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A THEORETICAL FRAMEWORK ON THE LINK BETWEEN MOTIVATION AND INNOVATION IN HACKERS

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Abstract

The purpose of this paper was to develop a set of theoretical propositions surrounding the link between motivation and innovation. The amount of money spent on research and development in organizations suggests that companies are paying more attention to innovation because it is needed in order for them to gain market advantage and survive. The question that this raises is how to motivate employees to be more innovative. This paper proposes the use of hackers as a basis to understand how innovative solutions are developed. Through doing so, detailed arguments are presented on how varying levels of innovation can be derived from different types of hackers based on the level and type of motivators they possess. Areas for future research are provided, as are practical implications for organizations on how to facilitate develop similar levels of innovation as those of hackers.

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A Theoretical Framework on the Link between Motivation and Innovation in Hackers

In today's competitive work environment, organizations need to continually develop innovative solutions to age old problems in order to survive. Being able to adapt to changes and uncertainties is especially important for organizations working within technology fields (Massey, 2002). Whether designing software or hardware, the quality of innovations in technology driven organizations can be the deciding factor in determining whether or not they will succeed or fail. Two such examples of successful and unsuccessful adaptability in organizations can be seen in Apple and General Motors.

While multiple reasons exist to explain why Apple has attained such strong growth whereas General Motors has had to file for bankruptcy, the major reason cited for the differences in their success was their ability to adapt to changing consumer demands through the development of innovative products (Cohan, 2009). Fifteen years ago, the state of Apple was questionable. Sales of Apple products had dropped dramatically and the company had been within three months of declaring bankruptcy (Kirsner, 2011). The executives at Apple noted this danger and, with the help of Steve Jobs, redeveloped Apple's strategic plan to focus on areas of the market in which it dominated creative agencies and schools. The company worked to redesign its hardware and software each year to stay ahead of the market. One example of this is their iPod line for which Apple has released new models, designs, and functions each year since the start of the iPod in 2001 (Apple, 2012). In addition to their iPod products, they have provided yearly updates to their operating systems. Apple's focus on new innovations has been highlighted in their 2010 report, which showed that 60% of their revenue came from products that did not exist three years ago.

Similar to Apple, General Motors noticed a decrease in their sales after years of being at the top of their industry. General Motors was in operation for 101 years, during which they led global sales in automobiles and was the largest automaker in the United States (Isidore, 2009). However, in 2009 General Motors filed for bankruptcy (Cohan, 2009). One of the main reasons cited for their failure was their inability to adapt to changing customer needs. Whereas other successful automakers were able to create new and innovative features, General Motors sacrificed innovation for short-term financial gains (Maynard, 2008).

Therefore, in order to survive companies need to be able to innovate. In fact, a survey by Global Innovation 1000 revealed that worldwide Research and Development spent $550 billion in 2010 (Jaruzelski, Loehr, & Holman, 2011). With such a large investment placed on innovations, companies are often trying to find novel ways to develop new ideas. An increasingly popular method for developing innovations, particularly in technology-driven organizations, is through the use of hackers. Hackers, as defined by Falk (2004) and Mulhall (1997), are the users of unorthodox methods to tinker with technologies. Hackers are often viewed in a negative light through typically being associated with having malicious intentions (Falk, 2004). However, there are multiple examples in which organizations have benefited from the unique innovations that hackers were able to provide.

Two recent examples of the generation of novel ideas through hackers can be seen with George Hotz and Steve Kondik. George Hotz gained immediate fame in the user community when he hacked the iPhone (Clemmitt, 2011). Hotz was able to make configurations that allowed the iPhone to be used outside of the AT&T network and allowed its users to install third-party applications. This attracted attention and demand from many individuals in the user community, which led Hotz to design and release multiple versions of his software. Facebook took advantage

of Hotz's innovativeness and hired him as a full-time employee (Smith, 2011). Similarly, Steve Kondik became famous from his hacking activities on Android smart phones (Clemmitt, 2011). He created a new operating system called CyanogenMod for the Android smart phones, which improved the overall efficiency of the Android phone. This operating system gained quick recognition and utilization among Android users and eventually, Samsung Mobile took notice of Kondik's innovativeness and made him a part of their staff.

Even though Hotz and Kondik were able to generate and implement novel ideas through hacking, Hotz's actions, like those of many hackers, were declared by Apple to be illegal (Clemmitt, 2011). Hotz was also sued by Sony for hacking into the PlayStation 3 gaming system. Despite the unique perspective that hackers are able to offer on software design, their actions are often viewed negatively by organizations. The question this raises is, how can we benefit from the unique ideas developed by hackers and the act of hacking without encountering a negative response from organizations? In order to answer this question, it is first important to take an in-depth look at what motivates hackers and how this motivation leads to innovation.

The purpose of this study is therefore twofold. First, to catalog the motivations of hackers and develop a set of theoretical propositions on how these motivations link to innovation and second, to elaborate on how the process of directly employing hackers may impact their level of innovation. The secondary purpose of this study is linked to the growing trend used by organizations in making hackers a part of their full-time staff (cf. Clemmitt, 2011). Through addressing both goals of the study, my primary contribution to the field will be to combine the emerging stream of literature in information sciences on hackers with the more established literatures in organizational behavior on work motivation, innovation, and socialization to better characterize the role of hackers in organizations

Definitions of Hackers

As shown in Table 1, hackers can be defined in many ways. One of the most frequently cited definitions of hacking comes from Mulhall (1997), who defines hacking as an act of using unorthodox methods to test and tinker with technologies. Hacking activities can further be classified according to the type of hacker performing the task. These hackers consist of three main types: White Hats, Black Hats, and Gray Hats (Arnone, 2005; Falk, 2004). White Hats refer to the professionals paid to research the vulnerabilities of the employers' or clients' system. These hackers typically operate within the rules of their organizations and government laws (Arnone, 2005). They are also called Ethical Hackers (Palmer, 2001). Black Hats are hackers who break the laws. Their malicious actions often involve illegitimately exploiting the targets' security flaws. Black Hats are also called Crackers (Curran, Breslin, McLaughlin, & Tracey, 2008). Gray Hats refer to hackers who penetrate other parties' systems without malicious intentions. Arnone (2005) also identified Gray Hats as hackers who alert users of vulnerabilities after tinkering with the system. Hackers are also often times confused with Cybercriminals (Arnone, 2005). However, cybercriminals typically use existing tools and techniques created by Black Hats and Gray Hats to steal information and financial data. Given that Cybercriminals do not manipulate or develop their own systems, they are not considered to be hackers (cf. Arnone, 2005).

The classification of hackers proposed by Arnone (2005) and Falk (2004) has been the most comprehensive to-date. As illustrated in Table 1, despite the number of definitions that exist on hackers or hacking, they can all be classified as referring to one or more of the types in Arnone's (2005) and Falk's (2004) typology. It is difficult for individuals conducting research on hacking to develop a cohesive body of literature without first having a shared definition on what

hacking or hackers are. Arnone (2005) and Falk (2004) therefore help to address this gap in the literature. In addition to having a shared definition or typology on hackers, research is also needed that further characterizes the differences among these three roles. The current paper will help to address this through determining how these roles differ according to their levels and sources of motivation.

Definition of Motivation: Review of Previous Theoretical Models

Many definitions and theories of motivation exist. Campbell, Dunnette, Lawler, and Weick (1970) categorize the various theories of motivation into two groups: content theories and process theories. Content theories were created to apply to all people under all circumstances. They assume that people behave in ways to satisfy their needs. Content theories include Maslow's Needs Hierarchy Theory, Alderfer's ERG Theory, McClelland's Needs Theory, Herzberg's Two-Factor Theory, and Self-Determination Theory (SDT). Content theories formed the basis of early theories on work motivation. As motivation theories solidified, researchers focused on specific variables of motivation, in more specific settings. This led to the birth of process theories. Process theories assume that people behave in ways that involve cognitive thought processes. Process theories are concerned with explaining behaviors and thought processes when people attempt to satisfy their needs. These theories include Vroom's Expectancy Theory, Locke's Goal-Setting Theory, and Adams' Equity Theory. A third type of motivation theory that arose was environmental-based theories. The most prominent theory in this category was Skinner's Operant Conditioning. This theory attempted to explain how people keep behaving in certain ways. Skinner's (1974) theory makes the assumption that peoples' behaviors are determined by external factors and that there is no need to examine their inner needs. These motivation theories have built upon each other and evolved from universal application of human needs to more specific settings such as work environments.

Among this list of motivation theories, only Self-Determination Theory will be used in the formulation of propositions regarding the relationship between hackers' motivations and innovation. The sections below will provide a brief summary of each theory mentioned above and provide rationales on their applicability to the ideas being developed in this paper.

Needs Theories

The original needs theory is Maslow's (1943) Hierarchy of Needs. The theory states that there is a hierarchy in which people are motivated to fulfill their needs that include: physiological needs, safety and security needs, love and belongingness, esteem needs, cognitive needs, aesthetic needs, and self-actualization. According to the theory, people must fulfill all of their lower level needs (such as physiological needs) before they are motivated to fulfill higher level needs.

Alderfer's (1972) ERG Theory built on the ideas of Maslow's (1943) theory. The key difference between these theories is that needs are classified into only three categories: existence needs (E), relatedness needs (R), and growth needs (G). Existence needs correspond to Maslow's (1943) physiological and safety and security needs. Relatedness needs correspond to Maslow's (1943) belongingness and esteem needs and it also overlaps with security needs. Growth needs correspond to self-actualization needs. The main difference between Alderfer's ERG Theory and Maslow's Hierarchy of Needs is that Alderfer's theory does not have a strict hierarchy in the structure of needs, therefore people can go back into earlier stages of the needs hierarchy.

McClelland's (1965) need theory establishes no hierarchy within needs. This theory concentrates on three needs: achievement needs, affiliation needs, and need for power. According to this theory, people may become biased toward one of these needs based on their

own social and life experiences. An assumption this theory makes is that people can be trained to have certain needs and one of the three needs can be enhanced.

Given that needs theories focus on multiple contexts and apply to human needs and in all circumstances, these theories may have limited applicability to the model being proposed in this paper. The goal of this paper is to develop propositions related to the motivation and innovation of individuals working in a particular context, which requires a more theory that focuses on context-specific behaviors as opposed to global behaviors. Needs theories are too broad and cover in excess of what is needed in order to understand the implications. For example, this study already assumes that the physiological needs are already fulfilled and hackers are fulfilling higher level needs.

Two-Factory Theory

Herzberg's (1959) Two-Factor Theory states that there are two independent dimensions of motivation: hygiene factors (also known as extrinsic factors) and motivators (also known as intrinsic factors). Hygiene factors refer to aspects of a job that prevent dissatisfaction but do not increase motivation; these aspects do not relate to the person's needs for growth and development. Motivators are aspects of a job that encourage growth. Motivators help to increase satisfaction in a job. Herzberg's theory suggests that hygiene factors must be present in the work environment to prevent job dissatisfaction and motivators must be present to increase satisfaction and work performance. There are multiple similarities that exist between this theory and the needs theories. According the Herzberg (1959), in order to achieve the higher level needs of intrinsic motivators, individuals need to have the basic needs present in the extrinsic or hygiene factors. Similar to the needs theories, Herzberg's two-factor theory is limited by the assumption

that behavior is consistent across all work contexts. Based on this reason, this theory will not be integrated into model being proposed.

Expectancy Theory

Vroom's (1964) Expectancy Theory assumes that there are three components for motivation: expectancy, instrumentality, and valence. Expectancy is when it is believed that one's increased effort will lead to good performance. Instrumentality is the perception that good performance will lead to a particular outcome. Valence refers to the perceived attractiveness of the outcome. This theory suggests that people will select the behavior that will yield the most valuable rewards. For example, if a person believes that an improvement in work quality will yield a higher salary and promotion, then the person will act accordingly. This theory is not applicable to the model being proposed because according to interviews with hackers, they are mainly interested in the hacking tasks themselves rather than the result (Jordan & Taylor, 1998).

Equity Theory

Adams' (1963) Equity Theory suggests that people are motivated to behave in certain ways to preserve an inner psychological balance. This theory states that people want to feel that they are being treated fairly compared to their peers, and when this is disrupted people have the tendency to change their behaviors to regain the balance. Equity theory focuses on inputs and outputs within an organization; the work and effort people put into a task in an organization are inputs and the things received from the organization are outputs. If the input-output ratio for an employee is different compared to another employee, behaviors will change to reduce the inequity. For example, if two employees are inputting the same effort of work, but one employee gets paid more, then a tension will arise. This tension will motivate the individuals to increase or decrease effort to reduce the inequity. The Equity Theory is not applicable for the proposed

model either because hackers (mainly Black and Gray Hats) are more interested in the process and experience of the hacking activity rather than the outcome (Jordan & Taylor, 1998). In addition, hackers mainly commit hacking activities anonymously, so it would be difficult to compare the equity of their own inputs and outputs with their peers.

Goal-Setting Theory

Locke's (1990) Goal-Setting Theory states that goals determine task-related motivation. This theory suggests that performance increases as a person sets or accepts a difficult but realistic goal; a person will become motivated once they set or accept a goal and the higher the difficulty of the goal, the better they will perform in order to achieve it. This theory can be used to apply to this study. Different types of hackers may set different types of goals and the varying difficulties of those goals will impact how motivated each type of hacker is. For example, Black Hats, who often take on more challenging goals by operating in riskier environments, may, according to goal-setting theory, have a higher level of motivation. Despite the applicability of this theory to the activities of Black Hats, the theory is limited in its ability to explain the differences in motivation between Black and Gray Hats or White and Gray Hats. Given the limited applicability of this theory to the context of hacking, it will not be used in the development of the proposed model.

Self-Determination Theory

Deci and Ryan's (1985) Self-Determination Theory (SDT), is similar to Herzberg's Two-Factor Theory in that motivators are categorized into intrinsic (motivators) and extrinsic (hygiene factors) motivations. The main difference is the way the authors defined these two factors. In SDT, intrinsic motivation is defined as being inherently interested in and enjoying a task, whereas extrinsic motivation is defined as acting on a task because it will lead to a separable

outcome (Ryan & Deci, 2000). Extrinsic motivators can include reward systems, evaluations, and grades; and intrinsic motivators can include interests, curiosity, challenge, and care (Deci & Ryan, 1985). Both types of motivators are considered to be independent of each other. On the other hand, in Herzberg's Two-Factor Theory, examples of intrinsic and extrinsic motivators often overlap; this is considered to be one of the many criticisms of the theory. Herzberg (1959) also assumes that individuals need to be extrinsically motivated before they can be intrinsically motivated. Based on later research on intrinsic and extrinsic motivation, these two constructs are best considered independently (e.g., Stajkovic & Luthans, 2001). The SDT is most applicable to the model proposed in this paper because it focuses on understanding independent motivators which vary across different contexts.

Definition of Innovation

The definition of innovation cannot be understood without first understanding how it differs from creativity. Creativity can be considered to be an integral part of the innovation process (Hammond, Neff, Farr, & Schwall, 2011). While the literature does not have a broad consensus on the definition and dimensions of creativity, there is agreement in the literature that there is a difference between creativity and innovation. Unsworth (2001) and Anderson, De Dreu, and Nijstad (2004) noted that creativity is the generation of novel ideas, while innovation is the generation of ideas, selecting from those ideas, and implementing the selected ideas. This definition can be understood as a process that includes both idea generation and implementation. Innovation is therefore considered to be the overarching construct which includes creativity as one of its key components. Other researchers, such as Patterson (2002), noted that innovation models propose an idea generation stage, when the task or problem is identified and ideas are developed, and then an implementation stage, when ideas are examined and selected to be implemented. An example of this type of model was explained by Farr, Sin, and Tesluk (2003).

They suggested that innovation contains two broad stages: creativity and innovation implementation. Each stage also includes two phases: preparatory phase and action phase. During the creativity stage, problems are identified and examined (preparatory phase) and then alternative ideas and solutions are developed (action phase). In the innovation implementation stage, alternative ideas are evaluated and selected (preparatory phase), and then the selected ideas are implemented (action phase).

Given that creativity is considered to be a key component of innovation, this paper will use supporting literature from both the innovation and creativity literatures to help justify the relationship between motivation and innovation. According to the creativity literature, a high level of creativity is directly associated with a high level of innovation.

Predictors of Innovation: Review of Empirical Research

The current paper focuses on the theorized effect of hacker motivation on their level of innovation. However, the four main types of predictors of innovation include individual differences, job characteristics, contextual influences, and motivation (Amabile, 1996; Patterson, 2002; Zhou & Shalley, 2003). This section will provide a brief summary of the empirical research related to these predictors followed by a rationale on why the current paper focuses on motivation as a predictor of hacker's innovation.

Individual differences refer to individuals' personality dimensions and their potential to be creative. Early empirical studies of creativity were based on the idea that individuals vary in their potential to be creative (Baron & Harrington, 1981; Feist, 1999). Based on this premise, researchers developed scales like the Creative Personality Scale to measure creativity (Gough, 1979). The results from the application of this scale revealed significant relationships between

creative personality and innovative performance (Oldham & Cummings, 1996; Zhou & Oldham, 2001).

Job characteristics may significantly affect individual innovation. Job characteristics include job complexity, autonomy, and role obligations (Hammond et al., 2011). As the complexity of the job increases, the challenge increases as well. Creativity increases when individuals are required to focus on different factors in complex jobs (Amabile, 1988). Autonomy gives employees the ability and independence to determine the procedures of a task. Having high autonomy enables employees to approach tasks using their own unique/creative method. Role obligation refers to individuals' expected behaviors. If employees feel obligated to engage in innovative behaviors, they will invest more time and effort in these activities. All of the above factors in job characteristics have been found to be positively correlated to innovative behaviors (cf. Farmer, Tierney, & Kung, 2003; Oldham & Cumming, 1996).

Contextual influences also play a role in predicting creativity and innovation. Contextual factors include organizational climate, availability of resources, managerial support, and leadership. Organizational climate can include support for innovation, psychological safety, participative safety, sociopolitical support, and open group climate (Baer & Frese, 2003; Axtell et al., 2000; Spreitzer, 1995; Choi, 2004). Organizational resources include information, technical support, and instrumental support (Spreitzer, 1995; Choi, 2004; Madjar, 2008). These contextual factors assist in developing more innovative solutions. Managerial support and leadership also play a role in innovation through their guidance, support, and motivating strategies (Harackiewicz, 1979; Oldham & Cummings, 1996; Jaussi & Dionne, 2003). They can encourage innovative behaviors in employees that they supervise, and they have the ability to increase individuals' intrinsic motivation through their motivating tactics. These contextual

factors have been found to have a positive effect on innovative behaviors (Hammond et al., 2011), suggesting that organizations need to provide the right context in which employees work in order to increase their level of innovation.

Finally, motivation refers to individuals' interests in the task or in the outcome of the task. The motivation literature on innovation has focused on intrinsic and extrinsic motivators (George & Zhou, 2002; Taggar, 2002). While the effect of intrinsic motivation and innovation is consistently positive, the effect of extrinsic motivation and innovation is questionable (Hammond et al., 2011). Amabile, Hennessey and Grossman (1986) argue that extrinsic rewards and resource investments are necessary in motivating employee creativity. Studies have shown that there is a positive correlation between extrinsic motivation and innovative behavior (Eisenberger & Cameron, 1996; Eisenberger & Armeli, 1997). However, some scholars argue that extrinsic rewards like contingent pay may be detrimental to creativity because they decrease individuals' intrinsic motivation and thus decrease innovative behavior (Amabile, 1996; Ariely, Gneezy, Loewenstein, & Mazar, 2009; Manso, 2010). Extrinsic rewards may also reduce the autonomy of individuals, diverting their attention to monetary benefits and their innovative behaviors (Deci & Ryan, 1985; Amabile et al., 1996; Cooper, Clasen, Silva-Jalonen, & Butler, 1999). This negative effect is evident in tasks that are ambiguous and require exploring (Amabile et al., 1986; Amabile, 1997). Rosenblatt (2011) also explained that extrinsic rewards can encourage innovative behavior by providing an incentive for creativity, but it could also dampen innovative behavior by deviating individuals' focus away from work quality towards receiving rewards.

Therefore one of the main gaps in the innovation literature relates to research done on motivation as a predictor of innovation. Within this research, various inconsistencies exist in the

relationship between different types of motivation and innovation (cf. Hammond et al., 2011). One probable reason for this inconsistency may be that the effect of motivation on innovation not only varies by type of motivator but also by type of context. The current theoretical model being proposed in this paper contributes to this literature by examining how different types of motivators influence innovation while holding the context consistent to that of individuals working in the role of a hacker. Doing an in-depth evaluation of a particular context may help to explain when the effects of intrinsic and extrinsic motivation on innovation vary.

Theoretical Research Linking Motivation and Innovation

Three interrelated theoretical perspectives can be used to explain how and why motivation would be related to innovation. First, emotion theorists have proposed that individuals that are intrinsically motivated experience positive emotions (Silvia, 2008), which engage them to broaden their availability of cognitive information, expand their attention to incorporating more ideas, and encourage cognitive ability to identify associations between different ideas (Amabile, Barsade, Mueller & Staw, 2005; Fredrickson, 1998). Through this process, the ideas generated are more innovative than individuals who are not intrinsically motivated. Second, self-determination theorists propose that individuals that are intrinsically motivated are more curious and interested in learning and have an increase in their cognitive flexibility, willingness to take risks, and openness to complexity (Gagne & Deci, 2005; Amabile, 1979, 1996). This, in turn, increases their opportunity to access new ideas and solutions.

Third, both emotion and self-determination theorists agree that intrinsic motivation is positively related to creativity because individuals become more persistent (Grant & Berry, 2011). Emotion theories state that the positive emotions generated from intrinsic motivation will increase individuals' psychological engagement and build energy to sustain their effort on a task

(Fredrickson, 1998). Similarly, self-determination theories argue that being intrinsically motivated encourages individuals to be more persistent, particularly in relation to challenging, complex, and unfamiliar tasks, because they enhance their confidence and interest levels (Gagne & Deci, 2005). This argument is similar to Amabile (1996), who has also suggested that fostering interest on tasks through increasing intrinsic motivation enables individuals to more effectively concentrate on tasks.

Empirical Research Linking Motivation and Innovation

In addition to theoretical research, empirical studies have also shown a positive relationship between motivation and innovation. Examples of studies that have demonstrated that intrinsic motivators yield more innovative behaviors than extrinsic motivators include Chen, Ford, and Farris (1999) and Bhaduri and Kumar (2010). Chen and colleagues (2009) conducted a correlational study using Research and Development engineers as participants. The results showed that motivation had a positive impact on organizational benefits. Organizational benefits included a wide range of positive consequences for the organization, including higher level of innovativeness. An in-depth analysis of the surveys revealed that intrinsic rewards generated greater organizational benefits than all types of extrinsic rewards, including socioemotional motivations. Similarly, Bhaduri and Kumar (2010) conducted a correlational study contrasting the effects of intrinsic and extrinsic motivators on innovation. Data were collected from innovators in India from the National Innovation Foundation. Innovative behaviors, as defined by the authors, included the process of idea generation, experimentation, and application. The results showed that extrinsic motivators were predictive of only a fraction of individual innovative behaviors, whereas intrinsic motivators were associated with more innovative behaviors than extrinsic motivators.

Other empirical studies have shown that intrinsic motivators not only have a stronger effect on innovation than extrinsic motivators, but that they also have a strong independent relationship on creativity and innovative behaviors. For example, Grant and Berry (2011) conducted a correlational study on security force officers to understand the relationship between intrinsic motivation and creativity. Intrinsic motivation was measured through self-report surveys and creativity was measured through supervisor ratings. The results showed that intrinsic motivation was a significant positive predictor of creativity, such that higher levels of intrinsic motivation were associated with higher levels of creativity. A similar study done by Hon (2011) collected data from employees in hotel companies. The purpose of the study was to examine the mediating effect of self-concordance (an intrinsic motivator) on the relationship between social-contextual factors (organizational modernity, empowering leadership, and coworker support and helping) and creativity. The participants self-reported their level of motivation through a survey and their managers were completed a survey to measure the participants' level of creativity. The results showed that the employees' self-concordance was significantly and positively related to creativity. In addition, self-concordance mediated the relationship between the three social-contextual factors and creativity. Therefore both Grant and Berry (2011) and Hon (2011) were able to show that higher levels of intrinsic motivation were associated with higher levels of creativity.

A third set of empirical research on the link between motivation and innovation has shown that both extrinsic and intrinsic motivation interact to predict innovative behaviors. For example, Zhou, Zhang, and Angeles (2011) explored the relationship between human resource rewards management and innovative behaviors. Data were collected from employees in Chinese telecommunications firms. Participants completed surveys on their level of motivation and

frequency of innovative behaviors. The results supported three main conclusions. First, tangible extrinsic reward was related to innovative behaviors of employees in an inverse-U shape. This indicated that the frequency of innovative behaviors was highest when extrinsic rewards were at moderate level (not too high or not too low). Second, intrinsic motivation had a substantially positive effect on the frequency with which employees engaged in innovative behaviors. Third, extrinsic rewards and intrinsic motivators interacted in predicting innovativeness. The nature of the interaction was such that the most innovative employees had both high intrinsic motivation and received moderate extrinsic rewards. Having high intrinsic motivation therefore reduced the negative effects of extrinsic motivation on innovation. This finding helps to support the idea that employees need the right mix of extrinsic rewards and intrinsic motivation in order to increase their level of innovativeness in the workplace.

Development of Propositions: Hacker Motivation and Innovation

Proposition 1: White Hat versus Black and Gray Hat Innovation

The propositions developed in this paper are based on reviews of the definitions of hackers (as shown in Table 1) and a detailed mapping of the typology consistently found in these definitions to a list of motivators identified by Jordan and Taylor (1998) collected through a series of interviews (see Table 2). As shown in Table 2, even though hackers are motivated by similar factors, there are key differences in the motivations of White Hats versus those of Black and Gray Hats, which has direct implications for their level of innovativeness. According to Falk (2004) and Arnone (2005), White Hats are professionals who earn money for hacking and are guaranteed a salary for their work, whereas Black and Gray Hats are not paid professionals. All hackers are motivated by challenge, risk, enjoyment, and the experience of hacking (Jordan & Taylor, 1998). However, these motivators have been identified as being strongest among Black

and Gray Hats, whereas salary has been identified as the strongest motivator among White Hats (Jordan & Taylor, 1998). Given these differences, it is likely that the intrinsically motivated Black and Gray Hats would be more innovative than the extrinsically motivated White Hats (Bhaduri & Kumar, 2010; Chen, Ford, & Farris, 2010).

A second reason to expect this pattern of relationship is related to the differences in working conditions between Black and Gray Hats and White Hats. White Hats work within structured environments in organizations in which they have to meet deadlines set by their supervisors. On the other hand, Black and Gray Hats work in unstructured settings and often complete hacking activities based on their own schedules. According to Amabile, Mueller, Simpson, Hadley, Kramer and Fleming (2002) time pressure can greatly impact creativity. The authors conducted a longitudinal field study on employees from seven different organizations. Data were collected using daily questionnaires over a 30 week time period. The results showed that while time pressure led employees to work harder, it also made them less likely to use creative cognitive resources. These results are consistent with three prior studies that have demonstrated the negative effect of time pressure on creativity (Amabile, Conti, Coon, Lazenby, & Herron, 1996; Andrews & Smith, 1996; Kelly & McGrath, 1985).

Given that White Hats are both more likely to be extrinsically motivated than Black and Gray Hats and that they operate in conditions of more time pressure as compared to Black and Gray Hats, it is likely that their level of innovation would be lower than that of Black and Gray Hats. The following propositions are therefore being suggested:

Proposition 1a. Black Hats are more innovative than White Hats because they are more intrinsically motivated.

Proposition 1b. Gray Hats are more innovative than White Hats because they are more intrinsically motivated.

Proposition 2: Black Hats versus Gray Hat Innovation

Even though the behaviors of Black Hats and Gray Hats may be influenced by similar motivators (see Table 2), a key distinction between the two types of hackers, according to Falk (2004) and Arnone (2005), is that Black Hats are involved in illegal activities whereas Gray Hats typically are not. By participating in illegal activities, Black Hats risk being caught and punished. Therefore, despite the fact that Black and Gray Hats are both intrinsically motivated by challenge and enjoyment, according to the definition of hackers, a distinguishing motivator between the two types of hackers is risk-taking, in which Black Hats are more motivated by the thrill or risk of getting caught than are Gray Hats (Arnone, 2005; Falk, 2004).

Risk-taking has been linked to differences in innovation by multiple researchers. For example, Martins and Terblanche (2003), in a study examining the determinants of organizational culture, found that organizational cultures characterized by risk-taking were associated with higher degrees of creativity and innovation. Based on this finding, Martins and Terblanche (2003) recommended that risk-taking be promoted by creating creating a tolerant atmosphere in which mistakes are accepted as part of the learning process, and assuming that there is a fair chance of risks being successful. Amabile and Hennessey (1992) also examined the relationship between risk-taking and innovation. The authors characterized intrinsic motivation as having interests in exploration and risk-taking. This characterization of intrinsic motivation led to the suggestion that higher level of risk-taking will yield a higher intrinsic motivation, which would lead to a higher level of innovation. Dewett (2007) also examined the link among common creativity antecedents, intrinsic motivation, and risk-taking to employee creativity.

Participants consisted of Research and Development personnel, which were given a survey to measure their creativity antecedents, intrinsic motivation, and willingness to take risks. Supervisors were then asked to rate the creativity of each individual personnel. The results from this study indicated that intrinsic motivation mediated the relationship between certain creativity antecedents and one's willingness to take risks. The results also showed that the willingness to take risks fully mediated the effect of intrinsic motivation on employee creativity. This relationship suggests that individuals' intrinsic motivation will further increase their willingness to take risks and that will further increase their creativity.

Another reason why risk-taking is expected to have an impact on innovativeness relates to the risky shift phenomenon (Bateson, 1966; Rim, 1963; Stoner, 1961). The risky shift phenomenon refers to the increase in individuals' risk-taking as the result of some group process in risk-taking situations. Research on the risky shift phenomenon has shown that risk-taking preferences are significantly related to measures of creativity (Glover & Sautter, 1976). Specifically, high-risk individuals have been found to be significantly more flexible and original than low-risk individuals in their responses to the Torrance (1974) Tests of Creative Thinking, a test which involved having participants do a number of tasks to measure their creativity. Glover (1977) continued the study of this phenomenon in relation to creativity in his experimental research among undergraduate student participants. The purpose of the study was to determine whether or not increased risk-taking in the risky shift group process would result in an increased level of creativity. The results were consistent with previous findings that risk-taking is positively related to creativity.

A related reason why Black Hats may be more innovative than Gray Hats is that the increased risky behaviors of Blacks Hats is associated with a greater perception of challenge in

their hacking activities (Jordan & Taylor, 1999). Challenge is an intrinsic motivator, which has been found to be consistently positively correlated with innovation (Bhaduri & Kumar, 2010; Grant & Berry, 2011; Hon, 2010; Zhou, Zhang & Angeles, 2011). Based on these reasons, it is expected that Black Hats have a higher level of intrinsic motivation than Gray Hats and will therefore have a higher level of innovation than Gray Hats. The distinction between Black Hats and Gray Hats led to the second proposition summarized below.

Proposition 2: Black Hats will be more innovative hackers than Gray Hats.

Proposition 3: Effect of Role Transitions on Black and Gray Hat's Innovation

Consistent with the stories of George Hotz and Steve Kondik (Clemmitt, 2011) and based on a series of interviews with hackers (Jordan & Taylor, 1998), many hackers switch from being Black Hats or Gray Hats to becoming White Hats. This means that unemployed hackers (Black Hats and Gray Hats) may at some point utilize their skills and experiences for an organization, thus making them White Hats. This occurrence raises the question of whether or not the initial degree of motivation and innovation associated with intrinsically motivated Black and Gray Hats changes when these hackers transition into the role of an extrinsically motivated White Hat.

Insight into how this role transition may impact the behaviors of the newly transformed Black and Gray Hats can be found in the literature on organizational socialization. Organizational socialization is the process of entering and becoming familiar with a new organization (Van Maanen & Schein, 1979). Through the socialization process in organizations, individuals learn what behaviors are acceptable on the job and how activities should be executed. This process also teaches the new employees the organization's values, to which the employees are expected to adhere.

Studies in the socialization literature show that the process of socialization can unfortunately decrease innovation in individuals. For example, Jones (1986) developed questionnaires to measure socialization dimensions to investigate the effects of socialization on new employees in their role orientation. Role orientation was described as being on a continuum with conformity to established roles and procedures on one end (custodial orientation) and innovation in defining and introducing new ways of doing things at the other end (role innovation). This questionnaire was given to M.B.A. degree holders five months after they had begun working. Results from this study showed that new employees were only exposed to a narrow range of situations and acceptable responses. The tactics used to socialize new employees inhibited innovation by limiting employees' choices on how they should response in situations. This study was later replicated by Allen and Meyer (1990). The participants in Allen and Meyer (1990) were undergraduate and graduate students from different business programs. At six months into their jobs, participants were given the questionnaires developed by Jones (1986), which measured socialization tactics and outcomes. At 12 months, participants were given the questionnaire again. The results confirmed Jones' findings that there is a significant negative correlation between socialization and role orientation, in that institutionalized tactics are associated with a custodial orientation in which employees conform to roles and procedures and become limited in their innovative behaviors.

Organizational socialization affects Black Hats and Gray Hats similarly when they become White Hats. When Black Hats and Gray Hats transition into the role of White Hats, they become limited in their actions because they are bounded by rules and regulations in the organization. This transition will also decrease their intrinsic motivation by lowering the risks in hacking activities—Black Hats will be able to hack into systems without having to worry about

the direct consequences of their activities. As previously discussed, this decrease in risk is highly likely to contribute to a decrease in innovation (cf. Amabile & Hennessey, 1992; Dewett, 2007; Martins & Terblanche, 2003). Additionally, the transition to White Hats will limit them in their freedom to choose the projects that interest them the most. In an organization, White Hats will be expected to work on projects that will benefit the organization, and the projects may not necessarily be interesting to the White Hats. As compared to Black Hats and Gray Hats, they are able to choose what type of projects they want to work on based on their interests. In this case, White Hats' intrinsic motivation is often times less than Black and Gray Hats (Jordan & Taylor, 1998), which decreases their level of innovation on hacking tasks. Based on these rationales grounded within the organizational socialization literature, it is expected that Black and Gray Hats will become less innovative when they transition into the role of a White Hat. This idea is summarized below in the third proposition.

Proposition 3: Black Hats and Gray Hats will become less innovative when they transition into the role of a White Hat.

Future Research

The primary are for future research need is empirical evaluation of the proposed model. Given the nature of the sample, in which many individuals are engaged in an illicit activity and are often anonymous, data collection may be difficult. It is therefore recommended that researchers begin with small scale in-depth analyses of hackers through the use of case study interviews, such as those used in Taylor (1999). Such studies are not only important for evaluating the propositions offered on the link between motivation and innovation among hackers but also for further evaluating the typology of hackers on which the theoretical model is based. Most of the research on the typology or definitions of hacker types has been anecdotal.

Even though efforts were made in this study to ensure that the definitions used encompassed those represented in the literature (see Table 1), without empirical research on the topic it is difficult to determine whether there may be deficiency errors in the construct that are being overlooked.

It is also important for future research to evaluate how well the current model (see Figure 1) generalizes across different technology-based contexts (e.g., security breaches, software redesign, hardware reconfiguration). The model should be able to be applied in different technology-based contexts, but the degree of applicability may vary. For example, some settings involve more risk than others, such as hackers breaching security networks versus hackers reconfiguring hardware devices. An assumption made in the development of this model is that the setting across each of the three types of hackers was held consistent. However, future research is needed to evaluate how the ideas proposed in this model vary across settings.

Future research should also work to break down the various motivators of Black Hats to evaluate whether they have differential effects on innovation. Previous research on positive affect found a relationship with innovation. Isen, Daubman, and Nowicki (1987) concluded in their research on affect and innovative problem solving that positive affect increases individuals' creative cognitive processes thus, increasing the level of innovativeness. In addition, positive affect also enhances individuals' experiences of interest, enjoyment and sense of satisfaction (Isen & Reeve, 2006). In regards to negative affect and innovation, researchers believe there is a negative relationship. Russ (1999) noted the detrimental effects of negative affect, due to its constriction in cue utilization. Similarly, Madjar, Oldham and Pratt (2002) argued that negative moods may constrain divergent thinking and creative thinking processes. Hence, Black Hats motivated by positive-affectively laden motivators, such as challenge, may demonstrate high

levels of innovation whereas those motivated by negative-affectively laden motivators, such as revenge, may have low levels of innovation.

Practical Implications

The theoretical model proposed in this paper focused on hackers because they are instrumental in helping organizations develop new ideas and innovations (Clemmitt, 2011). Given that change occurs so quickly in the technology field, organizations need to constantly develop new innovations in order to survive (Agars et al., 2008). Building on this trend in the field, the ideas proposed in this paper offer two key practical implications.

First, through decomposing how different hackers are motivated and examining how those motivators relate to their level of innovation, organizations can better understand what types of motivators they should provide to help improve the creativity and innovation of their employees. Based on patterns in the previous literature, which are likely to generalize to individuals operating in the role of a hacker, organizations that want to increase the innovativeness of their employees should make a greater effort to facilitate a culture in which intrinsic motivators, particularly those related to risk-taking, are emphasized while the importance of extrinsic motivators are lessened.

In addition to having a cultural shift in what they value, organizations could also facilitate innovation in hackers through their socialization process. During socialization it is typical for organizations to indoctrinate their own values into new employees; however, this method makes the new employees behave like the people who are already in the organization (Allen & Meyer, 1990). Organizations wishing to hire Black or Gray Hats as White Hats should limit the interaction between these new employees and the old or outgoing employees, such that they are not taught the old way of doing things. Allen and Meyer (1990) explain that new employees

typically try to think and act like their supervisors and mentors because they feel like their way of solving problems are the correct ways. It is important for managers to let their incoming employees know that they have some discretion in reinterpreting their role. This can be done through providing detailed job descriptions on what the individual's role is and what aspects of their role are flexible. Organizations also need to explicitly create a culture that values differences and autonomy. An example of this is Google, where they allow employees to spend 20 percent of their work time to pursue their own project interests (Mediratta, 2007). These types of cultures respect employees' own interests and help maintain individuals' own identity and methods of problem solving.

Conclusion

The purpose of this paper was to develop theoretical propositions on the importance of intrinsic motivators in generating innovation. These motivators play a vital role in understanding innovation in hackers. By examining hacker motivation, this study makes two key contributions. First, this paper contributed to the literature by building on the hacker typology through further characterizing the differences among the three types of hackers. Arnone (2005) and Falk (2004) differentiated the different types of hackers, and this study builds on this typology by categorizing the different motivators associated with the three hacker types. This characterization allows for further investigation into how and why hackers develop innovative solutions. Second, this study is one of the first conceptual papers, to the author's knowledge, to openly address how role transitions can influence hacking behaviors despite the fact that it is a fairly well-established trend in technology-based companies (cf. Clemmitt, 2011). The ideas proposed in this paper represent the first steps in better understanding an important area of the hacking literature and

help to provide a guide on how future empirical research can better evaluate the relationship between hacking motivation and innovation.

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Table 1. Summary of Definitions of Hackers.

Author	Definition	Types of Hackers		
		White Hats	Gray Hats	Black Hats
Arnone (2005)	"What hats are paid professionals hired by government and industry…Gray hats are unpaid tinkerers who find flaws to improve security for everyone…what separates black hats from other hackers is that they break the law and feel justified doing it." (p. 26)	X	X	X
Falk (2004)	"When this paper refers to a hacker it is speaking about a person who uses unorthodox methods for testing and perhaps penetrating computer security measures." (p. 1)	X	X	X
Jordan and Taylor (1998)	"Means of gaining unauthorized access to computer networks include guessing, randomly generating or stealing a password." (p. 759)		X	X
Flowers (2008)	"…Outlaw users are defined as users who, either individually or as part of a group, actively oppose or ignore the limitations imposed on them by proposed or established technical standards, products, systems or legal frameworks. " (p. 180)			X
Bachmann (2010)	"The English verb *hacking* in the context of computers is commonly described as referring to the act of re-designing the configuration of hardware or software systems to alter their intended function." (p. 643)	X	X	X
Mulhall (1997)	"The term 'hacker' will be used in its broadest sense to define those activities undertaken by computer enthusiasts and includes unauthorized access to computer systems/facilities. " (p. 282)		X	X
Voiskounsky and Smyslova (2003)	"Hackers were presented in 1960s as smart and competent enthusiasts, interested exclusively in computers and softwares." (p. 172)	X	X	X
Conti (2006)	"…highly skilled technical experts that frequently functions outside the mainstream of computer product development and conventional technology research." (p. 33)	X	X	X
Smith (2002)	"…which attempts to proactively increase security protection by identifying and patching known security vulnerabilities on systems owned by other parties." (p. 374)	X	X	

Note. An 'X' indicates my evaluation on which type of hacker the definition refers to.

Table 1 Continued. Summary of Hacker Definitions and Types.

Author	Definition	Types of Hackers		
		White Hats	Gray Hats	Black Hats
Palmer (2001)	…'hacking,' which was used to describe the rapid crafting of a new program or the making of changes to existing, usually complicated software" (769).	X	X	X
Wang and Kaye (2011)	"In this paper we look at a set of leisure practices that involve creating new, improved or different devices or objects. These practices are often referred to as 'hacking' or 'tinkering'. " (p. 264)		X	X
Young, Zhang, and Prybutok (2007)	"The original use of the term hacker refers to innovative programmers at MIT who wanted to explore the limits of mainframe computing. However, the term 'hacker' is now associated with a negative connotation describing computer intruders who carry out destructive acts. " (p. 281)			X
Hannemyr (1999)	"Hackers are identified as a specific subgroup of computer workers. Hacking is discussed in the context of being a method for system development. " (p. 1)	X	X	X
Mohrenschlager (1995)	"The term 'hacker' then became used more pejoratively to refer to those who are inquisitive or perhaps malicious (inter)meddlers who try to get information by unauthorized access and exchange it with like-minded people." (p. 104)			X
Von Hippel and Paradiso (2008)	"a hacker is often a 'user' who is reinventing or modifying products to better satisfy his or her own needs." (p. 66)		X	X
Furnell and Warren (1999)	"the usage of the term [hacker] has changed over the years and is now generally accepted as referring to persons who deliberately gain (or attempt to gain) unauthorized access to computer systems. " (p. 29)		X	X

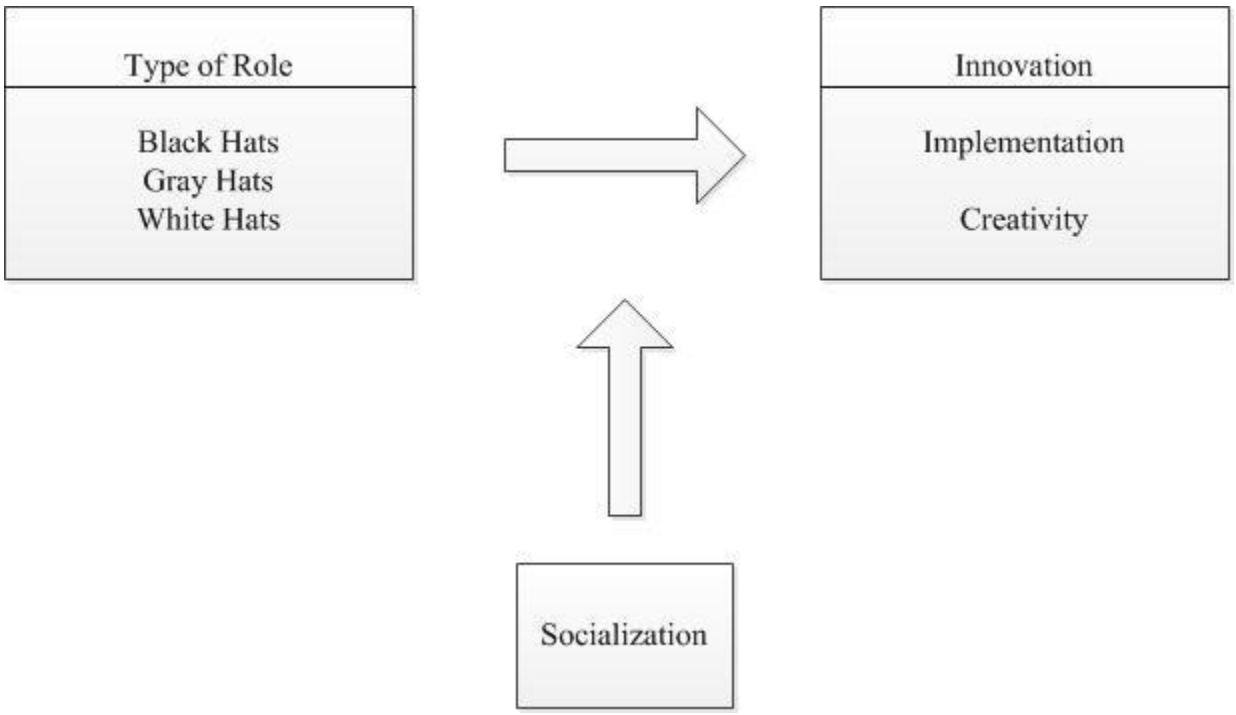
Note. An 'X' indicates my evaluation on which type of hacker the definition refers to.

Table 2. Motivations Mapped to Different Types of Hackers.

Motivations	White Hat	Gray Hat	Black Hat	Source
Addiction	X	X	X	Beveren (2001); Jordan (1998); Mulhall (1998)
Curiosity	X	X	X	Arnone (2005); Barber (2001); Beveren (2001); Jordan (1998); Mulhall (1998); Rennie and Shore (2007); Voiskounky (2003)
Thrill (due to boredom)		X	X	Bachmann (2010); Jordan (1998); Mulhall (1998); Rennie and Shore (2007)
Challenge	X	X	X	Bachmann (2010); Beveren (2001); Jordan (1998); Mulhall (1998); Voiskounsky (2003)
Feelings of Power	X	X	X	Beveren (2001); Jordan (1998); Rennie and Shore (2007)
Peer Recognition and Fame		X	X	Beveren (2001); Jordan (1998); Lakhani and Wolf (2003); Rennie and Shore (2007)
Service and Obligation	X	X		Jordan (1998); Lakhani and Wolf (2003)
Money/Greed	X	X	X	Barber (2001); Jordan (1998); Mulhall (1998); Rennie and Shore (2007)
Skill	X	X	X	Lakhani and Wolf (2003)
Opportunity		X	X	Mulhall (1998)
Revenge			X	Mulhall (1998); Rennie and Shore (2007)
Vandalism			X	Barber (2001)
Political acts/Hacktivism			X	Barber (2001); Jordan (1998); Taylor (1999)
Information warfare			X	Barber (2001)
Enjoyment	X	X	X	Lakhani and Wolf (2003)

Note. An ‘X’ indicates an evaluation on which motivations are associated with which type of hacker.

Figure 1. Model of theorized relationships.



Academic Vita

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Education:

The Pennsylvania State University — University Park, PA
Kanda University of International Studies — Tokyo, Japan
Schreyer Honors College Scholar
B.S. in **Information Sciences and Technology** — Expected: May 2012
Minor in **Supply Chain Management** — Expected: May 2012

Experience:

Penn State University – Lion Launch Pad — University Park, PA
Webmaster — May 2011 – Present

- Monitored and upgraded website functions using WordPress
- Redesigned existing forms to increase usability
- Updated users by posting new entrepreneurship events and opportunities

Penn State University — University Park, PA
Laboratory Assistant — Sept 2008 – Present

- Assisted in the configurations of various lab setups
- Operated and inspected lab items for malfunctions

W.L. Gore & Associates, Inc. — Elkton, Maryland
Systems Analyst — Summer 2011

- Committed to managing and leading the direction of the project
- Conducted 10 interviews for the Systems Development Lifecycle Assessment project
- Analyzed data collected from the interviews and presented to the whole IT team
- Facilitated the next phase of the project by assisting the formation of a new team

AVTEL — Tokyo, Japan
Intern — Fall 2010

- Designed and developed a GUI using MS Access to collect client information
- Collaborated with a global team throughout the project
- Discussed and exchanged intercultural experiences in bi-weekly seminars

Skills:

MS Office	MS Project	MS Access	MS Visio	C++
MySQL	SQL Server	JAVA	Visual Studio	

Language: Chinese – Fuzhounese; Proficient in Mandarin Chinese; Proficient in Japanese

Activities:

IES Abroad Ambassador — 2011 – 2012
Japanese Archery — 2010 – 2010
Asian American Christian Fellowship — 2008 – 2010
Game Design Club — 2008 – 2009