

## Cognitive Hacking

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### Abstract

In this chapter, we define and propose countermeasures for a category of computer security exploits which we call "cognitive hacking." Cognitive hacking refers to a computer or information system attack that relies on changing human users' perceptions and corresponding behaviors in order to be successful. This is in contrast to denial of service (DOS) and other kinds of well-known attacks that operate solely within the computer and network infrastructure. Examples are given of several cognitive hacking techniques, and a taxonomy for these types of attacks is developed. Legal, economic, and digital government implications are discussed.

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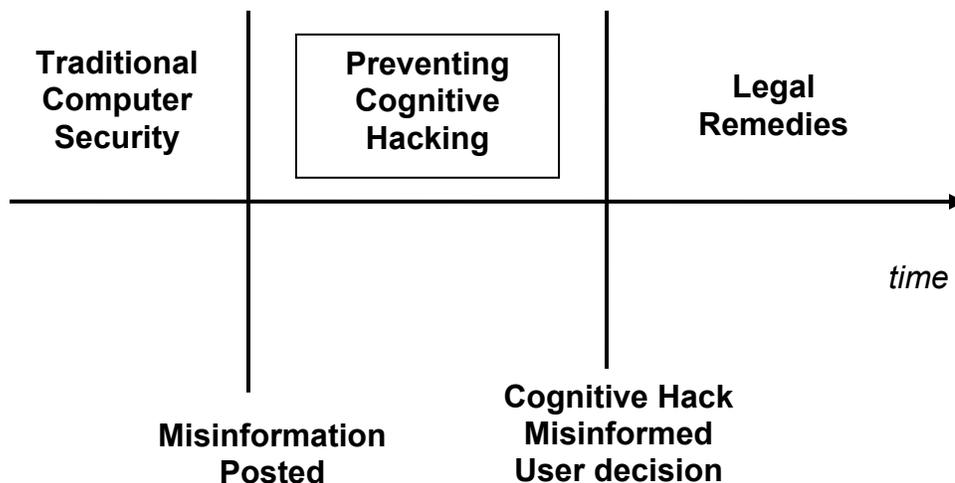
## 1. Introduction

Cognitive hacking refers to a computer or information system attack that relies on changing human users' perceptions and corresponding behaviors in order to be successful [24]. This is in contrast to denial of service (DOS) and other kinds of well-known attacks that operate solely within the computer and network infrastructure. With cognitive attacks neither hardware nor software is necessarily corrupted. There may be no unauthorized access to the computer system or data. Rather the computer system is used to influence people's perceptions and behavior through misinformation. The traditional definition of security is protection of the computer system from three kinds of threats:

unauthorized disclosure of information, unauthorized modification of information, and unauthorized withholding of information (denial of service). Cognitive attacks, which represent serious breaches of security with significant economic implications, are not well-covered by this definition.

In face to face interaction with other people, there is normally some context in which to evaluate information being conveyed. We associate certain reliability to information depending on who the speaker is and on what we know of the person. This type of evaluation cannot be transferred to the Web [99]. Anyone can post anything on a Web page with very few limitations. The issue is how to deal with false information on the Web and how to decide whether a source is reliable. People use Web technology for personal and economic reasons, e.g., buying shares or finding a job. What process takes place if a user makes a decision based on information found on the Web that turns out to be misinformation?

Consider the graph below. Most analyses of computer security focus on the time before misinformation is posted, i.e., on preventing unauthorized use of the system. A cognitive hack takes place when a user's behavior is influenced by misinformation. At that point the focus is on detecting that a cognitive hack has occurred and on possible legal action. Our concern is with developing tools to prevent cognitive hacking, that is, tools that can recognize and respond to misinformation before a user acts based on the misinformation.



## 1.1. Background

Computer and network security presents great challenges to our evolving information society and economy. The variety and complexity of cybersecurity attacks that have been

developed parallel the variety and complexity of the information technologies that have been deployed; with no end in sight for either. In this chapter, we distinguish three classes of information systems attacks: *physical*, *syntactic*, and *cognitive*. Physical and syntactic attacks can be considered together as autonomous attacks.

Autonomous attacks operate totally within the fabric of the computing and networking infrastructures. For example, the well-know Unicode attack against older, unpatched versions of Microsoft's Internet Information Server (IIS) can lead to root/administrator access. Once such access is obtained, any number of undesired activities by the attacker is possible. For example, files containing private information such as credit card numbers can be downloaded and used by an attacker. Such an attack does not require any intervention by users of the attacked system; hence we call it an "autonomous" attack.

By contrast, a *cognitive* attack requires some change in users' behavior, effected by manipulating their perceptions of reality. The attack's desired outcome cannot be achieved unless human users change their behaviors in some way. Users' modified actions are a critical link in a cognitive attack's sequencing. To illustrate what we mean by a cognitive attack, consider the following news report [62]:

"Friday morning, just as the trading day began, a shocking company press release from **Emulex** (Nasdaq: EMLX) hit the media waves. The release claimed that Emulex was suffering the corporate version of a nuclear holocaust. It stated that the most recent quarter's earnings would be revised from a \$0.25 per share gain to a \$0.15 loss in order to comply with Generally Accepted Accounting Principles (GAAP), and that net earnings from 1998 and 1999 would also be revised. It also said Emulex's CEO, Paul Folino, had resigned and that the company was under investigation by the Securities and Exchange Commission.

Trouble is, none of it was true.

The real trouble was that Emulex shares plummeted from their Thursday close of \$113 per share to \$43 -- a rapid 61% haircut that took more than \$2.5 billion off of the company's hide -- before the shares were halted an hour later. The damage had been done: More than 3 million shares had traded hands at the artificially low rates. Emulex vociferously refuted the authenticity of the press release, and by the end of the day the company's shares closed within a few percentage points of where they had opened."

Mark Jacob, 23 years old, fraudulently posted the bogus release on Internet Wire, a Los Angeles press-release distribution firm. The release was picked up by several business news services and widely redistributed scale without independent verification. The speed, scale and subtlety with which networked information propagates have created a new challenge for society, outside the domain of classical computer security which has

traditionally been concerned with ensuring that all use of a computer and network system is authorized.

The use of information to affect the behavior of humans is not new. Language, or more generally communication, is used by one person to influence another. Propaganda has long been used by governments, or by other groups, particularly in time of war, to influence populations [19, 30, 34]. Although the message conveyed by propaganda, or other communication intended to influence, may be believed to be true by the propagator, it usually is presented in a distorted manner, so as to have maximum persuasive power, and, often, is deliberately misleading, or untrue. Propaganda is a form of perception management. Other types of perception management include psychological operations in warfare [47], consumer fraud, and advertising [19, 77]. As described in section 1.5, deception detection has long been a significant area of research in the disciplines of psychology and communications.

## 1.2. Perception Management

As noted by many authors, e.g. [19, 28, 34, 77], perception management is pervasive in contemporary society. Its manifestation on the Internet is one aspect of the broader phenomenon. Not all perception management is negative, e.g., education can be considered a form of perception management; nor is all use of perception management on the Internet cognitive hacking (see definition in the next section). Clearly the line between commercial uses of the Internet such as advertising, which would not be considered cognitive hacking, and manipulation of stock prices by the posting of misinformation in news groups, which would be so considered, is a difficult one to distinguish.

## 1.3. Computer Security Taxonomies

In 1981 Landwehr provided a discussion of computer system security which has framed subsequent discussion of computer security [55]. His model arose from a consideration of the requirements of military security as automated systems replaced paper-based systems. He postulated that:

Information contained in an automated system must be protected from three kinds of threats: (1) the *unauthorized disclosure* of information, (2) the *unauthorized modification* of information, and (3) the *unauthorized withholding* of information (usually called *denial of service*).

He concludes his discussion by stating that “Without a precise definition of what security means and how a computer can behave, it is meaningless to ask whether a particular computer system is secure” [56]. If certain uses and sets of data can be completely isolated, then security modeling is tractable, but often this isolation is not possible, in part because the use of resources by a computer system conveys information. Although the analysis Landwehr presented was based on an analysis of secure military computing, he advises that the designer of an application must state in advance the security properties desired of the system, recognizing that systems with different goals and operating in different environments, will have different security needs.

Over the last 20 years earlier attempts in computer security research to develop formal security models designed into the computer system were abandoned as various models were shown to be undecidable [29]. As more and more elaborate security approaches were developed, they were rendered out of date by rapid changes in the computing environment, in particular the development of the World Wide Web. In recent years dramatic and costly computer viruses, denial of service attacks, and concerns with the security of e-commerce have drawn the attention of researchers in computer security. While these security breaches are a serious concern, cognitive hacking is a form of attack that deserves to receive more attention.

Cognitive hacking is defined here as gaining access to, or breaking into, a computer information system for the purpose of modifying certain behaviors of a human user in a way that violates the integrity of the overall user-information system. The integrity of such a system would for example include correctness or validity of the information the user gets from such a system. In this context, the integrity of a computer system can be defined more broadly than the definition implicit in Landwehr’s definition of computer security. Smith [87] refers to breaches in computer security as violations of the semantics of the computer system, i.e., the intended operation of the system. Wing argues a similar view [95]. In this sense the World Wide Web itself can be seen as a computer system used for communication, e-commerce, and so on. As such, activities conducted over the Web that violate the norms of communication or commerce, for example, fraud and propaganda, are considered to be instances of cognitive hacking, even if they do not involve illegitimate access to, or breaking into, a computer. For example, a person might maintain a website that presents misinformation with the intent of influencing viewers of the information to engage in fraudulent commercial transactions with the owner of the website.

Some examples of cognitive hacking, such as the manipulation of a Yahoo news item [68], are instances of Landwehr’s second threat, the *unauthorized modification* of information [55], but there are many other examples that do not fit Landwehr’s taxonomy. This is not surprising, because, as suggested by Landwehr, new applications, i.e., in this case web services, will have new security needs, which must be understood.

Two broad classes of cognitive hacking can be distinguished: overt and covert. With overt cognitive hacking no attempt is made to conceal the fact that a cognitive hack has occurred. For example, website defacement is a type of overt cognitive hacking. While a

website defacer may hope that the defacement is not noticed for as long as possible by a web page administrator, the web defacer's modification to the website is a blatant modification that the intended audience will realize immediately is not the unmodified website.

It has been estimated that 90% of attacks on web pages are total page hacks, where the attacker replaces the entire page of the attacked site [45]. This overt cognitive hacking, while much more prevalent than other covert forms discussed in this chapter, is more of a nuisance to web site administrators and an embarrassment to web site owners. Covert cognitive hacking, by contrast, is likely to have more significant consequences, because it can influence a user's perceptions and behavior.

Misinformation is often a covert form of cognitive hacking. Misinformation is an intentional distribution or insertion of false or misleading information intended to influence reader's decisions and / or activities. The open nature of the Internet makes it an ideal arena for the dissemination of misinformation [17].

The distinction between overt and covert cognitive hacking is not necessarily unambiguous. For example, the recent hacking of the Yahoo news story [68] was clearly not as blatantly overt as a typical web defacement. On the other hand, the changes introduced were obvious enough that the suspicions of a careful reader would soon be aroused. It is possible, though, to imagine subtler modifications that would have gone undetected by any reader not already familiar with a more reliable account of the news item.

#### 1.4. Semantic Attacks and Information Warfare

A definition of semantic attacks closely related to our discussion of cognitive hacking has been described by Schneier [85], who attributes the earliest conceptualization of computer system attacks as physical, syntactic, and semantic to Martin Libicki, who describes semantic attacks in terms of misinformation being inserted into interactions among intelligent agents on the Internet [60]. Schneier, by contrast, characterizes semantic attacks as “. . . attacks that target the way we, as humans, assign meaning to content.” He goes on to note, “Semantic attacks directly target the human/computer interface, the most insecure interface on the Internet” [85].

Denning's discussion of information warfare [28] overlaps our concept of cognitive hacking. Denning describes information warfare as a struggle over an information resource by an offensive and a defensive player. The resource has an exchange and an operational value. The value of the resource to each player can differ depending on factors related to each player's circumstances. The outcomes of offensive information warfare are: increased availability of the resource to the offense, decreased availability to the defense, and decreased integrity of the resource. Applied to the Emulex example, described below, Jakob is the offensive player and Internet Wire and the other newswire services are the defensive players. The outcome is decreased integrity of the newswires' content. From the perspective of cognitive hacking, while the above analysis would still hold, the main victims of the cognitive hacking would be the investors who were misled.

In addition to the decreased integrity of the information, an additional outcome would be the money the investors lost.

## **1.5 Deception Detection**

Deception of detection in interpersonal communication has long been a topic of study in the fields of psychology and communications [12, 21, 13]. The majority of interpersonal communications are found to have involved some level of deception. Psychology and communications researchers have identified many cues that are characteristic of deceptive interpersonal communication. Most of this research has focused on the rich communication medium of face to face communication, but more recently other forms of communication have been studied such as telephone communication and computer-mediated communication [99]. A large study is underway [14, 38] to train people to detect deception in communication. Some of this training is computer-based. Most recently a study has begun to determine whether psychological cues indicative of deception can be automatically detected in computer-mediated communication, e.g., e-mail, so that an automated deception detection tool might be built [98, 99].

## **1.6 Cognitive Hacking and Intelligence and Security Informatics**

Intelligence and security informatics [16] will be supported by data mining, visualization, and link analysis technology, but intelligence and security analysts should also be provided with an analysis environment supporting mixed-initiative interaction with both raw and aggregated data sets [89]. Since analysts will need to defend against semantic attacks, this environment should include a toolkit of cognitive hacking countermeasures. For example, if faced with a potentially deceptive news item from FBIS, an automated countermeasure might provide an alert using adaptive fraud detection algorithms [36] or through a retrieval mechanism allow the analyst to quickly assemble and interactively analyze related documents bearing on the potential misinformation. The author is currently developing both of these countermeasures.

Information retrieval, or document retrieval, developed historically to serve the needs of scientists and legal researchers, among others. Despite occasional hoaxes and falsifications of data in these domains, the overwhelming expectation is that documents retrieved are honest representations of attempts to discover scientific truths, or to make a sound legal argument. This assumption does not hold for intelligence and security informatics. Most information retrieval systems are based either on: a) an exact match Boolean logic by which the system divides the document collection into those documents matching the logic of the request and those that do not, or b) ranked retrieval. With ranked retrieval a score is derived for each document in the collection based on a measure of similarity between the query and the document's representation, as in the vector space model [83], or based on a probability of relevance [63, 82].

Although not implemented in existing systems, a utility theoretic approach to information retrieval [20] shows promise for a theory of intelligence and security informatics. In information retrieval predicting relevance is hard enough. Predicting utility, although harder, would be more useful. When information contained in, say, a FBIS document,

may be misinformation, then the notion of utility theoretic retrieval, becomes more important. The provider of the content may have believed the information to be true or false, aside from whether it was true or false in some objective sense. The content may be of great value to the intelligence analyst, whether it is true or false, but, in general, it would be important to know not only whether it was true or false, but also whether the provider believed it to be true or false. Current information retrieval algorithms would not take any of these complexities into account in calculating a probability of relevance.

Predictive modeling using the concepts of cognitive hacking and utility-theoretic information retrieval can be applied in two intelligence and security informatics settings which are mirror images of each other, i.e., the user's model of the system's document content and the systems model of the user as a potential malicious insider. Consider an environment where an intelligence analyst accesses sensitive and classified information from intelligence databases. The accessed information itself may represent cognitive attacks coming from the sources from which it has been gathered, e.g., FBIS documents. As discussed above, each of these documents will have a certain utility for the analyst, based on the analyst's situation, based on whether or not the documents contain misinformation, and, if the documents do contain misinformation, whether, or not, the analyst can determine that the misinformation is present. On the other hand, the analyst might be a malicious insider engaged in espionage. The document system will need to have a cost model for each of its documents and will need to build a model of each user, based on the user's transactions with the document system and other external actions.

Denning's theory of information warfare [28] and an information theoretic approach to the value of information [22, 23] can be used to rank potential risks given the value of each document held by the system. Particular attention should be paid to deception on the part of the trusted insider to evade detection. Modeling the value of information to adversaries will enable prediction of which documents are likely espionage targets and will enable development of hypotheses for opportunistic periods and scenarios for compromise. These models will be able to detect unauthorized activity and to predict the course of a multi-stage attack so as to inform appropriate defensive actions.

Misinformation, or cognitive hacking, plays a much more prominent role in intelligence and security informatics than it has played in traditional scientific informatics. The status of content as information, or misinformation, in turn, influences its utility for users. Cognitive hacking countermeasures are needed to detect and defend against cognitive hacking.

## **2. Examples of Cognitive Hacking**

This section summarizes several documented examples of cognitive hacking on the Internet and provides a more detailed discussion of the problem of the insider threat.

## 2.1 Internet Examples

Goals	Mode	Syntactic	Cognitive-overt	Cognitive-covert
Denial of Service				
Theft of Services		8		8,15
Theft of Information				4
Fraud Financial				1,2,3,4,5
Fraud- non Financial				6,7
Political			10,11,14,15,17	17
Commercial or Private Perception Management			6,9	6
Self-aggrandizement			12,13,15	
White Hat Hack			13,16	

**Table 1. Hacking with the Goal of Modifying User Behavior**

- |   |   |
|---|---|
| 1. NEI Webworld pump and dump               | 2. Jonathan Lebed case                              |
| 3. Fast-trades.com website pump and dump    | 4. PayPal.com                                       |
| 5. EMULEX press release to Internet Wire    | 6. Non-financial fraud - search engine optimization |
| 7. Non-financial fraud - CartoonNetwork.com | 8. Bogus virus patch report                         |
| 9. Usenet perception management             | 10. Hamas site                                      |
| 11. Ariel Sharon site                       | 12. New York Times site                             |
| 13. Yahoo site                              | 14. Afghanistan related web sites                   |
| 15. Fluffi Bunni declares Jihad             | 16. CNN site  |
| 17. WTO site                                |   |

Table 1 categorizes the types according to mode and goals. The various modes have been defined above while the goals are self-explanatory and discussed in more detail in the examples themselves.

### 1. NEI Webworld case.

In November 1999 two UCLA graduates students and one of their associates purchased almost all of the shares of the bankrupt company NEI Webworld at a price ranging from 0.05 to 0.17 per share. They opened many Internet message board accounts using a computer at the UCLA BioMedical Library and posted more than 500 messages on hot web sites to pump up the stock of the company, stating false information about the company with the purpose of convincing others to buy stock in the company. They claimed that the company was being taken over and that the target price per share was between 5 and 10 dollars. Using other accounts they also pretended to be an imaginary third party, a wireless telecommunications company, interested in acquiring NEI Webworld. What the three men did not post was the fact that NEI was bankrupt and had liquidated assets in May 1999. The stock price rose from \$0.13 to \$15 in less than one day, and they realized about \$364,000 in profits. The men were accused of selling their shares incrementally, setting target prices along the way as the stock rose. On one day the stock opened at \$8 and soared to \$15 5/16 a share by 9:45 a.m. ET and by 10:14 a.m. ET, when the men no longer had any shares, the stock was worth a mere 25 cents a share.

On Wednesday, December 15, 1999, the U.S. Securities and Exchange Commission (SEC) and the United States Attorney for the Central District of California charged the three men with manipulating the price of NEI Webworld, Inc. In late January 2001, two of them, agreed to gave up their illegal trading profits (approximately \$211,000). The Commission also filed a new action naming a fourth individual, as participating in the NEI Webworld and other Internet manipulations. Two of the men were sentenced on January 22, 2001 to 15 months incarceration and 10 months in a community corrections center. In addition to the incarcerations, Judge Feess ordered the men to pay restitution of between \$566,000 and \$724,000. The judge was to hold a hearing on Feb. 26 to set a specific figure. Anyone with access to a computer can use as many screen names as desired to spread rumors in an effort to pump up stock prices by posting false information about a particular company so that they can dump their own shares and give the impression that their own action has been above board.

## 2. The Jonathan Lebed case

A 15 years old student using only AOL accounts with several fictitious names was able to change the behavior of many people around the world making them act to his advantage [58]. In six months he gained between \$12,000 and \$74,000 daily each time he posted his messages and, according to the US Security Exchange Commission, he did that 11 times increasing the daily trading volume from 60,000 shares to more that a million. His messages sounded similar to the following one [59]:

DATE: 2/03/00 3:43pm Pacific Standard Time  
FROM: LebedTG1

FTEC is starting to break out! Next week, this thing will EXPLODE . . .  
Currently FTEC is trading for just \$21/2. I am expecting to see FTEC at  
\$20  
VERYSOON . . .  
Let me explain why . . .  
Revenues for the year should very conservatively be around \$20 million.  
The average company in the industry trades with a price/sales ratio of  
3.45. With 1.57 million shares outstanding, this will value FTEC at . . .  
\$44.  
It is very possible that FTEC will see \$44, but since I would like to  
remain very conservative . . . my short term price target on FTEC is still  
\$20!  
The FTEC offices are extremely busy . . . I am hearing that a number of  
HUGE deals are being worked on. Once we get some news from FTEC  
and the word gets out about the company . . . it will take-off to MUCH  
HIGHER LEVELS!  
I see little risk when purchasing FTEC at these DIRT-CHEAP PRICES.  
FTEC is making TREMENDOUS PROFITS and is trading UNDER BOOK  
VALUE!!!  
This is the #1 INDUSTRY you can POSSIBLY be in RIGHT NOW.  
There are thousands of schools nationwide who need FTEC to install  
security systems . . . You can't find a better positioned company than  
FTEC!  
These prices are GROUND-FLOOR! My prediction is that this will be the  
#1 performing stock on the NASDAQ in 2000. I am loading up with all of

the shares of FTEC I possibly can before it makes a run to \$20.  
Be sure to take the time to do your research on FTEC! You will probably never come across an opportunity this HUGE ever again in your entire life.

He sent this kind of message after having bought a block of stocks. The purpose was to influence people and let them behave to pump up the price by recommending the stock. The messages looked credible and people did not even think to investigate the source of the messages before making decisions about their money. Jonathan gained \$800,000 in six months. Initially the SEC forced him to give up everything, but he fought the ruling and was able to keep part of what he gained. The question is whether he did something wrong, in which case the SEC should have kept everything. The fact that the SEC allowed Jonathan to keep a certain amount of money shows that it is not clear whether or not the teenager is guilty from a legal perspective. Certainly, he made people believe that the same message was post by 200 different people.

Richard Walker, the SEC's director of enforcement, referring to similar cases, stated that on the Internet there is no clearly defined border between reliable and unreliable information, investors must exercise extreme caution when they receive investment pitches online.

### **3. Fast-Trade.com website pump and dump**

In February and March 1999, Douglas Colt, a Georgetown University law student, manipulated four traded stocks using the web site Fast-trade.com. Together with a group of friends he posted hundreds of false or misleading messages on Internet message boards such as Yahoo! Finance Raging Bull with the purpose of encouraging people to follow Fast-trade.com advice. The site offered a trial subscription and in less then two months more than 9,000 users signed up. The group was able to gain more than \$345,000.

### **4. PayPal.com**

"We regret to inform you that your username and password have been lost in our database. To help resolve this matter, we request that you supply your login information at the following website."

Many customers of PayPal received this kind of email and subsequently gave personal information about their PayPal account to the site linked by the message (<http://paypalsecure.com> not <http://www.paypal.com>) [52]. The alleged perpetrators apparently used their access to PayPal accounts in order to purchase items on eBay.

### **5. Emulex Corporation**

Mark S. Jakob, after having sold 3,000 shares of Emulex Corporation in a "short sale" at prices of \$72 and \$92, realized that, since the price rose to \$100, he lost almost \$100,000 [62]. This kind of speculation is realized by borrowing shares from a broker and selling them in hope that the price will fall. Once this happens, the shares are purchased back and the stock is returned to the broker with the short seller keeping the difference.

On August 25<sup>th</sup> 2000, when he realized the loss, he decided to do something against the company. The easiest and most effective action was to send a false press release to Internet Wire Inc. with the goal of influencing the stock price. He claimed that Emulex Corporation was being investigated by the Security and Exchange Commission (SEC) and that the company was forced to restate 1998 and 1999 earnings. The story quickly spread, and half an hour later other news services such as Dow Jones, Bloomberg and CBS Marketwatch picked up the hoax. Due to this false information, in a few hours Emulex Corporation lost over \$2 billion dollars. After sending misinformation about the company, Jakob executed trades so that he earned \$236,000. Jakob was arrested and charged with disseminating a false press release and with security fraud. He is subject to a maximum of 25 years in prison, a maximum fine of \$220 million, two times investor losses, and an order of restitution up to \$110 million to the victims of his action.

## **6. Non-financial fraud - web search engine optimization**

Con artists have defrauded consumers for many years over the telephone and via other means of communication, including direct personal interaction. Such financially-motivated fraud continues over the Internet, as described above. Some cognitive hacking uses misinformation in a fraudulent way that does not directly attack the end user.

One such use of misinformation is a practice [61] that has been called “search engine optimization”, or “index spamming”. Because many users of the Internet find pages through use of web search engines, owners of web sites seek to trick web search engines to rank their sites more highly when searched by web search engines. Many techniques, for example inaccurate metadata, printing white text on white background (invisible to a viewer of the page, but not to a search engine) are used. While this practice does not directly extort money from a user, it does prevent the user from seeing the search results that the user’s search would have returned based on the content of the web site. Thus the primary attack is on the search engine, but the ultimate target of the attack is the end user. Developers at web search engines are aware of this practice by web site promoters and attempt to defeat it, but it is an on-going skirmish between the two camps.

## **7. Non-financial fraud - CartoonNetwork.com**

Another common misinformation practice is to register misleading web site names, e.g., a name that might be expected to belong to a known company, or a close variant of it, such as a slight misspelling. In October 2001, the FTC [94] sought to close thousands of web sites that allegedly trap web users after they go to a site with a misleading name. According to the FTC, John Zuccarini registered slight misspelling of hundreds of popular Internet domain names. When a user goes to one of these sites a series of windows advertising various products opens rapidly, despite user attempts to back out of the original site. Zuccarini allegedly made \$800,000 to \$1,000,000 annually in advertising fees for such attacks.

## **8. Bogus virus patch report**

Although computer viruses are syntactic attacks, they can be spread through cognitive attacks. The W32/Redesi-B virus [88] is a worm which is spread through Microsoft Outlook. The worm is contained in an e-mail message that comes with a subject chosen randomly from 10 possible subjects, e.g., “FW: Security Update by Microsoft”. The text of the e-mail reads “Just received this in my email I have contacted Microsoft and they say it’s real” and then provides a forwarded message describing a new e-mail spread virus for which Microsoft has released a security patch which is to be applied by executing the attached file. The attached file is the virus. Thus a virus is spread by tricking the user into taking action thought to prevent the spread of a virus.

## **9. Usenet perception management**

Since the Internet is an open system where everybody can put his or her opinion and data, it is easy to make this kind of attack. Each user is able to influence the whole system or only a part of it in many different ways, for example by building a personal web site or signing up for a Newsgroup. Blocking the complete freedom to do these activities, or even checking what people post on the web, goes against the current philosophy of the system. For this reason technologies for preventing, detecting and recovering from this kind of attack are difficult to implement [17].

## **10. Political Web site defacements – Ariel Sharon site**

Web site defacements are usually overt cognitive attacks. For example, in January 2001, during an Israeli election campaign, the web site of Likud leader Ariel Sharon was attacked [8]. In this attack, and in the retaliatory attack described in example 11, no attempt was made to deceive viewers into thinking that the real site was being viewed. Rather the real site was replaced by another site with an opposing message. The Sharon site had included a service for viewers that allowed them to determine the location of their voting stations. The replacement site had slogans opposing Sharon and praising Palestinians. It also had a feature directing viewers to Hezbollah “polling stations”.

## **11. Political Web site Defacements – Hamas site**

Following the January attack on the Sharon web site, the web site of the militant group Hamas was attacked in March 2001 [7]. When the Hamas website was hacked, viewers were redirected to a hard-core pornography site.

## **12. New York Times site**

In February 2001 the New York Times web site was defaced by a hacker identified as “splurge” from a group called “Sm0ked Crew”, which had a few days previously defaced sites belonging to Hewlett-Packard, Compaq, and Intel [79, 80]. The New York Times defacement included html, a .MID audio file, and graphics. The message stated, among other things, “Well, admin I’m sorry to say by you have just got sm0ked by splurge. Don’t be scared though, everything will be all right, first fire your current security

advisor . . .” Rather than being politically motivated, such defacements as these appear to be motivated by self-aggrandizement.

### **13. Yahoo site**

In September of 2001 Yahoo’s news web site was edited by a hacker [68]. This cognitive hacking episode, unlike the defacements discussed above, was more subtle. While not as covert as hacking with the intent to engage in fraud or perception management, neither were the changes made to the website as obvious as those of a typical defacement. A 20-year old researcher confessed that he altered a Reuters news article about Dmitry Sklyarov, a hacker facing criminal charges. The altered story stated that Sklyarov was facing the death penalty and attributed a false quote to President Bush with respect to the trial.

### **14. Web site defacements since 11 September terrorist incident**

Since the 11 September terrorist incident, there have been numerous examples of web site defacements directed against web sites related to Afghanistan [57]. While official Taliban sites have been defaced, often sites in any way linked with Afghanistan were defaced indiscriminately, regardless of which sides they represented in the conflict.

### **15. Fluffi Bunni declares Jihad**

Another type of politically motivated cognitive hacking attack has been perpetrated by “Fluffi Bunni”, who has redirected numerous websites to a page in which Bunni’s opinion on current events is presented. This redirection appears to have been accomplished through a hacking of the Domain Name System Server of NetNames [41].

### **16. Web site spoofing - CNN site**

On 7 October 2001, the day that the military campaign against Afghanistan began, the top-ranked news story on CNN’s most popular list was a hoax, “Singer Britney Spears Killed in Car Accident”. The chain of events which led to this listing started with a web site spoofing of CNN.com [75]. Then, due to a bug in CNN’s software, when people at the spoofed site clicked on the “E-mail This” link, the real CNN system distributed a real CNN e-mail to recipients with a link to the spoofed page. At the same time with each click on “E-mail This” at the bogus site, the real site’s tally of most popular stories was incremented for the bogus story. Allegedly this hoax was started by a researcher who sent the spoofed story to three users of AOL’s Instant Messenger chat software. Within 12 hours more than 150,000 people had viewed the spoofed page.

In 1997 Felton and his colleagues showed that very realistic website spoofings could be readily made. More recently, Yuan et al. [97] showed that these types of website spoofs could be done just as easily with more contemporary web technologies.

## **17. Web site spoofing - WTO site**

Use of misleading domain names can also be political and more covert. Since 1999, a site, [www.gatt.org](http://www.gatt.org), has existed which is a parody of the World Trade Organization site, [www.wto.org](http://www.wto.org) [73]. Again, as in the case of the spoofing of the Yahoo new site mentioned above, the parody can be seen through fairly easily, but still could mislead some viewers.

## **2.2 Insider Threat**

Trusted insiders who have historically caused the most damage to national security were caught only after prolonged counterintelligence operations. These insiders carried out their illegal activities for many years without raising suspicion. Even when it was evident that an insider was misusing information, and even when attention began to focus on the insider in question as a suspect, it took more years before the insider was caught. Traditionally apprehension of trusted insiders has been possible only after events in the outside world had taken place, e.g., a high rate of double agents being apprehended and executed that led to an analysis eventually focusing on the insider. Once it was clear that there was likely a problem with insider misuse of information, it was eventually possible to determine the identity of the insider by considering who had access to the information and by considering other factors such as results of polygraph tests.

The insider threat, is much more pervasive, however, than a small number of high profile national security cases. It has been estimated that the majority of all computer security breeches are due to insider attacks, rather than to external hacking [4]

As organizations move to more and more automated information processing environments, it becomes potentially possible to detect signs of insider misuse much earlier than has previously been possible. Information systems can be instrumented to record all uses of the system, down to the monitoring of individual keystrokes and mouse movements. Commercial organizations have made use of such clickstream mining, as well as analysis of transactions to build profiles of individual users. Credit card companies build models of individuals' purchase patterns to detect fraudulent usage. Companies such as Amazon.com analyze purchase behavior of individual users to make recommendations for the purchase of additional products, likely to match the individual user's profile.

A technologically adept insider, however, may be aware of countermeasures deployed against him, or her, and operate in such a way as to neutralize the countermeasures. In other words, an insider can engage in cognitive hacking against the network and system administrators. A similar situation arises with Web search engines, where what has been referred to as a cold war exists between Web search engines and search engine optimizers, i.e., marketers who manipulate Web search engine rankings on behalf of their clients.

Models of insiders can be built based on: a) known past examples of insider misuse, b) the insider's work role in the organization, c) the insider's transactions with the information system, and d) the content of the insider's work product. This approach to

the analysis of the behavior of the insider is analogous to that suggested for analyzing the behavior of software programs by Munson and Wimer [70]. One aspect of this approach is to look for known signatures of insider misuse, or for anomalies in each of the behavioral models individually. Another aspect is to look for discrepancies among the models. For example, if an insider is disguising the true intent of his, or her, transactions by making deceptive transactions that disguise the true nature of what the insider is doing, then this cognitive hacking might be uncovered by comparing the transactions to the other models described above, e.g., to the insider's work product.

User models have long been of interest to researchers in artificial intelligence and in information retrieval [81,26]. Several on-going research programs have been actively involved in user modeling for information retrieval. The Language Modeling approach to probabilistic information retrieval has begun to consider query (user) models [54]. The Haystack project at MIT is building models of users based on their interactions with a document retrieval system and the user's collections of documents. The current focus of this project, however, seems to be more on overall system architecture issues, rather than on user modeling as such [46].

The current type of user modeling that might provide the best basis for cognitive hacking countermeasures is recommender system technology [92, 93, 44]. One of the themes of the recommender systems workshop held at the 1999 SIGIR conference [43] was the concern to make recommender systems applicable to problems of more importance than selling products. Since then, recommender systems technology has developed, but applications are generally still largely commercial. Researchers are concerned with developing techniques that work well with sparse amounts of data [31] and with scaling up to searching tens of millions of potential neighbors, as opposed to the tens of thousands of today's commercial systems [84]. Related to this type of user modeling, Anderson and Khattak [5] described preliminary results with the use of an information retrieval system to query an indexed audit trail database, but this work was never completed [3].

### **3. Economic and Digital Government Issues Related to Cognitive Hacking**

#### **3.1 An Information Theoretic Model of Cognitive Hacking**

Information theory has been used to analyze the value of information in horse races and in optimal portfolio strategies for the stock market [22]. We have begun to investigate the applicability of this analysis to cognitive hacking. So far we have considered the simplest case, that of a horse race with two horses. But the analysis can be easily extended to the case of the stock market.

Sophisticated hackers can use information theoretic models of a system to define a gain function and conduct a sensitivity analysis of its parameters. The idea is to identify and target the most sensitive variables of the system, since even slight alterations of their value may influence people's behavior. For example, specific information on the health of a company might help stock brokers predict fluctuations in the value of its shares. A cognitive hacker manipulates the victim's perception of the likelihood of winning a high payoff in a game. Once the victim has decided to play, the cognitive hacker influences which strategy the victim chooses.

### 3.1.1 A Horse Race

Here is a simple model illustrating this kind of exploit. A horse race is a system defined by the following elements [22]

- There are  $m$  horses running in a race
- each horse  $i$  is assigned a probability  $p_i$  of winning the race (so  $\{p_i\}_{i=1..m}$  is a probability distribution)
- each horse  $i$  is assigned an odds  $o_i$  signifying that a gambler that bet  $b_i$  dollars on horse  $i$  would win  $b_i o_i$  dollars in case of victory (and suffer a total loss in case of defeat).

If we consider a sequence of  $n$  independent races, it can be shown that the average rate of the wealth gained at each race is given by

$$W(b, p, o) = \sum_{i=1}^m p_i \log b_i o_i$$

Where  $b_i$  is the percentage of the available wealth invested on horse  $i$  at each race. So the betting strategy that maximizes the total wealth gained is obtained by solving the following optimization problem

$$W(p, o) = \max_b W(b, p, o) = \max_b \sum_{i=1}^m p_i \log b_i o_i$$

subject to the constraint that the  $b_i$ 's add up to 1. It can be shown that this solution turns

out to be simply  $b=p$  (proportional betting) and so  $W(p, o) = \sum_{i=1}^m p_i \log p_i o_i$ .

Thus, a hacker can predict the strategy of a systematic gambler and make an attack with the goal of deluding the gambler on his/her future gains. For example, a hacker might lure an indecisive gambler to invest money on false prospects. In this case it would be useful to understand how sensitive the function  $W$  is to  $p$  and  $o$  and tamper with the data in order to convince a gambler that it is worth playing (because  $W$  appears illusionary larger than it actually is).

To study the sensitivity of  $W$  to its domain variables we consider the partial derivatives of  $W$  with respect to  $p_i$  and  $o_i$  and see where they assume the highest values. This gives us information on how steep the function  $W$  is on subsets of its domain.

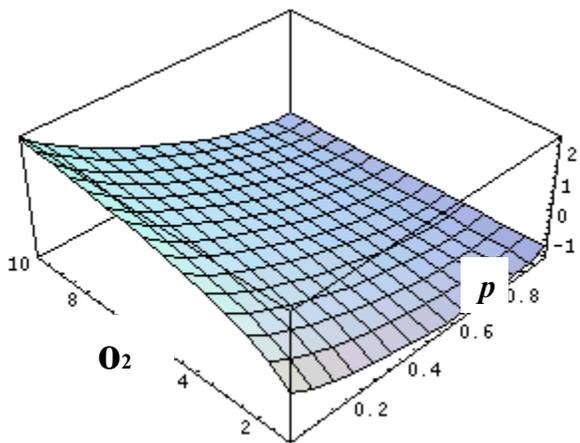
If we consider the special case of races involving only two horses ( $m=2$ ), then we have

$$W(p, o_1, o_2) = p \log p o_1 + (1 - p) \log(1 - p) o_2$$

- $\frac{\partial W}{\partial p}(p, o_1, o_2) = \log\left(\frac{p}{1-p} \frac{o_1}{o_2}\right)$
- $\frac{\partial W}{\partial o_1}(p, o_1, o_2) = \frac{p}{o_1}$
- $\frac{\partial W}{\partial o_2}(p, o_1, o_2) = \frac{1-p}{o_2}$

Thus, if we fix one of the variables then we can conduct a graphic analysis of those functions with a 3D plot.

**Case 1.**  $o_1$  is constant.



$$W(p, 3, o_2)$$

This is the doubling rate function. The most sensitive parameter to let  $W$  increase is  $o_2$ . Increasing this variable  $W$  grows at a fast rate for low values of  $p$  and grows with a smaller rate for higher values of  $p$ .

### 3.1.2 Applying the Horse Race Example to the Internet

Let's take into consideration the Mark Jacob case discussed earlier. In this example the two horses are: horse 1, Emulex stock goes up; and horse 2, Emulex stock goes down. First the cognitive hacker makes the victim want to play the game by making the victim think that he can make a large profit through Emulex stock transactions. This is done by spreading misinformation about Emulex, whether positive or negative, but news that, if true would likely cause the stock's value to either sharply increase, or decrease, respectively. Positive misinformation might be the news that Emulex had just been granted a patent that could lead to a cure for AIDS. Negative misinformation might be that Emulex was being investigated by the Securities and Exchange Commission (SEC) and that the company was forced to restate 1998 and 1999 earnings. This fraudulent negative information was in fact posted by Jakob.

### 3.2 Theories of the Firm and Cognitive Hacking

Much attention in economics has been devoted to theories of the market. The economic actor has been modeled as enjoying perfect, costless information. Such analyses, however, are not adequate to explain the operation of firms. Theories of the firm provide a complementary economic analysis taking into account transaction and organizing costs, hierarchies, and other factors left out of idealized market models. It has been argued that information technology will transform the firm, such that “. . . the fundamental building blocks of the new economy will one day be ‘virtual firms’, ever-changing networks of subcontractors and freelancers, managed by a core of people with a good idea” [33]. Others argue that more efficient information flows not only lower transaction costs, thereby encouraging more outsourcing, but also lower organization costs, thereby encouraging the growth of larger companies [2]. More efficient information flow implies a more standardized, automated processing of information, which is susceptible to cognitive attack. In this light Libicki’s characterization of semantic attacks in terms of misinformation being inserted into interactions among intelligent software agents [60] can be applied to misinformation’s potential to disrupt increasingly automated business processes, as well.

### 3.3 Digital Government and Cognitive Hacking

The National Center for Digital Government is exploring issues related to the transition from traditional person-to-person provision of government services to the provision of such services over the Internet. As excerpted from the Center’s mission statement:

Government has entered a period of deep transformation heralded by rapid developments in information technologies. The promise of digital government lies in the potential of the Internet to connect government actors and the public in entirely new ways. The outcomes of fundamentally new modes of coordination, control, and communication in government offer great benefits and equally great peril [71].

A digital government workshop held in 2003 [72], focused on five scenarios for future authentication policies with respect to digital identity:

- Adoption of a single national identifier
- Sets of attributes
- Business as usual, i.e., continuing growth of the use of ad-hoc identifiers
- Ubiquitous anonymity
- Ubiquitous identify theft.

The underlying technologies considered for authentication were: biometrics; cryptography, with a focus on digital signatures; secure processing/computation; and reputation systems.

Most of the discussion at the workshop focused on issues related to authentication of users of digital government, but, as the scenario related to ubiquitous identity theft implies, there was also consideration of problems related to misinformation, including cognitive hacking.

In the face to face interaction with other people associated with traditional provision of government services, there is normally some context in which to evaluate the reliability of information being conveyed. As we have seen, this type of evaluation cannot be directly transferred to digital government. The Internet's open nature makes it an ideal arena for dissemination of misinformation. What happens if a user makes a decision based on information found on the Web that turns out to be misinformation, even if the information appears to come from a government website? In reality, the information might be coming from a spoofed version of a government website. Furthermore, the insider threat is a serious concern for digital government.

#### **4. Legal Issues Related to Cognitive Hacking**

The Internet is a medium of communication, perception management, advertising and e-commerce, among other things. Laws that apply to other media related to these activities also apply to the Internet. However, as stated by Mensik and Fresen [66] of Baker & McKenzie:

As a new medium, the Internet compels the legal system to reexamine its fundamental principles. To accommodate the new medium, the legal system must adapt traditional doctrines and adopt new concepts in a way that protects rights and establishes a fair framework for assessing liability. Some say that neither common law nor civil law jurisdictions are capable of keeping pace with the rapid development of new technologies. This may be especially true in the global business arena of the Internet that defies the application of traditional legal principles. . . future electronic transactions will be performed solely between computers by electronic agents or "know-bots" and this lack of human involvement challenges fundamental assumptions of contract law, such as presented in the Uniform Commercial Code, that are necessarily based upon human interaction in the contracting process.

From a cognitive hacking perspective this last point about electronic agents is of interest as it relates this paper's definition of cognitive hacking as being targeted against a human user, to Libicki's [60] original definition of semantic attacks as being against agents (see below).

An attorney from Buchanan Ingersoll P.C. [11] provides this additional perspective:

Content providers, the businesses which hire them, as well as their advertising agencies and Web site developers, may be liable directly to victims for false or misleading advertising, copyright and trademark infringement, and possibly for vicarious infringements. The difference

between other forms of media and the Internet is that the Internet contemplates the publishing and linking of one site to another, which geometrically multiplies the possibility for exposure to claims. The electronic benefits of the Internet promotes the linking of information contained in one site to another and creates a higher likelihood of dissemination of offending material.

The Lanham Act, 15 U.S.C. §1125(a) [65] has been applied to the prosecution of false advertising on the Web. It provides that any person who “. . . uses in commerce any word, term, name, symbol, or device . . . false description of origin, false or misleading description of fact . . . which, (A) is likely to cause confusion, or to cause mistake, or to deceive as to affiliation, connection, or association of such person with another person, or as to the origin, sponsorship, or approval of his or her goods, services, or commercial activities by another person, or (B) in commercial advertising or promotion misrepresents the nature, characteristics, qualities, or geographic origin of his or her or another person’s goods, services, or commercial activities, shall be liable in a civil action by any person who believes that he or she is likely to be damaged by such an act.”

The Lanham Act, copyright, and trademark law, among other established areas of the law, are being used to decide cases related to cognitive hacking. For example in the area of search engine optimization, if company A’s web site uses the trademark of company B in metatags for company A’s web site in order to divert web searches for company B to company A’s web site, then company A could be liable for trademark infringement or false advertising under the Lanham Act. On the other hand company A could argue that its use of metatags was protected under trademark principles of fair use or First Amendment principles of free speech. As a more extreme action, company A might download the entire content of a popular web site from company B and incorporate it into company A’s web site with all of the company B content printed white on white background, so that it would be invisible to human viewers, but visible to web search engines. This would be a violation of copyright laws and possibly also be considered unfair competition and trademark dilution [1].

The application of the law to cognitive hacking and other areas related to the Internet is a very volatile area of the law. The events of September 2001 have only made the situation more volatile as the debate between privacy and security has shifted. It is to be expected that more legislation affecting this area will be enacted and that the associated case law will continue to evolve over the coming years.

If cognitive hacking challenges security experts because it aims at the vulnerable human/computer interface, it challenges legal experts because it both targets and exploits information, the very lifeblood of free speech and democracy [25]. Criminal prosecution and civil lawsuits may help combat cognitive hacking, but this will be possible only in compliance with free speech protection. Laws already exist that can fight disinformation without violating fundamental rights. But cognitive hacking introduces new characteristics requiring revised legal doctrines. Ultimately, confronting cognitive hacking will require integrating legal and technological anti-hacking tools.

Within the United States, where the U.S. Constitution prevails, legal action seeking to regulate cognitive hacking can conflict with First Amendment free speech protection. The First Amendment prohibits government punishment of “false” ideas or opinions. The competition of ideas, not legislatures or courts, determines what ideas and opinions society accepts. And while false *facts* lack constitutional protection, the U.S. Supreme Court has ruled that the news media as well as non-news media discussion of public issues or persons require some margin of factual error to prevent chilling legitimate debate. “The First Amendment requires that we protect some falsehood in order to protect speech that matters.” [39]

Punishing web defacement should present no First Amendment concerns. As with graffiti in the physical world [74], the First Amendment does not shield unauthorized damage to property of others. Distribution of false information with an intent to defraud or manipulate should also require little First Amendment consideration.

However, a regulatory measure aimed at the content of the cognitive hacking, on what the hacking *says*, would likely fail constitutionally unless the state interest were compelling and no content-neutral alternative were available. Attempts within the United States to stop a web site or metatags or list server postings from expressing unpopular views would also struggle to pass First Amendment muster [78].

Indeed, many legal avenues already exist for attacking cognitive hacking consistent with First Amendment rights.

Some forms of cognitive hacking are tightly coupled with conduct that has legal consequences. Web defacement requires breaking into another’s web site, and therefore could be characterized as vandalism, destruction of property, trespassing, or, under the right circumstances, a violation of the Electronic Communications Privacy Act of 1986. As described above, manipulating securities markets through cognitive hacking can trigger prosecution under the securities laws. If unauthorized use of a software robot to harvest information from another’s web site can be trespassing [32], perhaps so is feeding false data into another’s software robot that is harvesting web information.

Other forms of cognitive hacking involve incendiary or factually false statements beyond First Amendment protection. Disseminating false information to secure an agreement could be the basis of legal actions for fraud or misrepresentation. Disseminating false information that damages the reputation of a person, business, or product could lead to a libel, defamation, or commercial disparagement suit. Incorporating trademarks of others as metatags that mislead consumers about the origin of goods or services or reduce the goodwill associated with a mark could be reached through the legal remedies provided by trademark and trademark antidilution statutes.

The special persuasive powers of computer output create an extra dimension of legal concern. Humans are quick to believe what they read and see on their computer screen. Even today, it is common to hear someone say a fact must be true because they read it on the web. A web site’s anthropomorphic software agent is likely to enjoy greater credibility than a human, yet no conscience will prevent an anthropomorphic agent from saying whatever it has been programmed to say [42]. Cognitive hackers may therefore

require new legal doctrines because their mechanisms apparently bypass normal human critical thinking.

Still more elusive will be identifying and taking meaningful legal action against the perpetrator. The speed and lack of human intervention that is typically associated with cognitive hacking, combined with the lack of definitive identification information generally inherent in the Internet's present architecture, complicate legal proof of who is the correct culprit. Privacy protection makes the task more difficult. Even if identified, the individual or entity may disappear or lack the assets to pay fines or damages.

Attention may therefore focus instead on third-party intermediaries, such as Internet service providers, web sites, search engines, and so forth, just as it has for Internet libel, copyright infringement, and pornography. Intermediaries are likely to have greater visibility and more assets, making legal action easier and more productive. A cognitive hacking victim might contend that an intermediary or the producer of web-related software failed to take reasonable measures to defend against cognitive hacking. An intermediary's legal responsibility will grow as the technological means for blocking cognitive hacking become more effective and affordable. Rapid technological advances with respect to anti-hacking tools would empower raising the bar for what is considered reasonable care.

The actual application of the law to cognitive hacking is still in formation. It is to be expected that case law with respect to cognitive hacking will continue to evolve over the coming years. Enactment of specific legislation is also possible.

## **5. Cognitive Hacking Countermeasures**

Given the variety of approaches documented above and the very nature of cognitive hacking, *preventing* cognitive hacking reduces either to preventing unauthorized access to information assets (such as in web defacements) in the first place or detecting posted misinformation before user behavior is affected (that is, before behavior is changed but possibly after the misinformation has been disseminated). The latter may not involve unauthorized access to information, as for instance in "pump and dump" schemes that use newsgroups and chat rooms. By definition, *detecting* a successful cognitive hack would involve detecting that the user behavior has already been changed. We are not considering detection in that sense at this time.

Our discussion of methods for preventing cognitive hacking will be restricted to approaches that could automatically alert users of problems with their information source or sources (information on a web page, newsgroup, chat room and so on). Techniques for preventing unauthorized access to information assets fall under the general category of computer and network security and will not be considered here. Similarly, detecting that users have already modified their behaviors as a result of the misinformation, namely that a cognitive hack has been successful, can be reduced to detecting misinformation and correlating it with user behavior.

The cognitive hacking countermeasures discussed here will be primarily mathematical and linguistic in nature. The use of linguistic techniques in computer security has been pioneered by Raskin and colleagues at Purdue University's Center for Education and Research in Information Assurance and Security [6]. Their work, however, has not addressed cognitive hacking countermeasures.

## 5.1 Single Source Cognitive Hacking

In this section, we propose a few possible approaches for the single source problem. By single source, we mean situations in which redundant, independent sources of information about the same topic are not available. An authoritative corporate personnel database would be an example.

### 5.1.1 Authentication of Source

This technique involves due diligence in authenticating the information source and ascertaining its reliability. Various relatively mature certification and PKI technologies can be used to detect spoofing of an information server. Additionally, reliability metrics can be established for an information server or service by scoring its accuracy over repeated trials and different users. In this spirit, Lynch [61] describes a framework in which trust can be established on an individual user basis based on both the identity of a source of information, through PKI techniques for example, and in the behavior of the source, such as could be determined through rating systems. Such an approach will take time and social or corporate consensus to evolve.

### 5.1.2 Information "Trajectory" Modeling

This approach requires building a model of a source based on statistical historical data or some sort of analytic understanding of how the information relates to the real world. For example, weather data coming from a single source (website or environmental sensor) could be calibrated against historical database (from previous years) or predictive model (extrapolating from previous measurements). A large deviation would give reason for hesitation before committing to a behavior or response.

As an interesting aside, consider the story lines of many well-scripted mystery novels or films. We believe that the most satisfying and successful stories involve a sequence of small deviations from what is expected. Each twist in the story is believable but when aggregated, the reader or viewer has reached a conclusion quite far from the truth. In the context of cognitive hacking, this is achieved by making a sequence of small deviations from the truth, not one of which fails a credibility test on its own. The accumulated deviations are however significant and surprise the reader or viewer who was not paying much attention to the small deviations one by one. However, a small number of major "leaps of faith" would be noticed and such stories are typically not very satisfying. Modeling information sources is something that can be done on a case-by-case basis as determined by the availability of historical data and the suitability of analytic modeling.

### 5.1.3 Ulam Games

Stanislaw Ulam in his autobiography *Adventure of a Mathematician* posed the following question [91].

“Someone thinks of a number between one and one million (which is just less than  $2^{20}$ ). Another person is allowed to ask up to twenty questions, to which the first person is supposed to answer only yes or no. Obviously, the number can be guessed by asking first: "Is the number in the first half-million?" and then again reduce the reservoir of numbers in the next question by one-half, and so on. Finally, the number is obtained in less than  $\log_2(1000000)$ . Now suppose one were allowed to lie once or twice, then how many questions would one need to get the right answer?”

Of course, if an unbounded number of lies are allowed, no finite number of questions can determine the truth. On the other hand, if say  $k$  lies are allowed, each binary search question can be repeatedly asked  $2k + 1$  times which is easily seen to be extremely inefficient. Several researchers have investigated this problem, using ideas from error-correcting codes and other areas [69].

This framework involves a sequence of questions and a bounded number of lies, known a priori. For these reasons, we suspect that this kind of model and solution approach may not be useful in dealing with the kinds of cognitive hacking we have documented, although it will clearly be useful in cognitive hacking applications that involve a sequence of interactions between a user and an information service, as in a negotiation or multi-stage handshake protocol.

### 5.1.4 Linguistic Countermeasures with Single Sources

#### 5.1.4.1 Genre Detection and Authority Analysis

A careful human reader of some types of misinformation, e.g., exaggerated pump-and-dump scheme postings on the Web about a company's expected stock performance, can often detect the misinforming posting from other legitimate postings, even if these legitimate postings are also somewhat hyperbolic. Since Mosteller and Wallace's seminal work on authorship attribution in the 1964 [67], statistical linguistics approaches have been used to recognize the style of different writings. In Mosteller and Wallace's work this stylistic analysis was done to determine the true author of anonymous Federalist papers, where the authorship was disputed. Since then Biber and others [9,10,50] have analyzed the register and genre of linguistic corpora using similar stylistic analysis. Kessler et al. [51] have developed and tested algorithms based on this work to automatically detect the genre of text.

### 5.1.4.2 Psychological Deception Cues

The approach to genre analysis taken, e.g., by Biber and Kessler et al., is within the framework of corpus linguistics, i.e., based on a statistical analysis of general word usage in large bodies of text. The work on deception detection in the psychology and communications fields (see section 1.5) is based on a more fine-grained analysis of linguistic features, or cues. Psychological experiments have been conducted to determine which cues are indicative of deception. To date this work has not led to the development of software tools to automatically detect deception in computer-mediated communication, but researchers see the development of such tools as one of the next steps in this line of research [99].

## 5.2 Multiple Source Cognitive Hacking

In this section, we discuss possible approaches to preventing cognitive hacking when multiple, presumably redundant, sources of information are available about the same subject of interest. This is clearly the case with financial, political and other types of current event news coverage.

Several aspects of information dissemination through digital, network media, such as the Internet and World Wide Web, make cognitive hacking possible and in fact relatively easy to perform. Obviously, there are enormous market pressures on the news media and on newsgroups to quickly disseminate as much information as possible. In the area of financial news, in particular, competing news services strive to be to the first to give reliable news about breaking stories that impact the business environment. Such pressures are at odds with the time consuming process of verifying accuracy. A compromise between the need to quickly disseminate information and the need to investigate its accuracy is not easy to achieve in general.

Automated software tools could in principle help people make decisions about the veracity of information they obtain from multiple networked information systems. A discussion of such tools, which could operate at high speeds compared with human analysis, follows.

### 5.2.1 Source Reliability via Collaborative Filtering & Reliability Reporting

The problem of detecting misinformation on the Internet is much like that of detecting other forms of misinformation, for example in newsprint or verbal discussion. Reliability, redundancy, pedigree and authenticity of the information being considered are key indicators of the overall “trustworthiness” of the information. The technologies of collaborative filtering and reputation reporting mechanisms have been receiving more attention recently, especially in the area of on-line retail sales [96, 27]. This is commonly used by the many on-line price comparison services to inform potential customers about vendor reliability. The reliability rating is computed from customer reports.

Another technology, closely related to reliability reporting is collaborative filtering. This can be useful in cognitive hacking situations that involve opinions rather than hard objective facts. See [90] for details about collaborative filtering approaches.

Both of these approaches involve user feedback about information that they receive from a particular information service, building up a community notion of reliability and usefulness of a resource. The automation in this case is in the processing of the user feedback, not the evaluation of the actual information itself.

### **5.2.1.1 An Example of a Multiple Source Collaborative Filtering Model for Multiple News Sources**

Consider the following scenario. An end user is examining a posting to the business section of Google News [40]. The document purports to provide valuable news about a publicly traded company that the user would like to act on quickly by purchasing, or selling stock. Although this news item might be reliable, it might also be misinformation being fed to unwary users by a cognitive hacker as part of a pump-and-dump scheme, i.e., a cognitive hacker's hyping of a company by the spread of false, or misleading information about the company and the hacker's subsequent selling of the stock as the price of its shares rise, due to the misinformation. The end user would like to act quickly to optimize his or her gains, but could pay a heavy price, if this quick action is taken based on misinformation.

A cognitive hacking countermeasure is under development which will allow an end user to effectively retrieve and analyze documents from the Web that are similar to the original news item. First, a set of documents retrieved by the Google News clustering algorithm. The Google News ranking of the clustered documents is generic, not necessarily optimized as a countermeasure for cognitive attacks. We are developing a combination process in which several different search engines are used to provide alternative rankings of the documents initially retrieved by Google News. The ranked lists from each of these search engines, along with the original ranking from Google News, will be combined using the Combination of Expert Opinion algorithm [64] to provide a more optimal ranking. Relevance feedback judgments from the end user will be used to train the constituent search engines. It is expected that this combination and training process will yield a better ranking than the initial Google News ranking. This is an important feature in a countermeasure for cognitive hacking, because a victim of cognitive hacking will want to detect misinformation as soon as possible in real time.

## **5.2.2 Byzantine Generals Models**

Chandy and Misra [15] define the Byzantine General's Problem as follows:

A message-communicating system has two kinds of processes, *reliable* and *unreliable*. There is a process, called *general*, that may or may not be reliable.

Each process  $x$  has a local variable  $byz[x]$ . It is required to design an algorithm,

to be followed by all reliable processes, such that every reliable process  $x$  eventually sets its local variable  $byz[x]$ , to a common value. Furthermore, if  $general$  is reliable, this common value is  $d0[g]$ , the initial value of one of  $general$ 's variables. The solution is complicated by the fact that unreliable processes send arbitrary messages. Since reliable processes cannot be distinguished from the unreliable ones, the straightforward algorithm-- $general$  transmits its initial value to all processes and every reliable process  $u$  assigns this value to  $byz[u]$ --does not work, because  $general$  itself may be unreliable, and hence may transmit different values to different processes.

This problem models a group of generals plotting a coup. Some generals are reliable and intend to go through with the conspiracy while others are feigning support and in fact will support the incumbent ruler when the action starts. The problem is to determine which generals are reliable and which are not.

Just as with the Ulam game model for a single information source, this model assumes a sequence of interactions according to a protocol, something that is not presently applicable to the cognitive hacking examples we have considered, although this model is clearly relevant to the more sophisticated information sources that might arise in the future.

### 5.2.3 Detection of Collusion by Information Sources

Collusion between multiple information sources can take several forms. In pump and dump schemes, a group may hatch a scheme and agree to post misleading stories on several websites and newsgroups. In this case, several people are posting information that will have common facts or opinions, typically in contradiction to the consensus.

Automated tools for preventing this form of cognitive hack would require natural language processing to extract the meaning of the various available information sources and then compare their statistical distributions in some way. For example, in stock market discussion groups, a tool would try to estimate the "position" of a poster, from "strong buy" to "strong sell" and a variety of gradations in between. Some sort of averaging or weighting could be applied to the various positions to determine a "mean" or expected value, flagging large deviations from that expected value as suspicious.

Similarly, the tool could look for tightly clustered groups of messages, which would suggest some form of collusion. Such a group might be posted by the one person or by a group in collusion, having agreed to the form of a cognitive hack beforehand.

Interestingly, there are many statistical tests for detecting outliers but much less is known about detecting collusion which may not be manifest in outliers but in unlikely clusters that may not be outliers at all. For example, if too many eyewitnesses agree to very specific details of a suspect's appearance (height, weight, and so on), this might suggest

collusion to an investigator. For some interesting technology dealing with corporate insider threats due to collusion, see [100].

Automated software tools that can do natural language analysis of multiple documents, extract some quantitative representation of a "position" based on that document and then perform some sort of statistical analysis of the representations are in principle possible, but we are not aware of any efforts working at developing such a capability at this time.

## 5.2.4 Linguistic Countermeasures with Multiple Sources

### 5.2.4.1 Authorship Attribution

Stylistic techniques from linguistics are also potential tools for determining the likelihood of authenticity of multiple documents being analyzed [67]. Suppose we are given a set of documents authored by one or more people hiding themselves under possibly multiple pseudonyms. It would be desirable to group the documents according to the real author; that is, to partition the documents into subsets of papers all belonging to the same author.

The main idea is to embed the given document into a finite dimensional linear feature space of stylistic language usage with some notion of stylistic distance in that space. By performing cluster and other types of analyses on the writing and linguistic style of the whole document or sections thereof, it might be possible to establish which sections of documents are stylistically similar and so, presumably, authored by the same writer.

This kind of detection cannot be applied to short messages, but for a consistent length and enough words, it could determine, with high confidence the stylistic characteristic of the author, or source [77].

## 6. Future Work

In this chapter a variety of cognitive hacking countermeasures have been described, but implementation has begun on only a few of them. Our future work lies in implementation of the remaining countermeasures and in the development of countermeasures that can be used not only against cognitive attacks, but against semantic attacks more broadly, such as the attacks with misinformation against autonomous agents, as described in Libicki's original definition of semantic hacking.

## 7. Summary and Conclusions

This chapter has defined a new concept in computer network security, cognitive hacking. Cognitive hacking is related to other concepts, such as semantic hacking, information warfare, and persuasive technologies, but is unique in its focus on attacks via a computer network against the mind of a user. Psychology and Communications researchers have

investigated the closely related area of deception and detection in interpersonal communication, but have not yet begun to develop automated countermeasures. We have argued that cognitive hacking is one of the main features which distinguishes intelligence and security informatics from traditional scientific, medical, or legal informatics. If, as claimed by psychologists studying interpersonal deception, most interpersonal communication involves some level of deception, then perhaps communication via the Internet exhibits a level of deception somewhere between that of face to face interpersonal communication, on the one hand, and scientific communication on the other. As the examples from this chapter show, the level of deception on the Internet and in other computer networked settings is significant, and the economic losses due to cognitive hacking are substantial. The development of countermeasures against cognitive hacking is an important priority.

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