyber-warfare is a growing issue that needs to be addressed at the highest levels of government. It is an area that is always changing and evolving, and understanding the opinions of the general public is extremely important as the use of cyber-warfare increases and policies are implemented. This study is the start of a conversation about how and when the public believes that cyber-warfare use is acceptable. The first two chapters contain a short background of cyber-warfare and a review of the limited literature available in this area. It then examines how knowledgeable individuals are about the cyber-warfare environment. Finally, the study examines how the factors of gender, age, military service history, and technical skill level affect the opinions and perceptions of participants.

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Chapter 1

Purpose

Cyber-warfare is an issue that continues to grow and affect almost every government, public, and private entity. Cyber-warfare can be broadly defined as:

> …Warfare waged in cyberspace. It can include defending information and computer networks, deterring information attacks, as well as denying an adversary's ability to do the same. It can include offensive information operations mounted against an adversary, or even dominating information on the battlefield. (Hildreth, 2001)

Even with a rise in prevalence of this issue, little research has been done to see how the general public understands and feels about cyber-warfare and its many potential uses. It is important to understand these points as they influence everything from personal action to public policy. Learning what factors mold the knowledge and opinions of people can help correct common misconceptions. This study will attempt to provide insight into some of the above issues as well as start a conversation about cyber-warfare education, opinion, and policy making.

As an undergraduate student studying information technology and cyber security, I have developed an interest in cyber-warfare issues. Since starting school, cyber-warfare events have come to the front page. In 2007, Estonian websites were attacked, bringing down portions of the government and banking industry. In 2009, communications were crippled in the nation of Georgia by a coordinated cyber attack. This attack coincided with a conventional invasion by Russian ground forces. Most recently, StuxNet has changed the playing field again. The first known instance of a cyber-weapon with a specific target, StuxNet marked an interesting evolution in the cyber-warfare environment. Cyber-warfare is ever evolving and it is important, now more

than ever, to understand how the public learns and forms opinions about key cyber-warfare issues.

Chapter 2

Cyber-Warfare Background

Cyber-warfare is a broad field that encompasses many different areas and attack strategies. Related areas include cyber terrorism, hacking, malware and spyware, and industrial espionage. Many of these areas overlap. This will be discussed in more detail in this chapter.

There are many different strategies that a government or other entity can use to conduct a cyber-warfare attack. One of the most common attack types is a denial of service, or DoS, attack. The Computer Emergency Response Team at Carnegie Mellon University defines a DoS attack as "an explicit attempt by attackers to prevent legitimate users of a service from using that service" (CERT, 2001). DoS attacks can be conducted by flooding networks with traffic, disrupting individual connections between two machines, or disrupting access to an individual or system. Consumption of finite resources such as network bandwidth or processor time is one of the most common techniques used in a DoS attack.

Botnets are a common tool used by attackers when executing a DoS attack. A botnet is a network of compromised machines that is controlled by one or more central hosts. The compromised machines, or bots, contain malware that listens for instructions from the host machine. When a bot receives its instructions, it executes its program and commences the attack. In the case of a DoS attack, this usually means that the botnet attempts to consume all of the network resources of a given target by constantly attempting to open new connections. This limits or eliminates legitimate access to and use of the system.

Another strategy that can be used in cyber-warfare is the targeting of critical infrastructure such as communication, power, or transportation systems. Disabling the functionality of these systems can cripple a target and limit its capability to respond. A March

2007 experiment conducted by the United States Department of Homeland Security proved just how vulnerable critical infrastructures can be when hired hackers were able to destroy an electric generator from a remote location (Meserve, 2007).

Other cyber-warfare strategies include cyber vandalism, propaganda dissemination, industrial espionage, and data gathering. Cyber-warfare continues to evolve today as the list of tools, targets, and strategies is constantly changing. In addition to this evolution, incidents of cyber-warfare are also on the rise. According to the Emerging Cyber Threats Report for 2009, published by the Georgia Tech Information Security Center (2008), this is due to low costs of launching a cyber attack, plausible deniability, a lack of cyber defenses, and a lack of rules of engagement governing cyberspace.

Cyber-warfare is not a new phenomenon. The United States has been under attack for over ten years. In October 1999, the Department of Defense revealed Moonlight Maze. Moonlight Maze was a series of attacks on various government systems by hackers traced to Russia (Drogin, 1999). In 2005, the United States government again revealed that it had been under attack for the last three years, this time from attackers in China, in an event titled Titan Rain (Graham, 2005).

The United States has not been the only target of cyber-warfare. Beginning on April 27, 2007, the nation of Estonia suffered massive distributed DoS attacks that prompted many officials to declare Estonia as the victim of the first virtual war. Government, school, media, and banking systems were targeted. The attacks were launched soon after the Estonians removed a Soviet-era statue from a city square. All evidence points to Russian involvement but this cannot be proven due to the plausible deniability, or the inability to determine or confirm responsibility, that exists on the internet (Myers, 2007).

August 2008 marked another milestone in the evolution of cyber-warfare. When Russia launched traditional air and ground attacks against the nation of Georgia, a nearly simultaneous

cyber-war was launched as well. This marked one of the first known times that cyber-warfare was used to increase the effectiveness of a kinetic attack. The attackers chose targets that would cripple communications systems and limit the nation's ability to respond to the physical attack. Early evidence pointed directly to the Russian military as the entity responsible for the attack. However a United States Cyber Consequences Unit (US-CCU) (2009) investigation revealed that the distributed DoS attack was actually launched by coordinated private citizens who sympathized with the Russians. However the US-CCU did believe that there was military involvement with publication of vulnerabilities and tools as well as with timing the attack.

First discovered in July 2010, the Stuxnet worm may mark the true beginning of the era of cyber-warfare (Chen, 2010). Unlike previous worms, Stuxnet chooses its targets based on a very specific system signature, including a particular programmable logic controller. This targeting indicates that the goal of the malware is to control, and potentially destroy, mechanical infrastructure. Stuxnet also is extremely sophisticated for malware due to its complexity, stealth use of zero-day exploits, infection vector, and use of unpublished inside knowledge. This sophistication and the evidence that it targeted physical infrastructure provide further evidence that Stuxnet may be the first true cyber-weapon (Chen, 2010). A recent report by the BBC revealed that the Stuxnet worm repeatedly targeted five industrial facilities in Iran (Fildes, 2011). The overall success of the Stuxnet worm is unknown as there are different reports coming from industry and the Iranian government.

Chapter 3

Literature review

Direct research into opinions on cyber-warfare issues has been extremely limited. One study by industry security firm Sophos (http://www.sophos.com) provides some insight into the subject. Their study found that sixty-three percent of participants believe cyber espionage between countries is acceptable. However, forty percent of participants believed it was only acceptable in wartime (Sophos Group, 2010). Fifty-six percent believe that using cyber-warfare to disrupt communication or financial systems is acceptable. However, forty-nine percent of participants believe this is only acceptable in wartime (Sophos Ltd., 2010). Fewer respondents believed that countries should be able to target foreign, private companies with cyber-warfare in order to gain an economic advantage. Only thirty-two percent of respondents state that this was acceptable, with twenty- three percent stating that it is acceptable only in wartime (Sophos Ltd., 2010). Fifty-four percent of participants stated that they believed that their country was not doing enough to protect itself from cyber-warfare attacks. Only six percent stated that their country was doing enough to protect itself from attack. The remaining forty percent stated that they did not know if their country was doing enough (Sophos Group, 2010). When asked whether or not an international agreement should be reached regarding what types of cyber-warfare are acceptable, seventy-seven percent stated that they believed that an agreement should be reached (Sophos Group, 2010). These results show that the majority of the population views cyber-warfare as a viable weapon in a country's arsenal. However, they believe that its use should be controlled and that an agreement on acceptable use should be reached by the international community.

Similarities have been drawn between cyber-warfare and nuclear-warfare. In both cases, there are no reliable defenses against the weapons used (Dycus, 2010), and the cost of developing

offensive weapons is much cheaper than developing perfect defensive capabilities (Sulek & Moran, 2009). Also, similar to a nuclear strike, a cyber attack would probably come without a clear warning and the effects could be extremely widespread and indiscriminate (Dycus, 2010). Due to these similarities, it is pertinent to examine existing research into opinions related to nuclear-warfare.

It has been found that, in general, people are pessimistic about the imminence and survivability of nuclear war (Gwartney-Gibbs & Lach, 1991). Gwartney-Gibbs and Lach (1991) showed that women are more significantly more pessimistic about nuclear warfare. Rabow, Hernandez, and Newcomb (1990) also showed that women are more concerned with nuclear issues than men. Women exhibited more fear of, and less denial of, nuclear issues as well as less nuclear support (Rabow, Hernandez, & Newcomb, 1990). Contrary to these findings, Jensen (1987) found that gender was not indicative of support for nuclear armament or the use of nuclear weapons, and was only related to attitudes on military restraint. Schwebel (1990) provides evidence that the cognitive construction of the reality surrounding nuclear war changes with age as comprehension and appreciation of the dangers and safeguards related to nuclear war progress.

An attitude is made up of three components: affective, behavioral, and cognitive (Attitudes and Attitude Change). The affective part of attitude deals with an individual's feelings and evaluations. The way an individual behaves toward the attitude object makes up the behavioral component. The part of attitude addressed by this study is the cognitive part, or the beliefs of the individual. Attitudes are formed in many different ways. People can mimic the attitudes of others or can obtain attitudes through different forms of conditioning. Experiences can also have a direct effect on a person's attitude (Attitudes and Attitude Change). As such, studying factors such as gender, age, and military service could provide insight into how a person's attitudes toward cyber-warfare are formed. It has also been showed that greater exposure to the attitude object, which is cyber-warfare in the case of this study, the more positive

an individual's attitude will be (Attitudes and Attitude Change). People in the military or those with higher technical skill levels have the potential to be exposed to instances of, or areas related to, cyber-warfare. Therefore, studying the factors addressed in this survey may provide greater insight into the formation of attitudes toward cyber-warfare.

Chapter 4

Methodology

This study attempts to analyze people's general knowledge of cyber-warfare, as well as their attitudes toward many current cyber-warfare issues. Data was collected from study participants using a survey delivered online through Qualtrics (http://www.qualtrics.com). Demographics were also collected from respondents as part of the survey. The survey was distributed to respondents through email lists, social networking sites, and classroom visits.

The survey was divided up into three major sections. The first section provided participants with definitions of important terms that they would encounter throughout the survey. This section was included in order to decrease variations in responses that could result from participants using different definitions of these terms. The second section contained knowledge and opinion statements. These are described in more detail in the following paragraphs. The final section collected demographic information from respondents. Gender, age range, military service, and technical skill level of respondents were collected on a voluntary basis. This information was used as independent variables during analysis of the survey results.

All of the knowledge and opinion statements were delivered in the form of a five-point Likert scale. A response of one was labeled as "Strongly Disagree" and a response of five was labeled as "Strongly Agree." A response of three was labeled as "Neither Agree nor Disagree." The first five statements were based on a definition of cyber-warfare set forth by Richard A. Clarke on pages 30 and 31 of his book *Cyber War: The Next Threat to National Security and What to Do About It* (Clark & Knake, 2010). His five-point definition captured many of the important aspects of cyber-warfare, including that it is real, global, happens at the speed of light,

skips the battlefield, and that cyber-warfare has begun. This served as a knowledge check for participants.

The remaining statements focused on opinions relating to cyber-warfare and its potential uses. Some of these statements were based on the questions used in the Sophos study (Sophos Group, 2010) (Sophos Ltd., 2010) discussed above. However, the statements used in this survey broke down the multiple-response possibilities used by Sophos into multiple Likert-scored statements. There were also additional statements not introduced by Sophos dealing with issues such as cyber-warfare strikes on civilian targets, the use of cyber-warfare as preemptive strikes, and the use of cyber-warfare to save lives. The survey appears in its entirety in Appendix A.

A total of 149 responses were started with the online survey tool. 124 of those responses were satisfactorily completed. Satisfactory completion was defined as having seen all questions and click on the final submission button at the end of the online survey. For each question the mean of the answers was compared to a neutral value of three (neither agree nor disagree) using a one-sample t-test to see if the sample was significantly different from the neutral value. The responses were then divided into groups based on the answers to the demographic questions. The mean of the responses for each statement was then compared across the groups within that demographic. Males were compared to females using a two-sample t-test with a pooled standard deviation. The six age groups (18-24, 25-34, 35-44, 45-54, 55-64, 65+) were compared using a one-way ANOVA. Those identifying themselves as serving or having served in the military were compared to those stating they had not served in the military using a two-sample t-test with a pooled standard deviation. The three groups for self-identified technical skill level were compared using one-way ANOVA. If an ANOVA result was found to be significant, further analysis was completed using Tukey's HSD to determine where the difference in mean occurred. Comparing the means across the demographics shows which factors can potentially affect the opinions of an individual regarding cyber-warfare.

Chapter 5

Results

The table below numbers the statements. These numbers will be used to identify the statements for the remainder of the paper and in all further tables. K statements are knowledge statements. E statements deal with the cyber-warfare environment. P statements are related to peacetime use and W statements relate to wartime use. S statements deal with preemptive strikes.

Table 1. Survey Questions

Statement	Number
Cyberwarfare is real	K1
Cyberwarfare happens at the speed of light	K2
Cyberwarfare is global in scale	K3
Cyberwarfare is not conducted on traditional battlefields or against traditional defenses	K4
Cyberwarfare and preparations for future cyber conflicts have begun	K5
My country is doing enough to protect itself from Cyberwarfare Attacks.	E1
There needs to be an international agreement about what types of Cyberwarfare are acceptable	E2
It is acceptable for a country to spy on another country via the internet by hacking or installing malware in times of peace.	P1
It is acceptable for a country to spy on another country via the internet by hacking or installing malware in times of war.	W1
It is acceptable for a country to use Cyberwarfare to disrupt civilian activities in another country in times of peace. This could include power systems, communications, and financial systems.	P2
It is acceptable for a country to use Cyberwarfare to disrupt civilian activities in another country in times of war. This could include power systems, communications, and financial systems.	W2
It is acceptable for a country to spy on another country for economic gain in times of peace.	P3
It is acceptable for a country to spy on another country for economic gain in times of war.	W3
It is acceptable to use Cyberwarfare to attack civilian targets (e.g. power grids) when the goal is to disrupt military operations in times of peace.	P4
It is acceptable to use Cyberwarfare to attack civilian targets (e.g. power grids) when the goal is to disrupt military operations in times of war.	W4
It is acceptable to use Cyberwarfare in a preemptive strike against a purely military target.	S1
It is acceptable to use Cyberwarfare in a preemptive strike against civilian targets.	S2
It is acceptable to use Cyberwarfare in conjunction with standard, kinetic warfare in order to minimize loss of life.	W5
It is acceptable for countries to prepare for Cyberwarfare by hiding cyber weapons, exploits, and backdoors in the systems of other countries, even when there are no signs of impending conflict.	E3
I would be personally affected if an act of Cyberwarfare was carried out against my country.	E4

Statistical analysis using a one-sample t-test (H_o: $\mu=3$, H_a: $\mu\neq3$, $\alpha=0.05$) rejected the null hypothesis for all but three statements (W2, W3, and W4).

Table 2. Statistical analysis of overall responses

Statement	N	Mean	Standard Deviation	t	p
K1	124	4.556	0.616	28.13	0.000
K2	124	3.685	1.007	7.57	0.000
K3	124	4.419	0.745	21.21	0.000
K4	124	4.234	1.037	13.25	0.000
K5	124	4.161	0.859	15.05	0.000
E1	124	2.629	0.831	-4.79	0.000
E2	124	3.355	1.191	3.32	0.001
E3	124	2.613	1.221	-3.53	0.001
E4	124	3.976	0.975	11.15	0.000
P1	124	2.411	1.169	-5.61	0.000
P2	124	1.492	0.770	-21.81	0.000
P3	124	1.831	1.002	-12.99	0.000
P4	124	1.613	0.793	-19.48	0.000
W1	124	3.589	1.230	5.33	0.000
W2	124	2.831	1.389	-1.35	0.178
W3	124	2.831	1.458	-1.29	0.199
W4	124	3.153	1.414	1.20	0.231
W5	124	4.129	0.928	13.55	0.000
S1	124	3.573	1.191	5.36	0.000
S2	124	1.895	0.986	-12.48	0.000

All five of the knowledge-based statements (K1-5) had a significant result on the agreement side of the scale (greater than three). K1, K3, K4, and K5 had means between four (agree) and five (strongly agree) with the mean response to statement K2 falling midway between three and four. The T and p-values for the statements can be found in the accompanying table.

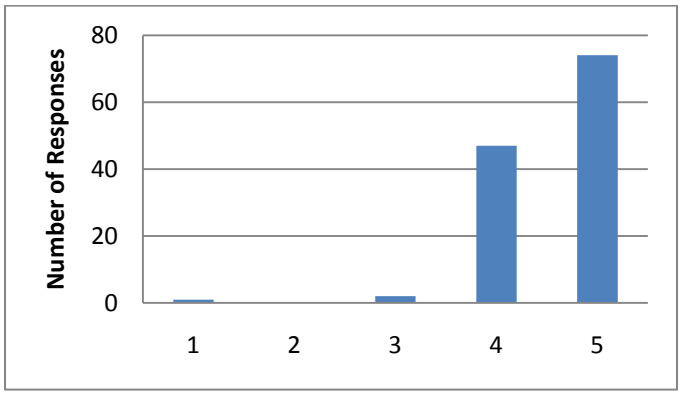


Figure 1. Histogram of responses to statement K1: Cyberwarfare is real

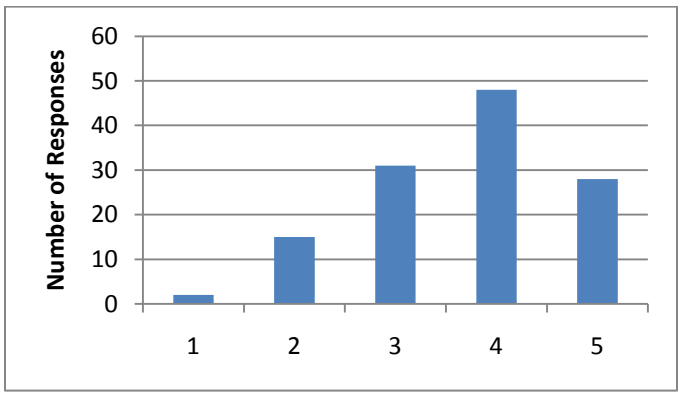


Figure 2. Histogram of responses to statement K2: Cyberwarfare happens at the speed of light

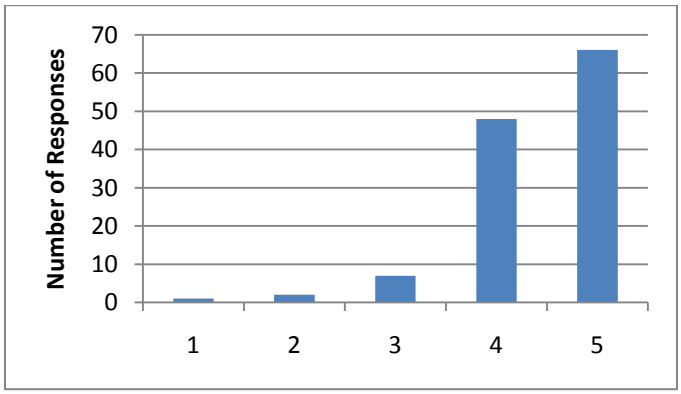


Figure 3. Histogram of responses to statement K3: Cyberwarfare is global in scale

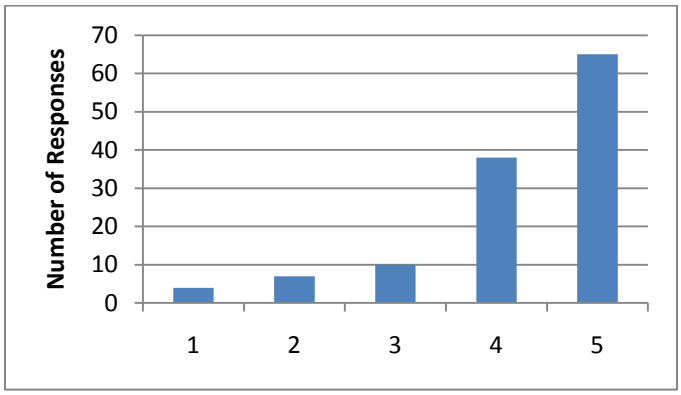


Figure 4. Histogram of responses to statement K4: Cyberwarfare is not conducted on traditional battlefields or against traditional defenses

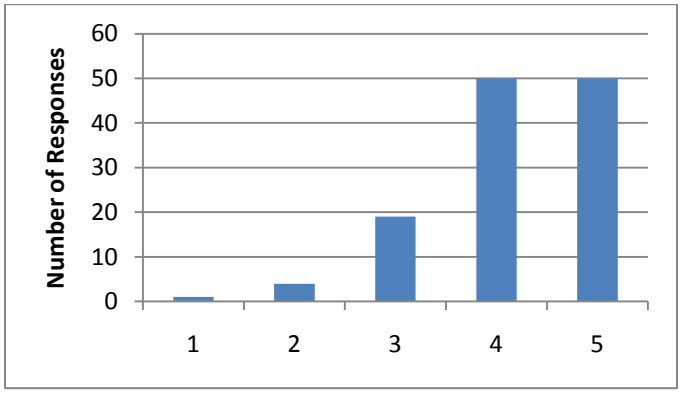


Figure 5. Histogram of responses to statement K5: Cyberwarfare and preparations for future cyber conflicts have begun

Visual analysis of the distributions of responses for these five statements supports the results of the statistical analysis. All five of the histograms show distributions that are strongly weighted toward the agree side of the Likert scale.

As stated earlier, statistical analysis produced a significant result for all but three of the opinion and situational questions. Statements E2, E4, W1, W5, and S1had significant results on the agreement side of the Likert scale. T and p-values can be found in the table earlier in this chapter.

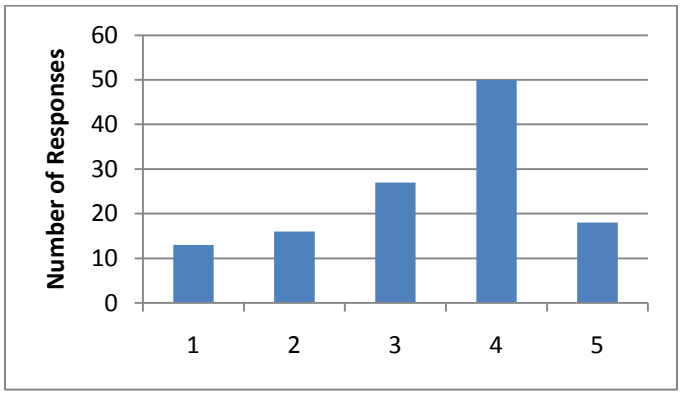


Figure 6. Histogram of responses to statement E2: There needs to be an international agreement about what types of Cyberwarfare are acceptable

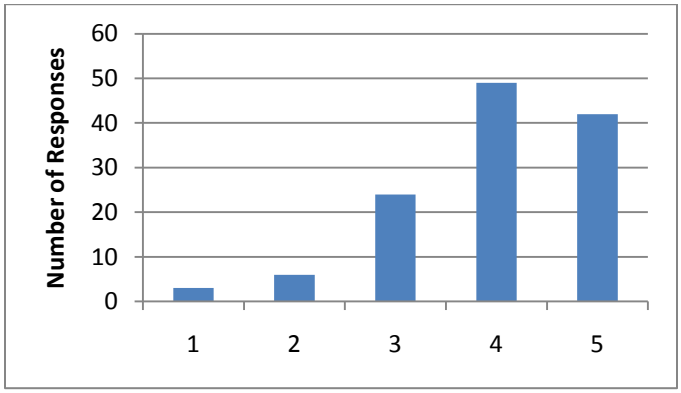


Figure 7. Histogram of responses to statement E4: I would be personally affected if an act of Cyberwarfare was carried out against my country

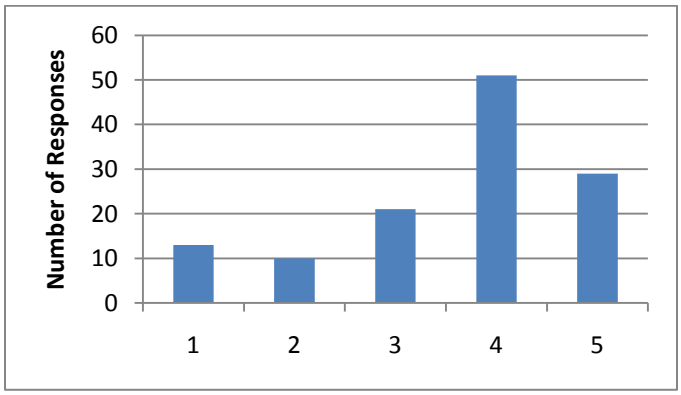


Figure 8. Histogram of responses to statement W1: It is acceptable for a country to spy on another country via the internet by hacking or installing malware in times of war

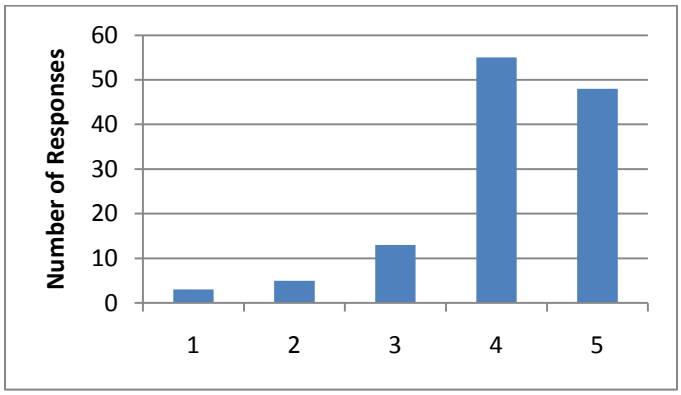


Figure 9. Histogram of responses to statement W5: It is acceptable to use Cyberwarfare in conjunction with standard, kinetic warfare in order to minimize loss of life

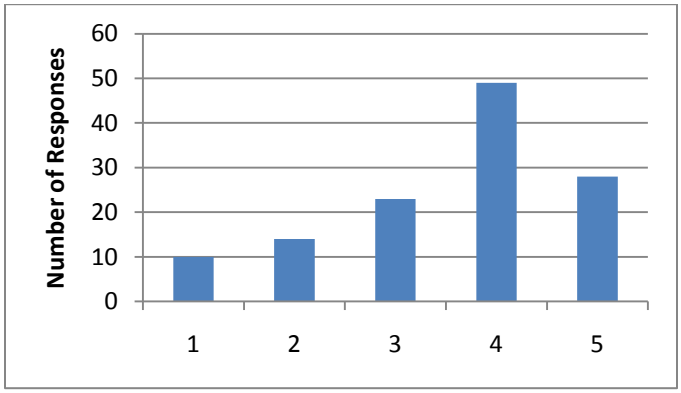


Figure 10. Histogram of responses to statement S1: It is acceptable to use Cyberwarfare in a preemptive strike against a purely military target

Visual analysis of the distribution of the results supports the results of the statistical analysis. In all cases, the most common response was "agree" and the distributions were skewed toward the agreement side of the scale.

Statistical analysis of statements E1, E3 P1, P2, P3, P4, and S2 showed a significant result on the disagree side of the scale.

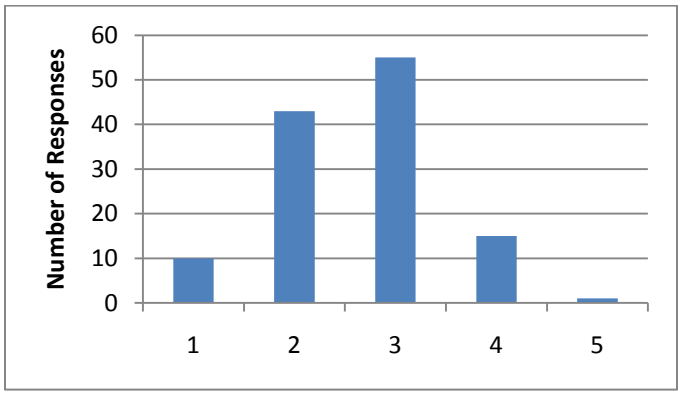


Figure 11. Histogram of responses to statement E1: There needs to be an international agreement about what types of Cyberwarfare are acceptable

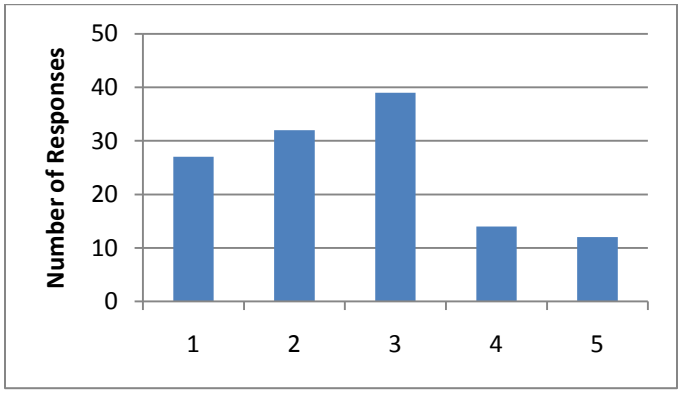


Figure 12. Histogram of responses to statement E3: It is acceptable for countries to prepare for Cyberwarfare by hiding cyber weapons, exploits, and backdoors in the systems of other countries, even when there are no signs of impending conflict

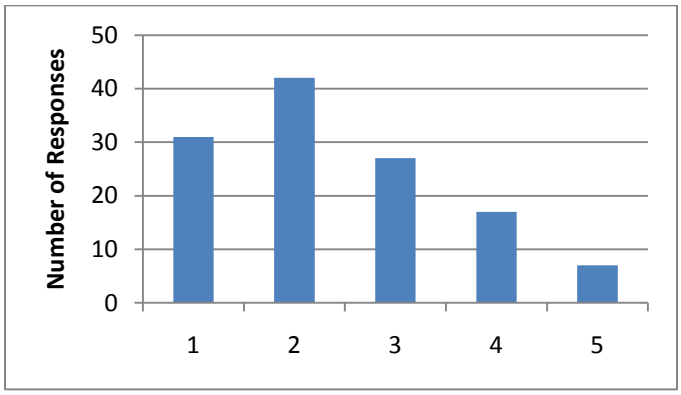


Figure 13. Histogram of responses to statement P1: It is acceptable for a country to spy on another country via the internet by hacking or installing malware in times of peace

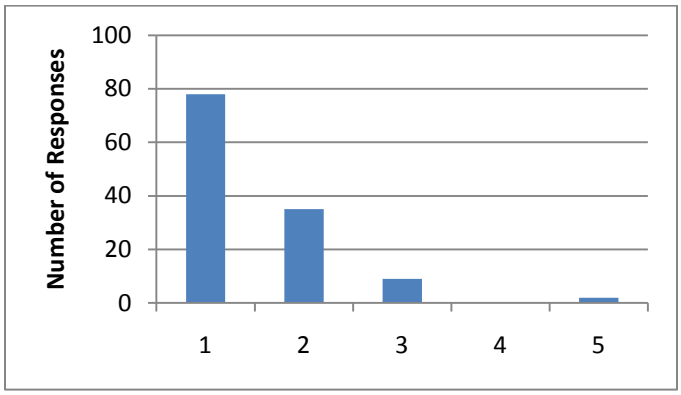


Figure 14. Histogram of responses to statement P2: It is acceptable for a country to use Cyberwarfare to disrupt civilian activities in another country in times of peace. This could include power systems, communications, and financial systems

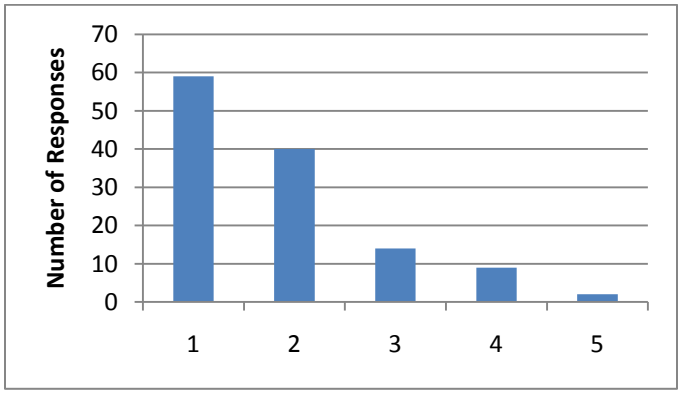


Figure 15. Histogram of responses to statement P3: It is acceptable for a country to spy on another country for economic gain in times of peace

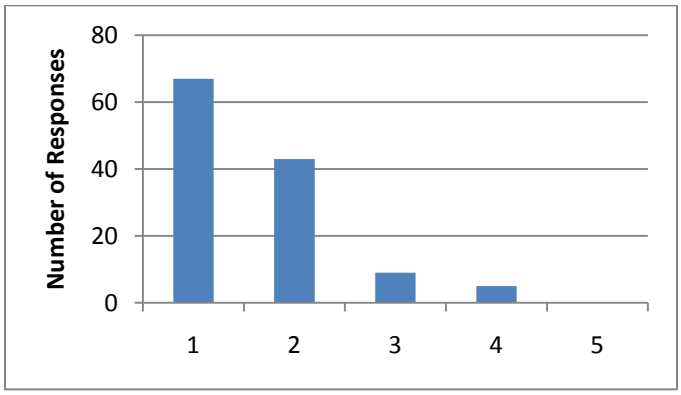


Figure 16. Histogram of responses to statement P4: It is acceptable to use Cyberwarfare to attack civilian targets (e.g. power grids) when the goal is to disrupt military operations in times of peace

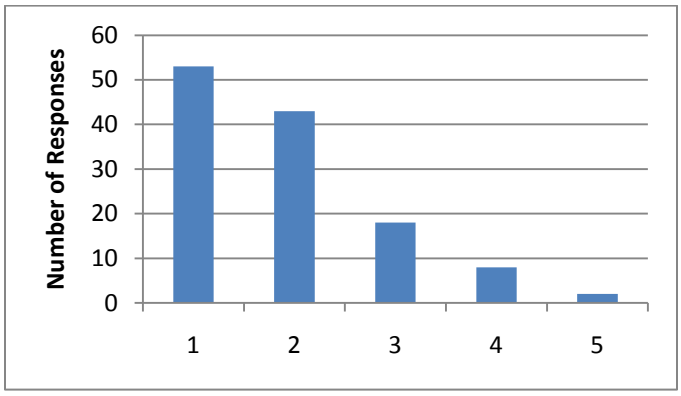


Figure 17. Histogram of responses to statement S2: It is acceptable to use Cyberwarfare in a preemptive strike against civilian targets

Visual analysis of the distribution of the responses reveals that the statistical analysis may not tell the whole story. For both statement E1 and E3, the most common answer was neither agree nor disagree. The number of agree and disagree responses for these questions are, however, much lower than the number of disagree and strongly disagree responses.

The statistical analysis of the responses to statements W2, W3, and W4 did not yield a significant result. Visual analysis of the distributions of these responses to these statements reveals flatter distributions that have roughly the same number of responses on the disagreement and agreement side of the scale.

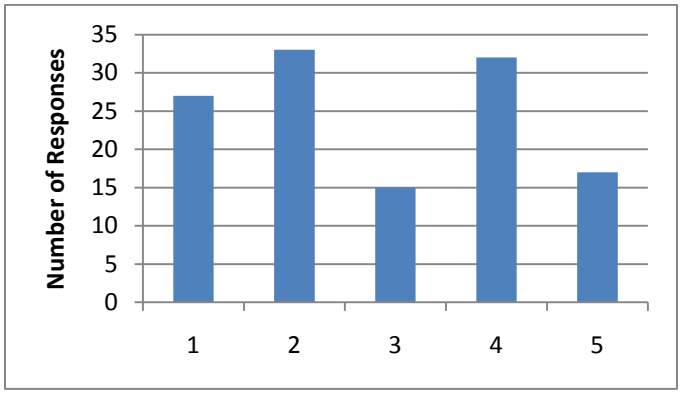


Figure 18. Histogram of responses to statement W2: It is acceptable for a country to use Cyberwarfare to disrupt civilian activities in another country in times of war. This could include power systems, communications, and financial systems

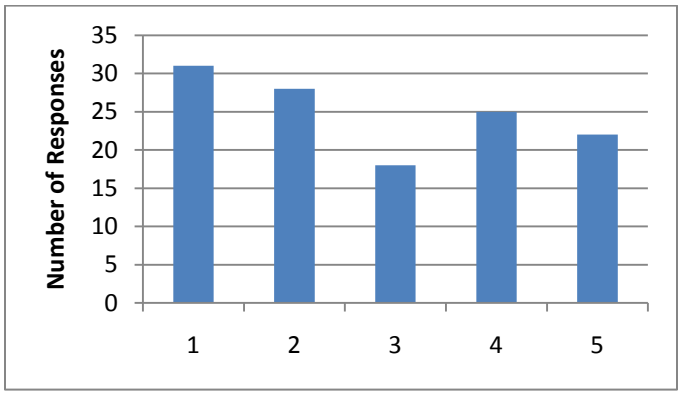


Figure 19. Histogram of responses to statement W3: It is acceptable for a country to spy on another country for economic gain in times of war

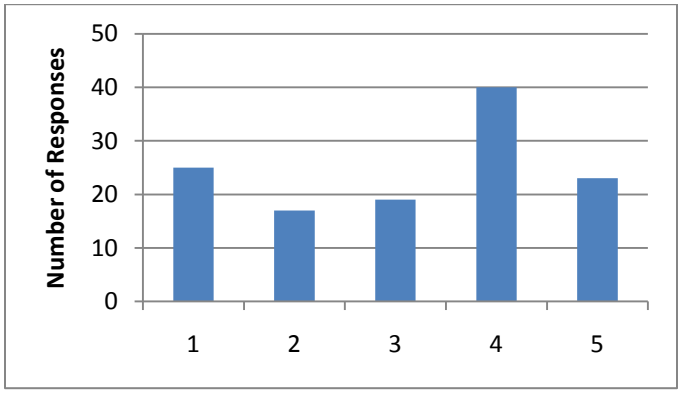


Figure 20. Histogram of responses to statement W4: It is acceptable to use Cyberwarfare to attack civilian targets (e.g. power grids) when the goal is to disrupt military operations in times of war

Gender Factor

Statistical analysis of the gender factor was conducted using a two sample t-test (H_o: $\mu_{Male}=\mu_{Female}$, Ha: $\mu_{Male}\neq\mu_{Female}$, $\alpha=0.05$) with a pooled standard deviation. This analysis rejected the null hypothesis for nine statements: K1, P1, P2, P3, W1, W2, W3, W5, and S1. The T and p-values for all statements can be found in the following table.

Table 3. Statistical analysis of gender factor

Statement		N	Mean	Standard Deviation	Pooled Standard Deviation	t	p
K1	Male	60	4.700	0.462	0.6032	2.49	0.014
	Female	63	4.429	0.712			
K2	Male	60	3.70	1.06	1.0144	0.18	0.857
	Female	63	3.667	0.967			
K3	Male	60	4.483	0.748	0.7475	0.88	0.383
	Female	63	4.365	0.747			
K4	Male	60	4.27	1.01	1.0446	0.32	0.747
	Female	63	4.21	1.08			
K5	Male	60	4.250	0.876	0.8618	1.10	0.274
	Female	63	4.079	0.848			
E1	Male	60	2.583	0.869	0.8344	-0.66	0.508
	Female	63	2.683	0.800			
E2	Male	60	3.15	1.29	1.1831	-1.83	0.070
	Female	63	3.54	1.08			
E3	Male	60	2.68	1.27	1.2282	0.57	0.568
	Female	63	2.56	1.19			
E4	Male	60	3.97	1.13	0.9827	-0.10	0.924
	Female	63	3.984	0.813			
P1	Male	60	2.67	1.27	1.1515	2.37	0.019
	Female	63	2.17	1.02			
P2	Male	60	1.683	0.911	0.7508	2.81	0.006
	Female	63	1.302	0.557			
P3	Male	60	2.03	1.13	0.9895	2.23	0.028
	Female	63	1.635	0.829			
P4	Male	60	1.650	0.899	0.7983	0.55	0.584
	Female	63	1.571	0.689			
W1	Male	60	3.85	1.21	1.2071	2.23	0.028
	Female	63	3.37	1.21			
W2	Male	60	3.20	1.44	1.3525	2.90	0.004
	Female	63	2.49	1.27			
W3	Male	60	3.33	1.55	1.3847	3.88	0.000
	Female	63	2.37	1.21			
W4	Male	60	3.42	1.47	1.4004	1.96	0.052
	Female	63	2.92	1.34			
W5	Male	60	4.333	0.816	0.9138	2.40	0.018
	Female	63	3.937	0.998			
S1	Male	60	3.90	1.07	1.1510	2.96	0.004
	Female	63	3.29	1.22			
S2	Male	60	1.90	1.00	0.9943	0.06	0.951
	Female	63	1.889	0.986			

Looking closer at the means relative to a neutral value of three, the results show that for all of the statements where the difference in the means was statistically significant, males had an

overall mean higher than females. This means that males agreed with the statement more than females. However, it should be noted that the means were on opposite side of the neutral value (three) in two of the nine significant statements: W2 and W3. This would indicate that males overall agree with the statement while females disagree. Statements K1, W1, W5, and S1 had means for both groups on the agreement side while the means for statements P1, P2, and P3 were both on the disagreement side of the scale.

Age Factor

The age factor was analyzed by dividing the responses into six groups based on the age data collected in the demographics section of the survey. These groups were then compared using a one-way ANOVA (H_o: All means are equal, H_a: At least one mean is different, α=0.05). This analysis rejected the null hypothesis for only one statement, K5. Post ANOVA Tukey's HSD reveals that the difference was between the 18-24 and 45-54 year old age groups with the mean response of the 45-54 year old age group being higher than the mean response of the 18-24 year old age group. However, both means are on the agreement side of the scale. The results of the analysis of statement K5 are in the tables below. The results of the remaining statements can be found in Appendix B.

Table 4. One-way ANOVA: K5 versus What is your Age?

```
Source              DF      SS     MS     F      P
What is your Age?    5  10.173  2.035  2.98  0.014
Error              116  79.212  0.683
Total              121  89.385

S = 0.8264   R-Sq = 11.38%   R-Sq(adj) = 7.56%

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level   N    Mean   StDev   -+---------+---------+---------+--------
18-24  33  3.7576  0.9024   (-----*-----)
25-34  10  4.0000  1.0541    (---------*---------)
35-44   6  4.6667  0.5164              (------------*-------------)
45-54  34  4.3824  0.6970                (-----*----)
55-64  22  4.4091  0.5032               (------*------)
65+    17  4.1765  1.1311          (-------*------)
                                   -+---------+---------+---------+--------
                                  3.50      4.00      4.50      5.00

Pooled StDev = 0.8264
```

Table 5. Post-HOC Tukey's HSD: Pairwise Comparisons (μ_1-μ_2) for K5 versus What is your Age?

μ_1	μ_2				
	25-34	35-44	45-54	55-64	65+
18-24	(-0.6224, 1.1072)	(-0.1542, 1.9723)	**(0.0393, 1.2102)**	(-0.0079, 1.3109)	(-0.2963, 1.1341)
25-34		(-0.5705, 1.9038)	(-0.4795, 1.2442)	(-0.5046, 1.3228)	(-0.7783, 1.1312)
35-44			(-1.3452, 0.7765)	(-1.3610, 0.8458)	(-1.6278, 0.6474)
45-54				(-0.6288, 0.6822)	(-0.9175, 0.5058)
55-64					(-1.0062, 0.5410)

Military Service Factor

Past or present military service was analyzed as a potential factor in determining a person's response by using a two sample t-test between those who are serving or had served and those who had never served (H_o: $\mu_{Military}=\mu_{Non\text{-}Military}$, H_a: $\mu_{Military}\neq\mu_{Non\text{-}Military}$, $\alpha=0.05$).

Table 6. Statistical analysis of military service factor

Statement		N	Mean	Standard Deviation	Pooled Standard Deviation	t	p
K1	Military	16	4.625	0.500	0.6205	0.49	0.623
	Non-Military	105	4.543	0.636			
K2	Military	16	3.69	1.20	1.0224	0.04	0.965
	Non-Military	105	3.676	0.995			
K3	Military	16	4.438	0.629	0.7519	0.14	0.890
	Non-Military	105	4.410	0.768			
K4	Military	16	4.25	1.18	1.0454	0.04	0.966
	Non-Military	105	4.24	1.02			
K5	Military	16	4.500	0.632	0.8590	1.71	0.089
	Non-Military	105	4.105	0.887			
E1	Military	16	2.688	0.602	0.8400	0.26	0.794
	Non-Military	105	2.629	0.869			
E2	Military	16	3.06	1.49	1.2034	-1.04	0.299
	Non-Military	105	3.40	1.16			
E3	Military	16	2.49	1.24	1.2126	1.19	0.238
	Non-Military	105	2.55	1.21			
E4	Military	16	4.00	1.16	0.9825	0.18	0.856
	Non-Military	105	3.952	0.955			
P1	Military	16	3.13	1.50	1.1506	2.69	0.008
	Non-Military	105	2.29	1.09			
P2	Military	16	1.75	1.13	0.7723	1.41	0.160
	Non-Military	105	1.457	0.707			
P3	Military	16	1.75	1.06	1.0180	-0.32	0.748
	Non-Military	105	1.84	1.01			
P4	Military	16	1.688	0.946	0.8037	0.45	0.650
	Non-Military	105	1.590	0.781			
W1	Military	16	3.88	1.46	1.2291	0.98	0.329
	Non-Military	105	2.55	1.19			
W2	Military	16	3.94	1.34	1.3164	3.60	0.000
	Non-Military	105	2.67	1.31			
W3	Military	16	3.63	1.50	1.4303	2.40	0.018
	Non-Military	105	2.71	1.42			
W4	Military	16	4.13	1.09	1.3682	3.04	0.003
	Non-Military	105	3.01	1.40			
W5	Military	16	4.750	0.447	0.9068	2.96	0.004
	Non-Military	105	4.029	0.995			
S1	Military	16	4.00	1.03	1.1891	1.52	0.130
	Non-Military	105	3.51	1.21			
S2	Military	16	1.813	0.655	0.9969	-0.31	0.760
	Non-Military	105	1.90	1.04			

The statistical analysis rejected the null hypothesis in five cases: P1, W2, W3, W4, and W5. In every statement that was found to have a significant difference between the groups, the military group had a higher mean than the non-military group. This indicates that respondents who had served or are serving in the military agree with these statements more than those who have not served. Also, the means for statements P1, W2, and W3 were on opposite sides of the neutral value. This indicates that, in general, those in the military agree with these statements while those not in the military disagree. The mean for the non-military group for statement W4 (3.01) was extremely close to our neutral value indicating no opinion, while the mean of the military group was between agree and strongly agree. Statement W5 had both means between agree and strongly agree.

Technical Skill Factor

The technical skill factor was analyzed by dividing the responses into three groups based on the data collected through the demographic question which asked respondents to personally rate their technical skill level. These groups were then compared using a one-way ANOVA (H_o: All means are equal, H_a: At least one mean is different, α=0.05). This analysis rejected the null hypothesis for five of the statements: K1, K3, E1, W1, and S1. Tukey's HSD was used to determine which group means for each statement were different. The results for these statements appear below. The remaining ANOVA results can be found in Appendix C.

Table 7. One-way ANOVA: K1 versus How would you rate your overall technical skill level?

```
Source                      DF      SS     MS     F      P
How would you rate your      2   4.486  2.243  6.44  0.002
Error                      121  42.119  0.348
Total                      123  46.605

S = 0.5900   R-Sq = 9.63%   R-Sq(adj) = 8.13%

                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N    Mean   StDev  -----+---------+---------+---------+----
Low     4  4.2500  0.5000  (---------------*----------------)
Mod.   77  4.4286  0.6772                   (---*--)
High   43  4.8140  0.3937                            (-----*----)
                           -----+---------+---------+---------+----
                              3.85      4.20      4.55      4.90

Pooled StDev = 0.5900
```

Table 8. Post-HOC Tukey's HSD: Pairwise Comparisons (μ_1-μ_2) for K1 versus How would you rate your overall technical skill level?

μ_1	μ_2	
	Moderate	High
Low	(-0.5403, 0.8974)	(-0.1688, 0.8974)
Moderate		**(0.1185, 0.6522)**

Table 9. One-way ANOVA: K3 versus How would you rate your overall technical skill level?

```
Source                      DF      SS     MS     F      P
How would you rate your      2   3.546  1.773  3.32  0.040
Error                      121  64.647  0.534
Total                      123  68.194

S = 0.7309   R-Sq = 5.20%   R-Sq(adj) = 3.63%

                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N    Mean   StDev  --+---------+---------+---------+-------
Low     4  4.2500  0.5000  (-----------------*-----------------)
Mod.   77  4.2987  0.8439                (---*----)
High   43  4.6512  0.4822                         (----*-----)
                           --+---------+---------+---------+-------
                           3.60      4.00      4.40      4.80

Pooled StDev = 0.7309
```

Table 10. Post-HOC Tukey's HSD: Pairwise Comparisons (μ_1-μ_2) for K3 versus How would you rate your overall technical skill level?

μ_1	μ_2	
	Moderate	High
Low	(-0.8419, 0.9393)	(-0.5066, 1.3090)
Moderate		**(0.0219,0.6831)**

Table 11. One-way ANOVA: E1 versus How would you rate your overall technical skill level?

```
Source                      DF      SS     MS     F      P
How would you rate your      2   6.247  3.123  4.80  0.010
Error                      121  78.689  0.650
Total                      123  84.935

S = 0.8064   R-Sq = 7.35%   R-Sq(adj) = 5.82%

                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N    Mean   StDev  --------+---------+---------+---------+-
Low     4  3.0000  0.8165    (---------------*---------------)
Mod.   77  2.7792  0.7716            (---*--)
High   43  2.3256  0.8652  (----*---)
                           --------+---------+---------+---------+-
                                 2.50      3.00      3.50      4.00

Pooled StDev = 0.8064
```

Table 12. Post-HOC Tukey's HSD: Pairwise Comparisons (μ_1-μ_2) for E1 versus How would you rate your overall technical skill level?

μ_1	μ_2	
	Moderate	High
Low	(-1.2033, 0.7618)	(-1.6760, 0.3271)
Moderate		**(-0.8184, -0.0889)**

Table 13. One-way ANOVA: W1 versus How would you rate your overall technical skill level?

```
Source                      DF      SS    MS     F      P
How would you rate your      2   10.19  5.10  3.51  0.033
Error                      121  175.83  1.45
Total                      123  186.02

S = 1.205   R-Sq = 5.48%   R-Sq(adj) = 3.92%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  -------+---------+---------+---------+--
Low     4  2.250  1.258  (--------------*--------------)
Mod.   77  3.519  1.199                              (--*--)
High   43  3.837  1.214                                (----*----)
                          -------+---------+---------+---------+--
                               1.60      2.40      3.20      4.00

Pooled StDev = 1.205
```

Table 14. Post-HOC Tukey's HSD: Pairwise Comparisons (μ_1-μ_2) for W1 versus How would you rate your overall technical skill level?

μ_1	μ_2	
	Moderate	High
Low	(-0.199, 2.738)	**(0.090, 3.084)**
Moderate		(-0.228, 0.863)

Table 15. One-way ANOVA: S1 versus How would you rate your overall technical skill level?

```
Source                      DF      SS    MS     F      P
How would you rate your      2   11.21  5.61  4.16  0.018
Error                      121  163.13  1.35
Total                      123  174.35

S = 1.161   R-Sq = 6.43%   R-Sq(adj) = 4.88%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  ------+---------+---------+---------+---
Low     4  2.250  0.500  (-------------*-------------)
Mod.   77  3.481  1.221                            (---*--)
High   43  3.860  1.082                                (---*----)
                          ------+---------+---------+---------+---
                              1.60      2.40      3.20      4.00

Pooled StDev = 1.161
```

Table 16. Post-HOC Tukey's HSD: Pairwise Comparisons (μ_1-μ_2) for S1 versus How would you rate your overall technical skill level?

μ_1	μ_2	
	Moderate	High
Low	(-0.184, 2.645)	**(0.168, 3.053)**
Moderate		(-0.145, 0.905)

Based on the above statistical analysis, the differences in statements K1, K3, and E1 were between the moderate and high technical skill level groups. In statement K1, the high group had a mean higher than the moderate group. However both means were on the agreement side of the scale. Statement K3 also had both means on the agreement side with the mean of the high group being larger than the mean of the moderate group. The mean for the moderate group in for statement E1 was higher than the mean for the moderate group with both of the means on the disagreement side of the scale.

Unlike the other three statements, W1 and S1 showed a difference in the means between the low and high technical skill groups. In both cases the mean of the high group was larger than the mean of the low group. The high group mean was above the neutral value for both statements while the low group mean was below the neutral value.

Chapter 6

Analysis of Results

In order to analyze the results presented in the previous section, the statements from the survey have been divided into six groups: knowledge, environment, peacetime, wartime, civilian, and military. Analyzing the responses in this manner will reveal how participants feel about each situation as well as the overall issues.

Knowledge

Five of the statements presented to participants were related to general knowledge about cyber-warfare. Statements K1, K2, K3, K4, and K5 were based off of the five-point definition of cyber-warfare presented in Clarke & Knake (2010). The overall mean of the responses for all five statements was found to be statistically significant ($\alpha=0.05$, $p < 0.001$) toward the agreement side of the Likert scale. The p-value indicates the probability that a result as extreme as, or more extreme than, this result will occur purely by chance. As the p-value is less than the alpha value of 0.05, the result is statistically significant. This indicates that respondents have a good working knowledge or perception of how cyber-warfare is conducted on which to base their responses to the opinion and attitude statements.

Factor analysis for these statements revealed that a few of the factors had an effect on the magnitude of an individual's agreement with the statement. Technical skill was shown to be a factor in the responses to K1 and K3. In both cases, participants identifying themselves as having a high technical skill level were shown to respond with a greater level of agreement. However,

the practical significance of this is very small as, in both cases, the mean response for each group was between four (agree) and five (strongly agree).

Gender and age were shown to be a factor in the responses to statement K5. The statistical analysis of the gender factor showed that males responded with higher levels of agreement than females. However, similar to the factors affecting K1 and K3, this information is of little practical significance as both males and females mean responses were between four (agree) and five (strongly agree). Statistical analysis of the age factor showed a difference between the means of the eighteen to twenty-four year old group and the forty-five year old group. This difference may show a practical significance as well as the mean for the eighteen to twenty-four year old group was between three (neither agree nor disagree) and four while the mean for the forty-five to fifty-four year old group was between four and five. However the reason that a younger age group would agree less that preparations for future cyber conflicts have begun is not evident from any evidence discovered during this study. Also, this was the only statement in which age was shown to be a factor so there are not other statements with which to compare this result.

Environment

Four of the statements presented to participants went beyond simple factual information and asked for opinions on the current cyber-war environment. Statement E1 dealt with their beliefs on the current state of protection that the participant's country has in place against cyber-attacks. Statistical analysis showed that the overall mean of the responses was significantly ($\alpha=0.05$, $p < 0.001$) toward the disagree side of the scale. However, the most common response to this statement was 3 (neither agree nor disagree). This may indicate that some participants did not know what was needed for cyber defense, were apathetic about the issue, or had truly not

formed an opinion. Statistical analysis also showed that technical skill level was a factor in the responses for statement E1. The mean response of participants identifying themselves as having a high technical skill level was lower than the mean response of participants identifying themselves as having a moderate technical skill level. Both means were between two (disagree) and three. This difference may be due to a greater understanding of the defensive environment by the high skill level group. They would be more likely to understand how hard it is to secure a system, even at the home level.

Statement E2 asked participants whether or not they believed that an agreement defining how cyber-warfare should be used should be reached by the international community. Statistical analysis showed that the mean of the responses was significantly toward the agreement side of the Likert scale (α=0.05, p = 0.001). The most common response was "agree". This indicates that participants believe that there needs to be an international agreement on the use of cyber-warfare. As no such agreement exists, this indicates a difference between the current state and the desired state of the cyber-warfare environment. None of the factors were shown to have an effect on the responses.

Another issue in the cyber-warfare environment is whether or not countries should prepare for future conflicts by planting malware and other cyber-weapons in the systems of other nations. This was addressed by statement E3. Statistical analysis showed that the mean of the responses was significantly toward the disagree side (α=0.05, p = 0.001). However, the most common response to this statement was a three (neither agree nor disagree). There is clearly some disagreement or uncertainty related to this statement. This may be due to a lack of information, conflicting information, or a misunderstanding of what these cyber-weapons can do and how and when they would be activated. There was no evidence to suggest that the factors examined had an effect on the responses to this statement.

The effect of a cyber-attack on the lives of an average citizen is also an important aspect of cyber-warfare. The attacks on Estonia and Georgia provide evidence that cyber-warfare can affect many aspects of life, including communication and banking systems. The planned, test attack on the electric generator described in the cyber-warfare background section shows that power systems can be taken down as well. As such, it is expected that the responses to statement E4, which asks participants if they believe they would be personally affected by an act of cyber-warfare against their country, to weigh heavily toward agreement. Statistical analysis supported this expectation with a significant result toward the agreement side of the scale ($\alpha=0.05$, $p < 0.001$). None of the factors analyzed showed an effect on the responses.

In summary, participants were not happy with the current state of the cyber-warfare environment. First, they did not believe that their nations were protecting them well enough from the threat of cyber-attack. Related to this, the majority believed that they would be affected by cyber-warfare. Second, participants believe that there should be an international agreement on cyber-warfare use, and no such agreement exists. This second finding could result from a need to rationalize cyber-warfare and make it more palatable. If an agreement permits its use in a situation, participants may feel that there is no need to rationalize or explain the use.

Peacetime

Many of the statements in the survey dealt with specific circumstances in which cyber-warfare could be used. One category that was covered was use of cyber-warfare during peacetime. Statements P1, P2, P3, P4, and E3 all dealt with peacetime cyber-operations.

Statement P1 dealt with spying on other nations during peacetime. Statistical analysis showed that the mean of the responses was significantly below the neutral response value ($\alpha=0.05$, $p < 0.001$). Of the factors analyzed, gender and military service were shown to

significantly affect the responses. The gender factor showed that the mean of responses given by males was significantly greater than the mean of the responses given by females. However, both means were between two and three. In other words, while both gender groups disagree with this statement, females disagree slightly more than males. It is unclear at this time what may have caused this difference. Analysis of the military service factor showed that those who are serving or had served in the military, on average, agree more with this statement than those who have never served. In fact, the mean of those with military service was greater than the neutral value of three and the mean of the no-service group was less than three. This difference may be explained by a lack of appreciation of the value of intelligence by the non-military group and/or a feeling by military personnel that it is important to understand the military environment and the capabilities of other nations, allied or enemy.

Disrupting civilian activities is another potential use of cyber-warfare. Statement P2 asked for participants opinions toward the use of cyber-warfare to disrupt civilian activities during peacetime. Statistical analysis of the responses found that the overall mean was significantly less than neutral ($\alpha=0.05$, $p < 0.001$). More specifically, the mean of responses was between one (strongly disagree) and two. Analysis of the factors showed that gender was a factor in affecting the responses of participants. Analysis of the gender factor showed that the mean of responses for males was significantly higher than the mean of the responses for females. However, both means were between one and two, limiting the practical significance of this finding.

Another potential use for cyber-warfare is spying on other nations, or companies in other nations, for some form of economic gain in peacetime. This issue was addressed by statement P3 and could include actions similar to cyber- and corporate-espionage. Statistical analysis showed that the mean of the responses was significantly less than the neutral value of three ($\alpha=0.05$, $p < 0.001$). The mean was between one and two. Analysis of the factors studied showed that gender

affected the responses. Statistical analysis showed that the mean of the responses by males was significantly higher than the mean of the responses by females. The mean for males was slightly greater than two while the mean for females was less than two. Both groups still disagree with the statement, but males disagree less strongly. The reason for this difference is unclear at this time.

Similar to statement P2 discussed earlier, statement P4 asked for opinions about disrupting civilian activities. However, this statement added that the goal of attacking the civilian targets would be to disrupt military activities. The addition of this goal did not change the overall result of the analysis as the mean of the responses was found to be significantly less than the neutral value ($\alpha=0.05$, $p < 0.001$). The mean was between one and two. None of the factors analyzed were found to significantly affect the mean of the responses.

Statement E3, discussed in the previous section, could also be considered in a discussion of peacetime cyber-warfare operations. The mean of responses was found to be significantly less than the neutral value; however a response of three was the most common.

Pulling all of this analysis together, it is clear that, in general, the responding participants frown upon cyber-warfare operations during peacetime. In all cases, the null hypothesis of $\mu=3$ was rejected and the mean was found to be significantly less than three. Also, gender was shown to be a factor in three of the five statements in this section. Reasons for this could include pre-conceived gender roles and other cultural factors. War has been linked to masculinity (Hutchings, 2008) and males may feel a need to display this masculinity when faced with wartime situations. Military service was found to be a factor in only statement P1. As stated earlier, the higher responses by those with a military service background may come from greater understanding of the situation or a feeling of needing to understand the capabilities of other nations. Age and technical skill level were not shown to be a factor in any of the statements dealing with peacetime operations.

While the distribution of responses for statements P2, P3, and P4 were very heavily weighted toward the disagreement side of the Likert scale, statements, P1 and E3 had much greater spreads. This could be due to the nature of the statements. The situations described in these statements do not have immediate effects on the target of the attack while the other situations discuss more direct attacks with immediate consequences, such as disrupted systems and economic damage. It may be that some of the participants viewed the preparatory steps as acceptable because consequences of the attack would only be felt in a future conflict.

Wartime

Many of the situations presented in the previous section were also presented to users to evaluate their acceptability during wartime. It is possible that participants may view similar situations as being more acceptable during wartime due to the presence of an ongoing conflict. Statements W1, W2, W3, W4, and W5 dealt with wartime usage situations.

Statement W1 asked participants to rate their agreement with the use of the internet and hacking to spy on another nation during wartime. Statistical analysis of this statement showed that the mean of responses was significantly above the neutral value (α=0.05, $p < 0.001$). Visual analysis showed that the most common response to this statement was a response of four (agree). However, there was some spread in the distribution. This spread may be caused by a feeling by some that espionage should not be used at any time or a lack of awareness of the value of espionage.

Analysis of the factors for statement W1 showed that gender and age both had an effect on the responses of participants. The statistical analysis of the gender factor showed that the mean response by males was significantly higher than the mean response by females. However both means were between three and four. This difference may be due to societal constructs. The

ANOVA used to analyze the technical skill factor showed that at least one of the means was different. Further analysis using Tukey's HSD showed that the difference occurred between the Low and High skill level groups. The mean of the low group was below the neutral value, while the mean of the high group was greater. Usefulness of this analysis may be limited, however, because the sample size of the low skill group was only four.

It is also important to take a look at whether or not people believe that cyber-warfare should be used to disrupt civilian activities during wartime. Statistical analysis of statement W2, which dealt with this issue, failed to reject the null hypothesis. This means that there is no clear outcome from the responses gathered. Visual analysis of the distribution of responses showed a bimodal distribution with responses of two and four being most common. This shows that there is clear disagreement within the sample concerning this issue. Analysis of the factors may provide some explanation for this distribution.

Factor analysis showed that both the gender and the military service factor had an effect on the responses of participants. Statistical analysis of the gender factor showed that the mean of the responses by males was significantly higher than the mean of responses by females. The mean response provided by the male group was greater than three while the mean response provided by females was less than three. Analysis also determined that the mean response provided by those who are serving or have served in the military was significantly greater than the mean response provided by those with no service history. The mean for the military group was greater than three and the mean for the non-military group was less than three. The reasons for these splits may include a differing understanding about what is sometimes necessary in order to prevail in a military conflict as well as societal preconceptions described earlier. As both groups show polarization, this could be the reason for a bimodal distribution for the overall responses.

Similar to statement W2, the overall mean of the responses for statement W3 was not found to be statistically significant from the neutral value of three and the gender and military factors were found to significantly affect the responses. Statement W2 asked for an opinion on whether or not it was acceptable to spy for economic gain during wartime. Unlike statement W2, the distribution of responses was nearly flat for this statement. Even with this flat distribution, the gender and military factors followed the same pattern as statement W2. The mean of responses by males was greater than three and the mean response by females was less than three. The mean of the responses by those with military service was greater than three while the mean of the responses by those with no military service history was less than three. The reasons for these differences are probably similar to those for statement W2.

The mean of the responses for statement W4, which deals with attacks on civilian targets with the goal of disrupting military operations, was also found to not be significantly different from the neutral value of three. The military service factor was found to be significant with the mean of respondents having a military service history being higher than the mean of respondents with no military history. However, unlike previously analyzed statements, the mean of the responses for those with no service history was very close to the neutral value of three (3.01) while the mean of the responses by the military group was greater than four (4.13). While the gender factor was not found to be statistically significant, it should be noted that the mean of the responses given by males was above three while the mean of the responses given by females was less than three.

The final statement which assessed opinions relating to wartime use of cyber-warfare was statement W5. This statement dealt with the use of cyber-warfare in conjunction with kinetic warfare with a goal of reducing loss of life. Statistical analysis for this statement showed evidence that the mean of the overall responses was greater than three ($\alpha=0.05$, $p < 0.001$). Further analysis showed that both the gender and military service factor had a significant effect

on the responses. As with previous statements, the mean for males was higher than the mean for females and the mean for the military group was higher than the mean for the non-military group. The practical significance of this factor analysis is limited however as all of these means were near or above 4 (agree).

Taking all of these statements into account, it is clear that there is some uncertainty, as the analysis of three of the five statements failed to reject the null hypothesis. It should be noted, however, that each of these three statements dealt with attacking civilian targets. Analysis of the other two statements resulted in a significant result toward the agreement side of the scale. Another important finding was that both gender and military service had a large effect on the responses to these statements. As mentioned earlier, this could be caused by societal constructs of how individuals of different genders should respond to these types of statements as well as by knowledge and/or acceptance of what is necessary to prevail in a military conflict.

Civilian

As the use of cyber-warfare is currently not governed by international treaty or agreement, it is important to determine whether the people believe that it is acceptable to use cyber-weapons against civilian targets. Statements P2, P4, W2, W4, and W5 dealt directly with attacks on civilian targets. The first four statements were analyzed in detail in the previous sections.

Statement W5 dealt with the use of cyber-warfare in a preemptive strike against civilian targets. Statistical analysis found that the mean of all responses was significantly lower than a neutral response value of three ($\alpha=0.05$, $p < 0.001$). Visual analysis of the distribution of responses showed that a response of 1 was most common. While low in number, there were a

few responses on the agreement side of the scale. None of the factors analyzed were found to be significant.

Overall, this analysis shows that participants did not approve of the use of cyber-warfare against civilian targets during peacetime and were divided on whether or not civilians should be targeted during wartime. This is not very surprising as targeting civilians is off-limits for many other types of warfare. Those with military service generally showed higher levels of agreement on wartime issues. This may come from a realization that targeting civilian targets such as power plants or transportation systems can have effects on military assets as well. The military group may also realize that attacking civilians during a conflict may be unavoidable.

Military

Two statements in the survey dealt specifically with cyber-warfare attacks on military targets. Analyzing public opinion in this area will provide a greater understanding of whether or not the public believes that cyber-warfare should be used against military assets, and whether or not they would support such an action.

Statement S1 asked participants to rate their agreement with the use of cyber-warfare in a preemptive strike against a military target. Statistical analysis showed that the overall mean of all responses was significantly greater than a value of three ($\alpha=0.05$, $p < 0.001$). Statistical analysis of the factors showed that both gender and technical skill level had an effect on the responses of the participants. The gender factor showed that the mean of the responses given by males were significantly greater than the mean of the responses given by females. Both means were between three and four. The ANOVA results for the technical skill level factor showed that there was at least one mean that was different. Further analysis using Tukey's HSD showed that the difference occurred between the low skill level group and the high skill level group. Also, the

mean of the low group was below three while the mean for the high group was greater than three. However, the practical significance of this difference may be limited as the sample size for the low technical skill level group was only four.

Using cyber-warfare in conjunction with kinetic warfare in order to minimize loss of life is another possible use of cyber-weapons against military targets. Statement W5 dealt with this situation and was analyzed in a previous section. The mean was found to be significantly greater than a neutral response and the gender and military service factors were found to be significant. The two means for the gender factor and the two means for the military service were all near or above four.

From these two questions, it would appear that using cyber-warfare against military targets would be supported by the public. Statistical analysis showed a gender difference in both questions. However, in both cases the practical significance was limited due to the means falling into similar areas of the scale.

Chapter 7

Conclusions

By categorizing the statements in the survey into one or more groups, the analysis made a few things very apparent. First, the participants in this study had a good working knowledge of cyber-warfare based on the five-point definition from Clark and Knake (2010). Second, most participants were not happy with the current environment in which cyber-warfare operates. They felt that they could be personally affected by attacks and that their countries were not doing enough to protect them from these attacks. They also believed that there should be some international governance on the use of cyber-warfare.

Taking a deeper look into potential situations in which cyber-warfare could be used, participants in this study generally disagreed with the use of cyber-warfare tactics in peacetime situations, especially against civilians. However, those with a military service background believed that spying and preparing for future conflicts by planting malware was acceptable during peacetime. Opinions on the use of cyber-warfare during wartime were much less clear. Participants generally agreed with its use in situations that involved simple spying, attacking military targets, or minimizing loss of life. Situations involving attacks on civilian targets during wartime did not show a significant opinion one way or the other. This is likely due to polarization in the gender and military factors. Males and those with military service history generally agreed with the use of cyber-warfare against civilian targets while females and those with no military service history were mostly against such use. Although age and technical skill level were shown to have a statistically significant effect on the responses to a few of the statements, the practical significance of these findings is very limited.

The use of cyber-warfare in preemptive situations was also addressed in the survey. The findings show that, as a whole, preemptive use against civilian targets is not supported by the participants while preemptively striking military targets with a cyber-weapon would be supported.

From the analysis conducted above, it is evident that there are some disparities in opinions. While some of this may be caused by personal predisposition, education may help to level the playing field. By informing the population about the events, technologies, and facts of cyber-warfare, it may be possible to build a more cohesive picture of how the people feel this new tactic should be used.

It is also important to remember that a significant finding as a result of statistical analysis may not provide any practical significance. For example, a difference between a mean of 1.9 and a mean of 2.1 may be statistically significant, but both means fall directly around disagree and provide little practical evidence of a difference.

Limitations

There are a few limitations to the conclusions reached through this research. First, the sample may not be representative of the population. The survey was solicited through email and online social media networks and delivered through an online survey system. While the demographic information collected shows a wide variety in the participants, the solicitation method assumes access to, and proficiency with, email, social networks, a computer and the internet. Also, those reached were in some way related to the study administrator, either through being on an email list or being part of an extended social network of which the administrator was a part of. As such, the results of this study cannot be generalized to the population as a whole.

A second limitation is the meaning of the response of "neither agree nor disagree" (three). While on the surface this clearly indicates that a participant does not agree or disagree with the statement, it also has the potential to mean that the participant has not formed an opinion about the issue. In addition to this, it could also indicate that the participant did not know enough about the subject to offer an opinion, or that they did not care about the issue at all. It is impossible to tell from the information gathered whether a response of a three was truly a "neither agree nor disagree" or simply an "I don't know" or an "I don't care."

Improvements and Future Research

While this study did cover a wide array of issues related to the public opinion of cyber-warfare, there are a number of ways in which it can be improved and expanded upon. First, obtaining a more randomized, representative sample would increase the ability to generalize the study results to the general population. Second, possibly including other options in the scale, such as "I don't know" might allow the response of "neither agree nor disagree" to become more meaningful. Also, including more specific questions about military targets may allow for greater comparisons to the civilian issues already covered in the survey.

Future research in this area might include the analysis of additional factors other than the four covered here. Including other factors such as career area, level of education, marital status, number of children, and income level might offer additional insight into what shapes opinions related to the use of cyber-warfare. Also, looking deeper into these factors for interactions could provide a deeper level of knowledge about what affects an individual's opinion on the use of cyber-warfare. Another area that could be analyzed in a future study is whether or not exposure to and knowledge of past cyber-warfare incidents has an effect on a person's opinion on how cyber-warfare should be used. It would also be interesting to study how defining the outcome of

an attack would change the results. In other words, do the responses differ for similar situations when stating that the system will only be down for a few days versus stating that the system will be permanently destroyed?

While the applicability of this study to the general public is restricted due to the limitations described above, it provides a stepping stone to the next level of research into cyber-warfare opinions and policymaking.

Appendix A

Research Survey

Informed Consent (PSU IRB#35611 12/03/10)
An Analysis of Cyberwafare Attitudes
Conducted as part of the undergraduate thesis requirement for the Schreyer Honors College, The Pennsylvania State University

Please read this consent document carefully before you decide to participate in this study.

Purpose of the research study:
This study is designed to determine what factors influence attitudes toward Cyberwarfare.

What you will be asked to do in this study:
We will ask you to answer some multiple choice questions about your Cyberwarfare knowledge and your opinions about Cyberwarfare.

Time required:
15 minutes

Risks:
We do not anticipate any discomfort arising out of this survey. You are free to withdraw from further participation at any stage of the survey.

Compensation and Benefit:
You will not receive any compensation or benefit for participating in the survey other than the knowledge that you have helped support undergraduate research at Penn State University.

Confidentiality:
Your identity will be kept confidential to the extent required by law. Your name will not be used in any report. No identifying information of any kind will be gathered. All responses are completely anonymous. Your confidentiality will be kept to the degree permitted by the technology being used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties.

Voluntary participation:
Your participation in the study is completely voluntary. There is no penalty for not participating.

Right to withdraw from the study:
You have the right to withdraw from the study at any time without consequence.

Who to contact if you have questions about the study:

Adam Jones, Undergraduate Student in the College of Information Sciences and Technology, Pennsylvania State University, adj5039@psu.edu, (814)-571-1018, 22 Atherton Hall, University Park, PA 16802

In addition you can contact Gerald Santoro, Honors Thesis Advisor and Asst. Professor of Information Sciences and Technology, Pennsylvania State University, gms@psu.edu, 301J IST Building, University Park, PA 16802

Agreement:

I have read the procedure described above. Clicking on the "proceed" button below signifies that I voluntarily agree to participate in the survey.

If you would like a copy of this informed consent document, please print this page now or contact Adam Jones as listed above.

Definitions

For the purposes of this survey, please use the following definitions when answering the questions:

Cyberwarfare: actions by a nation-state or other entity to penetrate another nation's computers or networks for the purposes of causing damage or disruption

Kinetic Warfare: Combat operations conducted in the three traditional theaters of war, land, air and sea, with conventional weapons.

Malware: short for malicious software, malware is used to access or disrupt computer systems without the owner's consent. Types of malware include, but are not limited to, Viruses, Trojans, Worms, and Spyware.

Preemptive Strike: an act of war conducted in an attempt to repel or defeat a perceived inevitable offensive act or invasion by another entity or to gain an advantage in an impending war before the threat materializes; an act of war conducted in anticipation of immediate enemy aggression.

Please rate your agreement with the following statements with 5 meaning strongly agree, 3 meaning neither agree nor disagree, and 1 meaning strongly disagree.

Cyberwarfare is real	1	2	3	4	5
Cyberwarfare happens at the speed of light	1	2	3	4	5
Cyberwarfare is global in scale	1	2	3	4	5
Cyberwarfare is not conducted on traditional battlefields or against traditional defenses	1	2	3	4	5
Cyberwarfare and preparations for future cyber conflicts have begun	1	2	3	4	5

My country is doing enough to protect itself from Cyberwarfare Attacks.

1 2 3 4 5

There needs to be an international agreement about what types of Cyberwarfare are acceptable

1 2 3 4 5

It is acceptable for a country to spy on another country via the internet by hacking or installing malware in times of peace.

1 2 3 4 5

It is acceptable for a country to spy on another country via the internet by hacking or installing malware in times of war.

1 2 3 4 5

It is acceptable for a country to use Cyberwarfare to disrupt civilian activities in another country in times of peace. This could include power systems, communications, and financial systems.

1 2 3 4 5

It is acceptable for a country to use Cyberwarfare to disrupt civilian activities in another country in times of war. This could include power systems, communications, and financial systems.

1 2 3 4 5

It is acceptable for a country to spy on another country for economic gain in times of peace.

1 2 3 4 5

It is acceptable for a country to spy on another country for economic gain in times of war.

1 2 3 4 5

It is acceptable to use Cyberwarfare to attack civilian targets (e.g. power grids) when the goal is to disrupt military operations in times of peace.

1 2 3 4 5

It is acceptable to use Cyberwarfare to attack civilian targets (e.g. power grids) when the goal is to disrupt military operations in times of war.

1 2 3 4 5

It is acceptable to use Cyberwarfare in a preemptive strike against a purely military target.

1 2 3 4 5

It is acceptable to use Cyberwarfare in a preemptive strike against civilian targets.

1 2 3 4 5

It is acceptable to use Cyberwarfare in conjunction with standard, kinetic warfare in order to minimize loss of life.

1 2 3 4 5

It is acceptable for countries to prepare for Cyberwarfare by hiding cyber weapons, exploits, and backdoors in the systems of other countries, even when there are no signs of impending conflict.

1 2 3 4 5

I would be personally affected if an act of Cyberwarfare was carried out against my country.

1 2 3 4 5

Demographics/independent variables

What is your gender? Male Female Prefer not to answer

What is your age? 18-24 25-34 35-44 45-54 55-64 65+ Prefer not to answer

Are you serving or have you ever served in the active or reserve military

Yes No Prefer not to answer

How would you rate your overall technical skill level?

Low(Uncomfortable with technology and struggle with basic tasks such as web browsing)

Moderate(comfortable using technology for tasks such as web browsing, email, gaming, and media consumption)

High(extremely comfortable with technology and can troubleshoot problems for myself and others)

Prefer not to answer

Appendix B

ANOVA Results for Age Factor

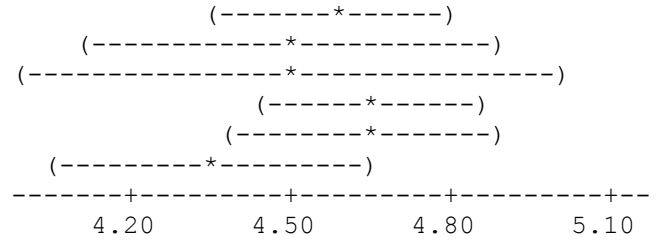
One-way ANOVA: K1 versus What is your Age?

Source	DF	SS	MS	F	P
What is your Age?	5	1.177	0.235	0.61	0.693
Error	116	44.799	0.386		
Total	121	45.975			

S = 0.6214 R-Sq = 2.56% R-Sq(adj) = 0.00%

Level	N	Mean	StDev
18-24	33	4.5758	0.5019
25-34	10	4.5000	0.5270
35-44	6	4.5000	0.5477
45-54	34	4.6471	0.4851
55-64	22	4.6364	0.4924
65+	17	4.3529	1.1147

Individual 95% CIs For Mean Based on Pooled StDev



Pooled StDev = 0.6214

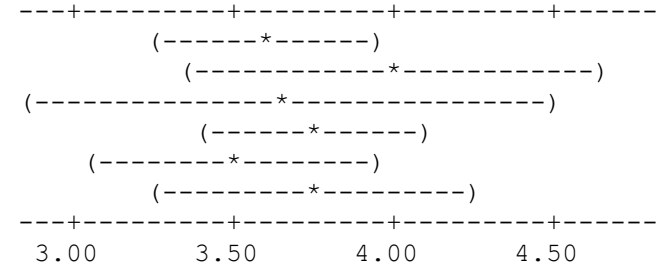
One-way ANOVA: K2 versus What is your Age?

Source	DF	SS	MS	F	P
What is your Age?	5	2.14	0.43	0.41	0.844
Error	116	122.39	1.06		
Total	121	124.53			

S = 1.027 R-Sq = 1.72% R-Sq(adj) = 0.00%

Level	N	Mean	StDev
18-24	33	3.606	0.864
25-34	10	4.000	0.943
35-44	6	3.667	1.033
45-54	34	3.735	1.082
55-64	22	3.500	1.144
65+	17	3.765	1.091

Individual 95% CIs For Mean Based on Pooled StDev



Pooled StDev = 1.027

One-way ANOVA: K3 versus What is your Age?

Source	DF	SS	MS	F	P
What is your Age?	5	2.115	0.423	0.75	0.590
Error	116	65.721	0.567		
Total	121	67.836			

S = 0.7527 R-Sq = 3.12% R-Sq(adj) = 0.00%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
18-24	33	4.3333	0.7773	(-----*------)
25-34	10	4.2000	1.0328	(-----------*-----------)
35-44	6	4.6667	0.5164	(---------------*--------------)
45-54	34	4.5294	0.5633	(-----*------)
55-64	22	4.5455	0.5958	(-------*-------)
65+	17	4.2941	1.0467	(--------*--------)
				4.00 4.40 4.80 5.20

Pooled StDev = 0.7527

One-way ANOVA: K4 versus What is your Age?

Source	DF	SS	MS	F	P
What is your Age?	5	6.69	1.34	1.24	0.296
Error	116	125.42	1.08		
Total	121	132.11			

S = 1.040 R-Sq = 5.07% R-Sq(adj) = 0.97%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
18-24	33	4.182	0.882	(-----*-----)
25-34	10	3.900	1.101	(----------*----------)
35-44	6	3.833	1.472	(-------------*-------------)
45-54	34	4.176	1.141	(-----*----)
55-64	22	4.682	0.568	(------*------)
65+	17	4.235	1.348	(--------*-------)
				3.00 3.60 4.20 4.80

Pooled StDev = 1.040

One-way ANOVA: E1 versus What is your Age?

Source	DF	SS	MS	F	P
What is your Age?	5	4.940	0.988	1.44	0.214
Error	116	79.462	0.685		
Total	121	84.402			

```
S = 0.8277   R-Sq = 5.85%   R-Sq(adj) = 1.79%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean   StDev  -------+---------+---------+---------+--
18-24  33  2.7273  0.8758                 (-----*----)
25-34  10  3.0000  1.0541                  (---------*---------)
35-44   6  2.3333  1.2111  (-------------*------------)
45-54  34  2.5000  0.6629            (-----*-----)
55-64  22  2.4091  0.8541         (------*------)
65+    17  2.8824  0.6966                  (-------*-------)
                          -------+---------+---------+---------+--
                               2.00      2.50      3.00      3.50

Pooled StDev = 0.8277
```

```
One-way ANOVA: E2 versus What is your Age?

Source              DF      SS    MS     F      P
What is your Age?    5    8.36  1.67  1.17  0.326
Error              116  165.18  1.42
Total              121  173.54

S = 1.193   R-Sq = 4.82%   R-Sq(adj) = 0.72%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  ------+---------+---------+---------+---
18-24  33  3.606  1.059                   (------*------)
25-34  10  3.200  1.135         (-----------*-----------)
35-44   6  3.000  1.265  (---------------*---------------)
45-54  34  3.353  1.152                (------*------)
55-64  22  2.909  1.377        (-------*--------)
65+    17  3.588  1.278                 (---------*--------)
                          ------+---------+---------+---------+---
                              2.40      3.00      3.60      4.20

Pooled StDev = 1.193
```

```
One-way ANOVA: P1 versus What is your Age?

Source              DF      SS    MS     F      P
What is your Age?    5   12.30  2.46  1.84  0.111
Error              116  155.21  1.34
Total              121  167.51

S = 1.157   R-Sq = 7.34%   R-Sq(adj) = 3.35%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  -------+---------+---------+---------+--
18-24  33  2.515  1.149              (----*----)
25-34  10  1.800  0.789  (---------*---------)
35-44   6  3.167  1.329                (-----------*----------)
```

```
45-54  34  2.118  0.977           (---*----)
55-64  22  2.682  1.171                (------*-----)
65+    17  2.529  1.546             (------*------)
                          -------+---------+---------+---------+--
                               1.60      2.40      3.20      4.00

Pooled StDev = 1.157
```

```
One-way ANOVA: W1 versus What is your Age?

Source              DF      SS    MS     F      P
What is your Age?    5    4.56  0.91  0.60  0.700
Error              116  176.33  1.52
Total              121  180.89

S = 1.233   R-Sq = 2.52%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev   -------+---------+---------+---------+--
18-24  33  3.545  1.252          (--------*-------)
25-34  10  3.700  1.337       (--------------*--------------)
35-44   6  3.667  1.366  (--------------------*--------------------)
45-54  34  3.588  1.076           (--------*-------)
55-64  22  3.955  1.133                 (---------*----------)
65+    17  3.294  1.490   (-----------*-----------)
                          -------+---------+---------+---------+--
                               3.00      3.50      4.00      4.50

Pooled StDev = 1.233
```

```
One-way ANOVA: P2 versus What is your Age?

Source              DF      SS     MS     F      P
What is your Age?    5   4.404  0.881  1.50  0.195
Error              116  68.088  0.587
Total              121  72.492

S = 0.7661   R-Sq = 6.07%   R-Sq(adj) = 2.03%

                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N    Mean   StDev   -+---------+---------+---------+--------
18-24  33  1.5758  0.7513          (-----*----)
25-34  10  1.6000  0.5164       (---------*---------)
35-44   6  2.1667  1.6021                (-----------*------------)
45-54  34  1.3529  0.5440       (----*----)
55-64  22  1.5000  0.9636         (-----*-----)
65+    17  1.2941  0.5879    (------*------)
                            -+---------+---------+---------+--------
                           1.00      1.50      2.00      2.50

Pooled StDev = 0.7661
```

One-way ANOVA: W2 versus What is your Age?

Source	DF	SS	MS	F	P
What is your Age?	5	15.24	3.05	1.62	0.160
Error	116	218.10	1.88		
Total	121	233.34			

S = 1.371 R-Sq = 6.53% R-Sq(adj) = 2.50%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
18-24	33	2.303	1.104	(------*------)
25-34	10	3.000	1.563	(-----------*-----------)
35-44	6	3.333	1.506	(---------------*--------------)
45-54	34	2.912	1.311	(------*-----)
55-64	22	3.136	1.612	(-------*-------)
65+	17	3.176	1.468	(--------*---------)
				2.10 2.80 3.50 4.20

Pooled StDev = 1.371

One-way ANOVA: P3 versus What is your Age?

Source	DF	SS	MS	F	P
What is your Age?	5	0.41	0.08	0.08	0.995
Error	116	122.31	1.05		
Total	121	122.72			

S = 1.027 R-Sq = 0.34% R-Sq(adj) = 0.00%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
18-24	33	1.848	1.034	(------*------)
25-34	10	1.900	0.738	(------------*------------)
35-44	6	1.833	0.753	(----------------*---------------)
45-54	34	1.765	0.987	(------*------)
55-64	22	1.818	1.053	(-------*--------)
65+	17	1.941	1.249	(---------*---------)
				1.00 1.50 2.00 2.50

Pooled StDev = 1.027

One-way ANOVA: W3 versus What is your Age?

Source	DF	SS	MS	F	P
What is your Age?	5	3.99	0.80	0.36	0.874
Error	116	256.05	2.21		
Total	121	260.04			

S = 1.486 R-Sq = 1.53% R-Sq(adj) = 0.00%

```
                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  ----+---------+---------+---------+-----
18-24  33  2.576  1.521     (-------*------)
25-34  10  2.900  1.595    (------------*-------------)
35-44   6  3.000  1.549  (-----------------*----------------)
45-54  34  2.912  1.311          (-------*------)
55-64  22  2.864  1.490        (--------*--------)
65+    17  3.118  1.654          (----------*---------)
                          ----+---------+---------+---------+-----
                            2.10      2.80      3.50      4.20

Pooled StDev = 1.486
```

```
One-way ANOVA: P4 versus What is your Age?

Source              DF      SS     MS     F      P
What is your Age?    5   2.518  0.504  0.78  0.564
Error              116  74.597  0.643
Total              121  77.115

S = 0.8019   R-Sq = 3.26%   R-Sq(adj) = 0.00%

                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N    Mean   StDev  ---+---------+---------+---------+------
18-24  33  1.8182  0.9828                        (-----*------)
25-34  10  1.4000  0.5164       (------------*------------)
35-44   6  1.3333  0.5164  (---------------*----------------)
45-54  34  1.5588  0.7464                (------*------)
55-64  22  1.5455  0.5958              (--------*-------)
65+    17  1.5882  0.9393              (---------*--------)
                            ---+---------+---------+---------+------
                             0.80      1.20      1.60      2.00

Pooled StDev = 0.8019
```

```
One-way ANOVA: W4 versus What is your Age?

Source              DF      SS    MS     F      P
What is your Age?    5    8.36  1.67  0.82  0.538
Error              116  236.36  2.04
Total              121  244.72

S = 1.427   R-Sq = 3.42%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  ------+---------+---------+---------+---
18-24  33  2.879  1.219           (------*------)
25-34  10  3.200  1.751          (------------*-----------)
35-44   6  2.833  1.722  (---------------*----------------)
45-54  34  3.147  1.374               (------*------)
```

```
55-64  22  3.636  1.529                    (--------*--------)
65+    17  3.235  1.480              (---------*---------)
                          ------+---------+---------+---------+---
                              2.10      2.80      3.50      4.20

Pooled StDev = 1.427
```

```
One-way ANOVA: S1 versus What is your Age?

Source              DF      SS    MS     F      P
What is your Age?    5    5.36  1.07  0.76  0.581
Error              116  163.96  1.41
Total              121  169.32

S = 1.189   R-Sq = 3.17%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  ----+---------+---------+---------+-----
18-24  33  3.667  0.924          (------*------)
25-34  10  4.100  1.287            (-----------*-----------)
35-44   6  3.833  0.983    (---------------*---------------)
45-54  34  3.412  1.305      (------*------)
55-64  22  3.682  1.171         (-------*--------)
65+    17  3.353  1.412  (---------*--------)
                          ----+---------+---------+---------+-----
                            3.00      3.60      4.20      4.80

Pooled StDev = 1.189
```

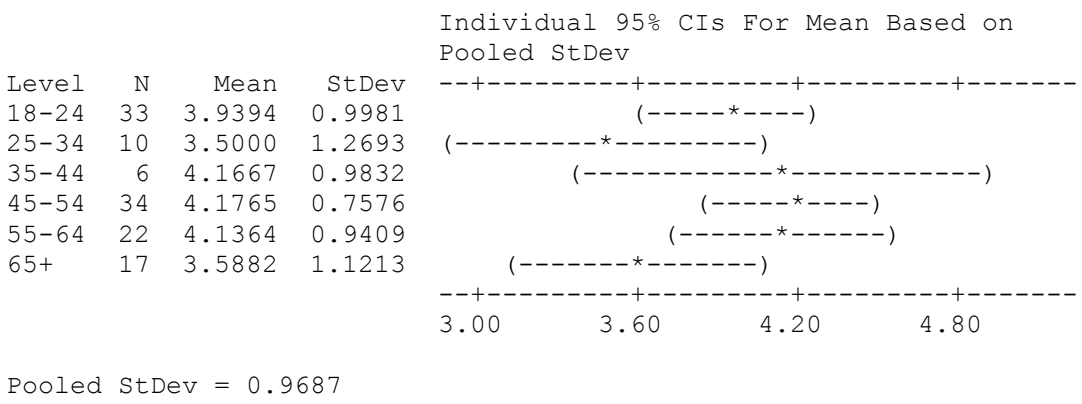
```
One-way ANOVA: S2 versus What is your Age?

Source              DF      SS    MS     F      P
What is your Age?    5    2.70  0.54  0.54  0.748
Error              116  116.91  1.01
Total              121  119.61

S = 1.004   R-Sq = 2.26%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on Pooled
StDev
Level   N   Mean  StDev    +---------+---------+---------+---------
18-24  33  2.030  0.951                (------*------)
25-34  10  2.200  1.398              (------------*------------)
35-44   6  1.833  1.602    (----------------*----------------)
45-54  34  1.853  0.958             (------*------)
55-64  22  1.682  0.839          (--------*-------)
65+    17  1.824  0.883            (--------*---------)
                            +---------+---------+---------+---------
                          1.00      1.50      2.00      2.50

Pooled StDev = 1.004
```

```
One-way ANOVA: W5 versus What is your Age?
```

```
Source              DF       SS     MS     F      P
What is your Age?    5    2.345  0.469  0.55  0.738
Error              116   98.999  0.853
Total              121  101.344

S = 0.9238   R-Sq = 2.31%   R-Sq(adj) = 0.00%

                           Individual 95% CIs For Mean Based on Pooled
StDev
Level   N    Mean   StDev    +---------+---------+---------+---------
18-24  33  3.9394  0.9981     (------*-------)
25-34  10  4.3000  1.2517       (-------------*--------------)
35-44   6  4.3333  0.8165    (-----------------*-----------------)
45-54  34  4.2059  0.6410           (-------*-------)
55-64  22  4.2727  0.9847           (---------*---------)
65+    17  4.1176  0.9926      (----------*----------)
                              +---------+---------+---------+---------
                            3.60      4.00      4.40      4.80

Pooled StDev = 0.9238
```

```
One-way ANOVA: E3 versus What is your Age?

Source              DF      SS    MS     F      P
What is your Age?    5    2.29  0.46  0.30  0.913
Error              116  178.11  1.54
Total              121  180.40

S = 1.239   R-Sq = 1.27%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on Pooled
StDev
Level   N   Mean  StDev    +---------+---------+---------+---------
18-24  33  2.606  1.029          (------*-------)
25-34  10  2.600  1.430    (------------*------------)
35-44   6  3.167  1.472          (----------------*---------------)
45-54  34  2.676  1.224            (------*------)
55-64  22  2.591  1.469        (--------*--------)
65+    17  2.471  1.125     (---------*---------)
                           +---------+---------+---------+---------
                         1.80      2.40      3.00      3.60

Pooled StDev = 1.239
```

```
One-way ANOVA: E4 affected versus What is your Age?

Source              DF       SS     MS     F      P
What is your Age?    5    7.007  1.401  1.49  0.197
Error              116  108.862  0.938
Total              121  115.869

S = 0.9687   R-Sq = 6.05%   R-Sq(adj) = 2.00%
```



Pooled StDev = 0.9687

Appendix C

ANOVA Results for Technical Skill Factor

```
One-way ANOVA: K2 versus How would you rate your overall technical
skill level?

Source                      DF      SS    MS     F      P
How would you rate your      2    0.56  0.28  0.27  0.763
Error                      121  124.18  1.03
Total                      123  124.73

S = 1.013   R-Sq = 0.45%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on Pooled
StDev
Level   N   Mean  StDev    +---------+---------+---------+---------
Low     4  4.000  0.000    (-----------------*---------------)
Mod.   77  3.701  0.974             (---*--)
High   43  3.628  1.113          (----*-----)
                            +---------+---------+---------+---------
                           3.00      3.60      4.20      4.80

Pooled StDev = 1.013
------------------------------------------------------------------------
One-way ANOVA: K4 versus How would you rate your overall technical
skill level?

Source                      DF      SS    MS     F      P
How would you rate your      2    0.99  0.49  0.46  0.635
Error                      121  131.23  1.08
Total                      123  132.22

S = 1.041   R-Sq = 0.75%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  -----+---------+---------+---------+----
Low     4  3.750  1.893  (-----------------*----------------)
Mod.   77  4.260  0.938                      (---*---)
High   43  4.233  1.130                    (-----*----)
                          -----+---------+---------+---------+----
                             3.00      3.60      4.20      4.80

Pooled StDev = 1.041
------------------------------------------------------------------------
One-way ANOVA: K5 versus How would you rate your overall technical
skill level?

Source                      DF      SS     MS     F      P
```

```
How would you rate your     2   0.640  0.320  0.43  0.652
Error                     121  90.134  0.745
Total                     123  90.774

S = 0.8631   R-Sq = 0.71%   R-Sq(adj) = 0.00%

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level   N    Mean   StDev  -------+---------+---------+---------+--
Low     4  4.0000  0.8165  (----------------*----------------)
Mod.   77  4.1169  0.8580                (---*---)
High   43  4.2558  0.8754                  (----*----)
                           -------+---------+---------+---------+--
                                3.50      4.00      4.50      5.00

Pooled StDev = 0.8631
------------------------------------------------------------------------
One-way ANOVA: E2 versus How would you rate your overall technical
skill level?

Source                      DF      SS    MS     F      P
How would you rate your     2    1.53  0.77  0.54  0.586
Error                     121  172.85  1.43
Total                     123  174.39

S = 1.195   R-Sq = 0.88%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev   ------+---------+---------+---------+---
Low     4  3.250  0.957   (-------------------*-------------------)
Mod.   77  3.442  1.164                    (---*----)
High   43  3.209  1.264              (-----*------)
                          ------+---------+---------+---------+---
                              2.40      3.00      3.60      4.20

Pooled StDev = 1.195
------------------------------------------------------------------------
One-way ANOVA: P1 versus How would you rate your overall technical
skill level?

Source                      DF      SS    MS     F      P
How would you rate your     2    2.50  1.25  0.91  0.404
Error                     121  165.53  1.37
Total                     123  168.02

S = 1.170   R-Sq = 1.49%   R-Sq(adj) = 0.00%

                          Individual 95% CIs For Mean Based on Pooled
StDev
Level   N   Mean  StDev    +---------+---------+---------+---------
Low     4  1.750  0.957    (-----------------*-----------------)
Mod.   77  2.377  1.136                           (----*---)
High   43  2.535  1.241                            (-----*-----)
                           +---------+---------+---------+---------
```

```
                        0.60      1.20      1.80      2.40

Pooled StDev = 1.170
------------------------------------------------------------------------
One-way ANOVA: P2 versus How would you rate your overall technical
skill level?

Source                      DF      SS     MS     F      P
How would you rate your      2   1.001  0.500  0.84  0.434
Error                      121  71.991  0.595
Total                      123  72.992

S = 0.7713   R-Sq = 1.37%   R-Sq(adj) = 0.00%

                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N    Mean   StDev  ----+---------+---------+---------+-----
Low     4  1.0000  0.0000  (------------------*------------------)
Mod.   77  1.5065  0.7543                          (----*---)
High   43  1.5116  0.8273                        (-----*-----)
                           ----+---------+---------+---------+-----
                             0.40      0.80      1.20      1.60

Pooled StDev = 0.7713
------------------------------------------------------------------------
One-way ANOVA: W2 versus How would you rate your overall technical
skill level?

Source                      DF      SS    MS     F      P
How would you rate your      2    1.63  0.81  0.42  0.659
Error                      121  235.81  1.95
Total                      123  237.44

S = 1.396   R-Sq = 0.69%   R-Sq(adj) = 0.00%

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level   N   Mean  StDev  --------+---------+---------+---------+-
Low     4  2.250  1.258  (-------------------*--------------------)
Mod.   77  2.883  1.367                         (---*----)
High   43  2.791  1.457                       (-----*-----)
                          --------+---------+---------+---------+-
                                1.40      2.10      2.80      3.50

Pooled StDev = 1.396
------------------------------------------------------------------------
One-way ANOVA: P3 versus How would you rate your overall technical
skill level?

Source                      DF      SS    MS     F      P
How would you rate your      2    0.98  0.49  0.48  0.618
Error                      121  122.47  1.01
Total                      123  123.44

S = 1.006   R-Sq = 0.79%   R-Sq(adj) = 0.00%
```

```
                          Individual 95% CIs For Mean Based on Pooled
StDev
Level   N   Mean  StDev    +---------+---------+---------+---------
Low     4  1.500  1.000    (-------------------*-------------------)
Mod.   77  1.792  0.937                       (----*---)
High   43  1.930  1.121                         (-----*-----)
                            +---------+---------+---------+---------
                          0.50      1.00      1.50      2.00

Pooled StDev = 1.006
------------------------------------------------------------------------------
One-way ANOVA: W3 versus How would you rate your overall technical
skill level?

Source                      DF      SS    MS     F      P
How would you rate your      2    6.54  3.27  1.55  0.216
Error                      121  254.90  2.11
Total                      123  261.44

S = 1.451   R-Sq = 2.50%   R-Sq(adj) = 0.89%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N   Mean  StDev  ---+---------+---------+---------+------
Low     4  2.000  0.816  (-----------------*-----------------)
Mod.   77  2.727  1.401                       (---*---)
High   43  3.093  1.571                          (-----*----)
                          ---+---------+---------+---------+------
                           0.80      1.60      2.40      3.20

Pooled StDev = 1.451
------------------------------------------------------------------------------
One-way ANOVA: P4 versus How would you rate your overall technical
skill level?

Source                      DF      SS     MS     F      P
How would you rate your      2   0.792  0.396  0.63  0.537
Error                      121  76.627  0.633
Total                      123  77.419

S = 0.7958   R-Sq = 1.02%   R-Sq(adj) = 0.00%

                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N    Mean   StDev  --+---------+---------+---------+-------
Low     4  1.5000  0.5774  (-----------------*-----------------)
Mod.   77  1.6753  0.7512                   (----*---)
High   43  1.5116  0.8830              (-----*-----)
                            --+---------+---------+---------+-------
                            0.80      1.20      1.60      2.00

Pooled StDev = 0.7958
------------------------------------------------------------------------------
```

One-way ANOVA: W4 versus How would you rate your overall technical skill level?

Source	DF	SS	MS	F	P
How would you rate your	2	4.63	2.31	1.16	0.317
Error	121	241.46	2.00		
Total	123	246.09			

S = 1.413 R-Sq = 1.88% R-Sq(adj) = 0.26%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
Low	4	2.250	0.957	(-------------------*-------------------)
Mod.	77	3.260	1.322	(----*---)
High	43	3.047	1.588	(------*-----)
				1.40 2.10 2.80 3.50

Pooled StDev = 1.413

One-way ANOVA: S2 versus How would you rate your overall technical skill level?

Source	DF	SS	MS	F	P
How would you rate your	2	0.148	0.074	0.08	0.928
Error	121	119.489	0.988		
Total	123	119.637			

S = 0.9937 R-Sq = 0.12% R-Sq(adj) = 0.00%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
Low	4	1.7500	0.5000	(-------------------*-------------------)
Mod.	77	1.8831	0.9173	(----*---)
High	43	1.9302	1.1422	(-----*-----)
				1.00 1.50 2.00 2.50

Pooled StDev = 0.9937

One-way ANOVA: W5 versus How would you rate your overall technical skill level?

Source	DF	SS	MS	F	P
How would you rate your	2	1.467	0.733	0.85	0.430
Error	121	104.469	0.863		
Total	123	105.935			

S = 0.9292 R-Sq = 1.38% R-Sq(adj) = 0.00%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev

```
Low     4  3.7500  1.2583  (-----------------*-----------------)
Mod.   77  4.0779  0.9565                    (----*---)
High   43  4.2558  0.8478                       (----*-----)
                           ---+---------+---------+---------+------
                            3.00      3.50      4.00      4.50

Pooled StDev = 0.9292
```

One-way ANOVA: E3 versus How would you rate your overall technical skill level?

```
Source                      DF      SS    MS     F      P
How would you rate your      2    3.32  1.66  1.12  0.331
Error                      121  180.10  1.49
Total                      123  183.42

S = 1.220   R-Sq = 1.81%   R-Sq(adj) = 0.19%

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level   N   Mean  StDev  --+---------+---------+---------+-------
Low     4  1.750  0.957  (----------------*----------------)
Mod.   77  2.675  1.152                          (---*---)
High   43  2.581  1.349                        (----*----)
                          --+---------+---------+---------+-------
                          0.70      1.40      2.10      2.80

Pooled StDev = 1.220
```

One-way ANOVA: E4 versus How would you rate your overall technical skill level?

```
Source                      DF       SS     MS     F      P
How would you rate your      2    0.604  0.302  0.31  0.731
Error                      121  116.323  0.961
Total                      123  116.927

S = 0.9805   R-Sq = 0.52%   R-Sq(adj) = 0.00%

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level   N    Mean   StDev  ---------+---------+---------+---------+
Low     4  4.0000  0.8165  (------------------*------------------)
Mod.   77  3.9221  0.8701              (---*----)
High   43  4.0698  1.1628               (-----*-----)
                           ---------+---------+---------+---------+
                                  3.50      4.00      4.50      5.00

Pooled StDev = 0.9805
```

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Education: Bachelor of Science Degree in Information Sciences and Technology, Spring 2011
Bachelor of Science Degree in Security and Risk Analysis, Spring 2011
Honors in Information Sciences and Technology
Thesis Title: A STUDY OF ATTITUDES RELATED TO THE USE OF CYBER-WARFARE
Thesis Supervisor: Gerald Santoro

Related Experience:

Information Security Internship and Part-Time work
The Boeing Company
Summer 2009 and Summer 2010 to present

Learning Assistant
College of Information Sciences and Technology
Classes: IST 220, IST411, IST 456 (3 semesters), SRA 221

Awards: Dean's List (7 semesters, expected 8)
Lockheed Martin IST Scholars Award
PNC Technologies Scholarship