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Cognitive Science in Technology

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Cognitive Science in Technology

by

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ABSTRACT

Cognitive Science is an interdisciplinary field that ties together the curricula of liberal arts and technical fields of study. However, it is de-emphasized in technical undergraduate studies such as Engineering. Cognitive Science is essentially the study of the human mind and how humans process information. It is the study of human responses, thinking, and perception. Human behavior and a person's reaction are undetermined, but it can be better understood. Although human behavior and interaction is a routine part of life, engineers are taught to decipher code and not how to decipher a human's behavior. Cognitive Science affects all aspects in the work environment. Organizational practices can be improved by understanding common biases and motivational theories in people. Having a cognitive awareness of typical human behavior will help to promote improved communication and positive reactions from people in the workplace.

Human behavior is inevitable in any field but more crucial in technical fields especially when there is lack of communication or ambiguous guidelines and definitions. In technical fields, miscommunication or ambiguity can be a matter of life or death. In many situations, miscommunication can drive ambiguity. Although some people are happy with flexible guidelines, others seek to have well defined expectations. How do people react in situations surrounding miscommunication or ambiguity? In both situations, some people create opportunities and others become a hindrance. Processes and procedures can be put in place to alleviate ambiguous situations, but human performance and psychological factors still play a role as well. Human error can result from psychological factors, but the environment can be improved to limit those factors. As with any situation, mishaps are still prone to happen. Although human error is preventable in most cases, it's never completely unavoidable. Human error continues to be a deep-rooted cause that can lead to negative outcomes. As stated by Alexander Pope, "to err is human…" (Moncur). This paper will explore underlying human behavior in daily activities. By understanding common biases and motivational theories driving human behavior, one can address negative behavior in a technical field in order to create opportunities.

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OVERVIEW

This report will help to provide a better understanding of human behavior and determine appropriate corrective actions that may be applied to the workplace to promote positive reactions and encourage leadership to enhance technological breakthroughs. Cognitive Science is an understanding of human behavior and a very in depth subject. Cognitive Science branches out from and combines several fields of study including the liberal arts and psychology to engineering and computer science. The intent of this paper is to focus on cognitive science in technology and provide recommendations for improving the workplace by understanding the general topics that drive human behavior. Although these fields are common to Cognitive Science, it's hard to find a good foundation of cognitive psychology in publications or books that are related to cognitive technology and vice-versa. One of the intents of this paper will be to capture a general basis for the reader to understand how cognitive science in technology comes full circle by explaining cognitive science applications related to cognitive psychology, by interpreting a survey related to these general cognitive factors, and explaining scenarios in technology that have been affected by cognitive science factors and human behavior.

Cognitive science will be covered first to explain general theories and biases that drive psychological viewpoints of human behavior. There are cognitive theories, heuristics, common biases and psychological factors that all affect human behavior and decision-making in the workplace. While these cognitive aspects typically affect people's decision making, they are not always aware of it. There are several aspects of human behavior that will be covered including environmental interactions, reactions to anomalies, and creating opportunities. Under different environments, people will use different decision-making processes. These processes are considered heuristics; methods of assisting humans in problem solving. Common biases are identified for each of the four heuristics that will be discussed. The four heuristics to be covered are availability, representativeness, confirmation and affect. The affect heuristic will cover individual motivation, but to better relate to workplace practices, organizational behaviors related to motivation will be elaborated on as well. There are many other heuristics related to human decision making processes that will not be covered in this paper. The ones identified are more closely related to the specific technical examples that will be discussed throughout this paper.

Psychologists have been divided in their theories with respect to how a scientific or engineering background person thinks. Those theories are related to deduction, reasoning, confirmation bias, selection task examples, and mental modeling. Therefore, those topics will be covered as part of the heuristics previously mentioned and throughout the technical specific example sections. Some psychologists have also theorized that there is a distinction between scientists and non-scientists' thinking processes. Since this paper is focused on cognitive science in technology, these theories will be discussed from both perspectives of whether or not a scientist or technical background person may or may not be categorized into these theories. To help with this distinction, a survey interview will be discussed where general theories have been presented to people of engineering or technical backgrounds.

This paper will then delve into different technical examples that demonstrate clear errors or opportunities with respect to technology. Those examples will include the Boston Molasses Disaster, medical cases, and artificial intelligence (AI) developments. The Molasses Disaster and medical cases will include both outcomes: hindrances that led to negative outcomes and opportunities that were created from learned mistakes. Some recommendations will be given for creating opportunities in various situations in the workplace by simply having awareness of cognitive science in technology.

COGNITIVE SCIENCE

History

Cognitive psychology is the study of the mental processes that are assumed to underlie human behavior (Wickens and Hollands 12). Although cognitive psychology stems back as far as the 18^{th} century, “cognitive science” was not considered a term until 1973 when Hugh Christopher Longuet-Higgins coined the term to describe the research of the mind. There are an extensive number of psychological theories in cognitive science that have since developed, and there are some that do not necessarily relate directly to the research contained in this paper. One such example is the ‘mother and baby’ theory that explains one of the theories behind why a person would be left-handed. This theory states that a mother is able to hold her child to her heartbeat by using her left hand (Mandal, Asthana, and Biswal 145). There are also divided theories among psychologists’ beliefs of general methods and theories surrounding cognitive science. Therefore, this paper will only be covering the theoretical history directly related to the interactions of human behavior and technology that have impacted organizations and new innovations. This section will provide a general outline of cognitive science with respect to methods and theories, describe heuristics that categorize typical individual biases, and describe organizational behaviors. All of which contribute to the human behaviors found in the technical workplace.

Methods/Theories

Normally, experimental studies or algorithmic computation is used to test methods and theories in cognitive science. The experimental tests normally lie around proving or disproving theories related to human behavior such as formal logic, rules, concepts, and images including memory and perception. Computational models have been developed with various forms of computer programming models by extending the theory-based information with artificial intelligence. This would include if/then statements and deduction from mental representation to conclude outcomes. Logic and rules are general methods that are used for simple planning programs, but they can be limited on direct translations from natural human language to computational logic. Concepts, analogies, and images then grasp the natural part of the spoken language and help to translate that information to a related idea, problem solving method, or image.

Mental representation and computation have branched out from the basic idea of logic. Thagard explains how Aristotle studied the studies of syllogisms some two thousand years ago from the underlying foundation of logic. There are two types of inferences in human behavior formed from logic: deductive and inductive. Although inductive logic involves more assumptions in generalizing a category, both inferences are drawn out from premises and a conclusion. They are essentially conditional statements similar to an if/then statement, along with rules. Both logic and rules can be simplified and applied to if/then thinking. Still, if/then statements have limitations in the sense of computation and artificial intelligence, because it is hard to capture various possibilities. As Thagard explains, "planning is monotonic: it can only draw new conclusions and not reject previous ones" (29). Even though logic computation may be limited to some extent, founders of Artificial Intelligence, such as Herbert Simon, have made enormous contributions to surpass those limitations as will be shown by some of the examples explored in the artificial intelligence section of this paper.

Mental representation and natural language is further explored by concepts, analogies, and images. Concepts and analogies can be described as envisioning a set of examples or images that relate to a given concept in a person's mind. Analogies are taking those set of examples or images and comparing them to other examples or situations. All in all, concepts form mental representations or ideas surrounding a given situation. There are some situations in which a person retrieves an image surrounding a concept that may or may not use logic rules as a combined relation. This would be an example of when a concept is used with the combination of an if/then relationship. "Jumping into a pool fully clothed is not a defining or typical feature of the concept drunk, but it fits with a theory of impaired judgment that is part of the concept: being drunk causes people to do silly things" (Thagard 72). Retrieving an image or idea surrounding a concept also leads into human memory storage. Images are closely related to concepts and analogies, because a visual image of an object can lead to a person's idea or memory of a given concept. In the example used, a pool might be that image. These cognitive factors all contribute to forming different psychological theories of human thinking, processing, and behavior.

Heuristics

Aside from the several theories discussed in the previous section, there are broader categories studied in cognitive science such as: reason; culture and upbringing; different mental models involving memory and imagery; content-specific rules and branching into Artificial Intelligence; computational models of the mind; and heuristics.

The previous section explained different methods of cognitive science that affect human thinking. Heuristics are a form of generalizing thinking processes that explain how people make decisions. Heuristics have common identified biases associated with them. Four heuristics will be described in this section: availability, representativeness, affect, and confirmation.

The availability heuristic describes a judgment that is made based on the accessibility of information surrounding an event. This heuristic is described as the "frequency or probability by the ease with which instances or associations come to mind" (Tversky and Kahneman, *Judgment Under Uncertainty*). The information that comes to mind surrounds emotions and frequency. This heuristic can lead to both positive and negative judgments. When using the frequency aspect, an accurate judgment can be formed from an event that may occur rather frequently. For example, if an engineer sees that a radio test is stalled during one of the bit checks and it is a typical issue of occurrence, the person can quickly recall the scenario from previous tests and evaluate how to fix the problem. However, at the same time, the emotions or clarity and distinctness of the information retrieved can be overwhelming. This may give the wrong impression that something is more important than it really is. "These irrelevant factors (such as vividness) can inappropriately influence an event's immediate perceptual salience, the vividness with which it is revealed, or the ease with which it is imagined" (Bazerman and Moore).

The representativeness heuristic suggests that people make judgments of frequency or probability based on how a trait or representation of other similar groups is associated. A general stereotype in technology that relates to this heuristic is that people with an engineering or technical related degree are seen to be people that are introverted, nerdy, shy, detail oriented, etc. This heuristic leads people to believe that the more similar something is to a category, the more likely it is that the object is a member of that category. “The representativeness heuristic can also work on an unconscious level, causing a person to engage in race discrimination or other behavior that he or she would consider morally reprehensible on a conscious level” (Bazerman and Moore).

With the affect heuristic, a person’s decision-making process is related to what is described as an “affect.” The affect is described to be an emotion, feeling or other stimuli such as environmental conditions that influence a person’s response. In simpler terms, the affect is described as something “good” or “bad.” Bazerman and Moore explain how sunny days can promote an overall sense of a better feeling, because it generates a good mood. The authors also explain how this can be such a natural reaction that people tend to use it more often when they are busy or under time constraints (Bazerman and Moore). With this heuristic, people tend to think that the outcome is a lower risk when they have a good feeling towards the situation. This theory is called a positive affect. “While these affective evaluations often are not conscious, Slovic, Finucane, Peters and MacGregor provide evidence that people nonetheless use them as the basis of their decisions rather than engaging in a more complete analysis and reasoning process” (Bazerman and Moore).

The confirmation heuristic, which is also sometimes referred to as the anchoring heuristic, is when a person seeks information to confirm a prior hypothesis or theory.

There are several biases associated with the confirmation heuristic. Bazerman and Moore describe the following: confirmation bias, anchoring, conjunctive and disjunctive events bias, overconfidence, and hindsight bias. The most common of those biases is known as the confirmation trap and will be explained, in detail, within the following paragraphs. For each of the heuristics described, there are individual common biases associated with each one that can occur on an unconscious level. “Identifying these biases is the first step toward changing one’s views and behavior in a positive direction” (Bazerman and Watkins).

Confirmation Bias

Psychology of Reason is commonly discussed in cognitive science research. Confirmation bias is discussed as a psychological factor affecting reasoning and decision-making. Confirmation bias is a term that builds into specific logic problems such as the Wason’s 2-4-6 problem and selection task problem. A confirmation bias is a common bias associated with the Confirmation Heuristic mentioned earlier. Some theories regarding the thinking processes of people with technical degrees are based upon the confirmation bias. Therefore, the confirmation bias is elaborated here. More information regarding the distinction between a scientist and non-scientist will be discussed later in this paper. The basis behind a confirmation bias is that a person will tend to seek out information that confirms his or her original theory for a problem. In the 2-4-6 problem, Wason created a simple ascending pattern. Wason asked that the research participants formulate a hypothesis for the rule associated with the given pattern and try to confirm their theory by creating their own triples. The participants were provided feedback on whether or not their triples could be applied to the rule; a simple yes or no was provided. Then, they were to continue this process until confident that their hypothesis was correct at which point they would announce their postulated rule.

Although his rule was simply an ascending pattern, the participants concluded much more difficult patterns such as adding each number by two, or multiplying the first number by an ascending number, etc. However, one of the things observed was that the majority of the participants did not try to disprove their theories. Rather than trying to show a triple that proved their theory wrong, they continued to choose additional triples that followed their original hypothesis. "The implication is that to make better decisions, we need to attach equal weight to information that both supports and questions our tentative choices and overcome our natural tendency to look for and attach greater weight to evidence that supports the initial attractive choice" (Garrett).

Wason then expanded on his original study by creating the selection task based on "if" logic. In this study, there were four cards, each with two sides, one side with a letter and one side with a number. He then asked the participants to pick a card(s) that would show the following statement is true or false. If a card has a vowel on one side, then it has an even number on the other side (Wason and Johnson-Laird). The same underlying argument was made where the subjects did not choose both options: to prove and disprove the statement.

One way to avoid the bias of a confirmation trap is to specifically seek out information to disprove the hypothesis. Interestingly enough, interview questions were asked as part of a survey for this paper to either confirm or disprove this theory among people with technical degrees. The results showed that more than three quarters of the people surveyed (76.2%) showed the same results, no disproving was attempted. In this case, the answer that used the disproving method was the choice selecting both A and 7. Figure 1 shows the A and 7 answer was only selected by 5 of the total participants. “The key to improved judgment lies in learning to distinguish between appropriate and inappropriate uses of heuristics, when your judgment is likely to rely on heuristics, and how to avoid them” (Bazerman and Moore). In most cases, the participants even asked what the right answer was, and they were convinced that the right answer was different than the one that both confirmed and disproved the answer.

Organizational Behaviors

Although this paper has covered the general aspects of individual decision-making, organizational behaviors from motivation have not yet been covered. Motivation can be described as a person’s drive and focus on accomplishing a set goal. There are multiple theories on work motivation within an organization, but this paper will only be covering goal setting, Maslow’s hierarchy of needs and the expectancy theory. In general, the motivational theories all discuss methods of finding means to satisfy a person’s needs.

Goal setting is the motivational theory that involves setting goals from both individual and job context inputs. “Goals are the cognitive representations of self-diagnosed needs, and wants, together with prescriptions for the states of the world which it is believed will satisfy them” (Lindsay and Gorayska 81). The individual input portion of goal setting involves various aspects including job knowledge and ability, beliefs and values, characteristic traits, and affect as described in the affect heuristic previously. The job context can also be categorized as an environmental affect. Job context inputs also include organizational culture, supervisory support, rewards and reinforcement, and social norms (Lewis). With the job context, rewards and reinforcement are ways to modify behavior by encouraging positive outcomes.

With the individual input portion of goal setting, it's important to understand that everyone's needs can't be fulfilled in the same manner, because people have different values. This is a general concept of other motivational theories such as Maslow's hierarchy of needs and the expectancy theory. Maslow's hierarchy of needs basically explains that people will act to fulfill their needs from the lower spectrum of his pyramid to the higher end of the pyramid. Maslow's pyramid is defined with survival necessities making up the bottom portion of his pyramid; this portion is categorized as physiological which would consist of sustenance. Other categories defined are: safety and security, love (social), esteem, and spiritual enlightenment (Lewis). The fundamental problem with this theory is that there are always exceptions to the rule so a manager can't always predict what needs people are trying to fulfill. One example of this is a soldier. A soldier will try to satisfy the safety needs prior to the physiological needs. Assuming that everyone needs the same thing in different work environments would be incorrect. This also leads into the expectancy theory that states that the employee needs to value the reward he/she is getting in order to be motivated (Lewis).

Expectancy and goal setting theories share another common trait, which is the concept of learning from mistakes. One can learn from mistakes with development and knowledge transfer. "Organizations suffer learning failures either when they fail to learn from experience or to disseminate lessons within the organization, or when hard-won knowledge is lost through erosion of institutional memory" (Bazerman and Watkins 110). Developmental training programs and knowledge transfer are essential in contributing to an employee's confidence, knowledge, and ability. Knowledge is valuable in the sense that like other assets, it does not depreciate in value. There are two different kinds of knowledge: explicit and tacit. With tacit knowledge, people are motivated to try to keep the information they know to themselves. Explicit knowledge is knowledge that can be articulated through the English language. It's information that can be documented or written whereas tacit knowledge cannot be written down and is embedded in the person or group (Lewis).

HUMAN BEHAVIOR

Psychological Factors

The cognitive science portion of this paper described general cognitive factors, decision-making processes, and organizational behaviors related to motivation. Although the cognitive science section covers a vast amount of information that contributes to human behavior, psychological factors are also another aspect to consider. Human behavior affects everything in the workplace yet technical professionals and technical fields still lack cognitive awareness. When human behaviors along with common psychological factors arise during ambiguous situations, two outcomes can occur, positive and negative. If humans are adaptive to their environment, it is important to understand how leaders can create opportunities from these situations. Still, human error remains as either a factor or the cause for major incidents. "Take, for example, any newspaper report of a major accident – it will almost certainly mention 'human error' as a factor in the accident and may even describe this as the 'cause' " (Gall). By expanding knowledge of cognitive science and bringing a heightened cognitive awareness, managers can minimize the negative occurrences.

Cognitive awareness involves addressing all aspects of human behavior and accepting them as commonplace in industry. However, along with the common cognitive factors previously identified, there are psychological factors that affect human behavior as well. Recommendations exist that mitigate negative effects and promote positive opportunities from typical human behavior. Some psychological factors that contribute to negative effects and litigation involve the following: workload and time pressure, poor risk identification methods, lack of communication and supervision, lack of rules/guidelines, fear of being wrong, complacency, invalid performance measures, resistance to new processes, ill preconceived ideas, and emotions.

The quality of a product can be scrutinized at multiple levels with both internal and external standards. Although processes and procedures are utilized to maintain consistency, there are many psychological factors that affect regular operations. Process execution stands to be inconsistent and may vary depending on the person and the situation. At times, this can occur in part by unclear rules. On the one hand, this provides flexibility to adapt to various environments. Unfortunately, the same vague guidelines can leave room for personal interpretation, which leads to varying practices. Each person can perceive the activity to have a different meaning thus preventing repeatability.

Aside from quality inconsistencies, there are multiple other psychological factors that contribute to irregular processes. There are some people who like to practice their power roles, show dominance in a situation, or play the role of the protagonist. In such cases, people bend the rules to satisfy their agenda or try to carry the full load on their own. When a person is carrying a full load, the priorities are constantly being shuffled around. However, by re-prioritizing the workload, the inadequacies of satisfying those requirements are exposed. Either the resources are not allocated to the lower priority items or the lower priority items are not recognized to be critical milestones until it is too late. “When stressed by overload and forced to focus their resources, the mind-sets of key people in the organization can create serious vulnerabilities” (Bazerman and Watkins). Meanwhile, others fear being wrong. In those cases, engineers can go to such measures as to modify test results or procedures to provide desired results. Others simply keep quiet and do not speak up against something they feel or know to be wrong.

There are also examples of complacency, when people allow themselves to become so comfortable in a situation that they lose the ability to see the wrong in actions and begin to lack creativity. Then, there is the “change” factor, where people become accustomed to old methods. They tend to resist change, because it has always been done a certain way. For sudden or dramatic changes, people also tend to resort to fear and denial. This results when people fear the change will not be accepted or will not succeed.

Invalid performance measures can lead people to accept shortcomings in practices, because they are feeling pressured to perform inadequately. One such example is when management tracks the number of tests completed. After one hundred tests were performed, say half of the requirements were not met or have changed. The procedure would have to then incorporate redlines and the tests re-executed at a later date. For now, they claim victory on having completed one hundred tests but do not account for the fact that the time spent on those tests is incomplete. This urges the test engineers to complete as many tests as possible, taking the focus away from the original intent of satisfying each requirement. This also leads to oversight and falsification of information.

Emotions

Lastly, there are emotions, which the situation that follows conveys in some form. People perform poorly when they have preoccupied mindsets. Imagine being at the end of a long week, on Friday afternoon at 5:00pm. Someone is sending out the last email for the day when the phone rings. There has been a death in the family. At that point, emotions fill that person's mind. That person's mind would start to wander and the last thought in his/her mind is to finish that *last* email. Feelings and emotions flood in and are now affecting that person's behavior. Still, there are times that technical people do not understand other aspects of human behavior that cannot be explained in scientific terms. Due to the lack of understanding, a coworker might proceed as normal and contact the distraught individual regarding work during their loss.

Emotions are a significant psychological factor that affects human behavior. In the past, some philosophers have viewed emotions as a mere distraction. Hence, in cognitive science, emotions were ignored. However, as is evident in this example, emotions can have an overarching role on behavior. There still lies a differing opinion on whether or not emotions should be categorized as a factor to be considered with cognitive science. Psychologists are still trying to understand what category emotions should fall under so it is not surprising that technical people do not always understand emotional effects either. Griffiths describes how this issue has been debated for quite some time. He described how B. Zanjonc denied that emotions were a part of cognition and stated that "emotions happen to people, rather than being planned and performed" (Griffiths 199).

Childhood development stages along with autism have been studied closer in relation to Artificial Intelligence to help improve the understanding of human behavior. Autism studies related to cognitive technology alone have considered several cognitive theories as well. Some of those studies include theories of emotion as part of cognition. Still, there are psychologists who will argue that emotional impacts to behavior are different than that of cognitive factors. "The review of theoretical analyses of autistic deficits, the review of neuropsychological evidence, and the new data that we report all seem consistent with the suggestion that the primary dysfunction underlying autistic disorders is associated with the emotional systems rather than the cognitive systems of the brain" (Bowman et al. 290).

Cognitive scientists are divided on their beliefs of whether or not emotions are part of cognition. However, emotions are now being discussed as a larger part of cognition and theory, because they are at the least recognized as a psychological factor that clearly affects human behavior. "There is increasing recognition that mental representations are often associated with emotional evaluations that contribute to many cognitive processes, especially decision making" (Thagard 173). Cognitive scientists are also torn between: theory based research and computational models. Computational models seem to be a more technical based relation. With computational models, cognitive technology is magnified, because they are exploring the models of the mind in relation to technology. "Computational models are being developed that show how decision making and problem solving integrate emotions with other kinds of information" (Thagard 173).

Environment

One of the considerations for a product or service is the overall benefits to the end user. Because of this, as long as the product performs as expected, the perceived value of the product and the quality of the product remains high. Unfortunately, as stated above, many negative cognitive and psychological factors may occur for numerous reasons. These occurrences force re-evaluation of the guidelines in place. Therefore, there are instances throughout the process that can be improved.

Meanwhile, other external processes are also put into place within a company, such as compliance with the International Organization for Standardization (ISO) and the Occupational Safety and Health Administration (OSHA). Both private and public sectors participate with ISO and OSHA to maintain consistency across processes and procedures. Depending on the company's product, some are mandated by their governments to comply with the standards set forth. However, as discussed earlier, there can be errors in internal processes that still need to be addressed before incorporating other external standards.

Although quality and value are very important factors in a product, human behavior should be considered with the same high level of importance. Recommendations and improvements to an existing process can always be put into place to make following them more repeatable. By incorporating changes, this also helps minimize complacency resulting from a repetitive task. The first goal after changes are implemented is to ensure that the users adopt them. Later in this paper, another situation of complacency is described where additional programs are being developed to help prevent pilot errors.

In all the examples that will be given, human behaviors can cause additional expenses to engineering or technical based companies including litigation expenses. As a result, processes and procedures are continuously in different stages of improvement. These improvements are necessary to satisfy the user or to adapt to particular cognitive factors that may preclude conformance. Humans have psychological limitations that inhibit their effectiveness of procedure creation and their ability to follow established processes. "We persist in believing that we can accomplish more in a day than is humanly possible, and we seem immune to the continued feedback that the world provides, pointing out our limitations" (Bazerman and Watkins 75). The remaining objective lies in identifying those human limitations in order to surpass the potentially negative impacts.

Leadership From Ambiguity

The combination of ambiguity with cognitive factors can lead to inefficiencies or irregularities. The term "quality," in itself, is very ambiguous. For example, different sources contain multiple definitions for the word. In legal matters, ambiguity is defined as a word that is reasonably susceptible to two meanings (Newburger). One such source, dictionary.com, even has a definition that includes the word itself. The defined adjective for the word quality reads, "having superior quality" ("Quality"). That is very unclear. A person is left with an undetermined meaning, when he/she searches for a word and finds the same word in the definition. Then, there is the term "value" that is just as ambiguous and is defined as "relative worth" ("Value"). The word relative leads to yet another word full of ambiguity. A perspective of value and relativity will change from person to person. The eye of the beholder analyzes all of these terms. Like the entire English language, there is always room for interpretation.

Wilkinson describes various types of ambiguity, one being cognitive dissonance. All of the cognitive and psychological factors that have previously been discussed can be categorized as cognition. "Cognitions are attitudes, values, beliefs, emotions, and goals that come together and form a perspective" (Wilkinson 64). Together, all the various factors contribute to decision-making processes and affect human behavior. At times, there are conflicting ideas in the mind of an individual that creates what is called cognitive dissonance. The simplest way to describe this conflict would be in the mind of an addict. In the case of an alcoholic, health issues might arise making the person consider quitting. However, due to the cognitive dissonance, the person can react in one of several ways, one being neglecting the health issues altogether as being a potential health risk and convincing oneself that alcohol is more important than the health issues. "In effect, cognitive dissonance occurs when an individual has to make a choice between conflicting attitudes, values, beliefs, or emotions" (Wilkinson 65). Psychologists from Illinois have demonstrated that people can altogether ignore the existence of something if they do not expect it. In these experiments, people were told to count the number of basketball dribbles on a video. Meanwhile, a person dressed as a gorilla walked into the video as well. Over 60% of the subjects failed to notice the gorilla (Wilkinson).

However, Wilkinson describes how to transform these potential negative outcomes of ambiguity into positive learning experiences. "The more we learn, the less ambiguous the situation gets and the situation moves into vagueness, uncertainty, and finally back to risk and possibly even certainty where we can predict exactly what will happen" (Wilkinson 47). In the *Ambiguity Advantage*, Wilkinson describes four modes of leadership. His book is based on the different modes of leadership that can transpire from ambiguity. His four modes are defined with increasing levels of ambiguity. Those four modes are Mode One: Technical Leadership, Mode Two: Cooperative Leadership, Mode Three: Adaptive/Collaborative Leadership, and Mode Four: Generative Leadership. Each of the four modes is described to bring different characteristics out of leaders. For example, technical leadership leaders will either deny that an ambiguity exists or create their own certainty. Mode two leaders will work to clarify any uncertainties and utilize their teams to minimize risks. Collaborative leaders engage their teams by allowing workers to collaborate; to discuss whatever ambiguities arise. Mode three leaders encourage team cohesion by consensus: when the team meets an agreement on the approach to follow. Finally, mode four leaders create opportunities from ambiguity.

In the various modes, Wilkinson describes leader interactions and responses to different work environments and ambiguity. The highest percentage of mode one characteristics was where the leaders kept their original ideas regardless of new information that may have been presented. In the discussion to follow, this behavior is being categorized as a characteristic of a scientist, which in this case, does not apply specifically to technical backgrounds. In this mode, and all the remaining modes, the leader's approaches towards unfamiliar problems that arise are what distinguish them as different mode leaders. Although each of the mode leaders is described to take in different levels of collaboration from their teams, they are all similar in the sense that with ambiguity, they seek definition and problem solving. With all the modes, one aspect is being considered as dynamic, ambiguity. "The perception of ambiguity is a state created by cognitive dissonance, which itself is a reaction to our need for cognitive consistency in the face of world conditions as we start to realize that our internal representation of the world does not match the reality anymore" (Wilkinson 66). It is important to understand that throughout all the mode definitions, one can successfully adjust the ambiguity to maintain cognitive consistency and create positive outcomes.

Distinction Between Scientist/Non-Scientist

In this digital era, text messaging and use of the Internet as a search tool has become commonplace. Internet searches now employ advanced programming languages to calculate the probability of the pre-defined phrases or concepts someone is looking for from a few initial characters that a person inputs. The search can then complete the phrase or concept for the user and even suggest or recommend related topics. While waiting in a restaurant, one can be sure to see someone else answer a call or text during meal times. Considering manners, isn't that rude? Or is it just rude for people who were raised with those beliefs? As mentioned previously, several psychological factors can impact human behavior. In this case, answering a text message while eating would be directly related to a cultural upbringing or nurturing mannerisms learned during development stages. In the medical surgery case described later, it will be identified that communication adaptation is critical to technological breakthroughs when a surgeon uses text messaging to perform a successful procedure.

Cell phones are becoming smaller than a dollar bill; music devices like an iPod are becoming smaller than a credit card. Considering that electronic communication is used more frequently, one could infer that personal interaction is becoming a past behavior. Tech savvy people tend to be stereotyped as being uncomfortable in a person-to-person interaction. Even though this common perception is known, psychologists have, in some instances, categorized scientists' (technically trained people) behaviors the same as non-scientists. Those two thoughts are contradictory.

Reactions to Anomalies

This topic is very controversial; therefore, this report will describe both sides of these claims. Some philosophers argue that scientists change their theories with anomalous data. Others argue that no matter what information is presented, scientists do not change their theories. Chinn and Brewer have categorized seven general scientist responses to anomalous data: Ignore data, reject data, exclude data, hold data in abeyance, reinterpret data, peripheral changes, and change theory (Chinn and Brewer). Brewer and Mishra describe how Chinn and Brewer's studies need to be expanded beyond undergraduate responses before drawing accurate conclusions on a scientist's responses. "Other philosophers of science (Thomas Kuhn, Paul Feyerabend) focus on the powerful role of theory and argue that scientists often do not change their theories in the face of anomalous data" (Brewer and Mishra 746).

Critique of Thoughts

Chinn and Brewer's idea of multiple responses will be evaluated in the survey to follow. In the least, it should be recognized that there could be different responses to data under different circumstances. In some cases, the anomalous data may be presented in one sample out of one hundred, in which case a scientist may be perplexed by the data and hold it in abeyance. Whereas, in another case, the anomalous data can present itself in half of the samples taken. In this case, however, a scientist can change theories, but rightly so, if he/she is provided with new information that he/she did not have before. Or in the highly intellectual case of Albert Einstein, he will hold strong with his original theory, " 'I think and think, for months, for years', said Einstein. 'Ninety nine times the conclusion is false. The hundredth time I am right' " (Adair 95). Is this wrong? As an engineer, one is taught to seek out a correct answer, to explore troubleshooting methods to find a solution (a right answer). In some cases, a problem has several methods leading to a correct answer. However, once a solution is found to be correct, it would be impractical to seek out all possible solutions to every problem. Another thing that should be considered, that has not been addressed in the previously conducted psychological experiments, is the time it takes to collect and analyze the data. For example, if a scientist discovers an anomalous data point and it takes him/her an entire season to recapture that data, he/she may be more wiling to hold the data in abeyance. Still, psychologists have labeled solution finding as a falseness of science, because all right and wrong outcomes are not exhausted.

However, those studies are solely based on the theory that scientists and non-scientists have similar behaviors. "Our analysis suggests that scientists' responses to anomalous data are not unique to scientists, but are similar to the responses of nonscientist adults and children" (Brewer and Chinn). This, in itself, is very controversial, because the experiments have primarily been given to nonscientist undergraduates. How can that assumption be made without gathering specific data from scientists and from other data sets other than undergraduates? Scientific reasoning studies should also be performed to establish a clear distinction between the aspects of a scientific trained person and a non-technical trained person.

Still, the research has shown a biased perspective from a non-technical aspect. Psychologists claim that scientists make improper inductive inferences, which lead to a false basis in science. The supporting research explains how scientists tend to use a confirmation bias and try to confirm their hypothesis rather than disconfirm it. One of the journals reads, “scientists are poor at drawing proper conclusions from their research” (Farris and Revline 497). However, in the Farris and Revline experiments, the subjects were told whether or not their hypothesis about a rule was correct or not. This would eliminate the need for a person to continue to seek out more information surrounding his/her hypothesis. “In effect, this experimenter feedback is simulating a situation in which the scientist can ask God whether his or her hypothesis is correct, and therefore be spared the necessity of conducting further tests” (Gorman).

Meanwhile, Chinn and Brewer also explain how theory change can be enhanced, namely by having personal involvement with the decision to change and justifying the reasoning behind the change. The authors emphasize that teachers should not “foster blind theory change but instead theory change that is rational and reflective” (Chinn and Brewer 31). Again, this is not taking into account that in industry or in a team environment, when a technically trained person changes his/her design or theory, while working with other individuals, upper management or team members will typically require a discussion surrounding the reasoning for those changes. Therefore, in a sense, the Chinn and

Brewer discussions surrounding this topic are contradictory.

Survey Results

In order to account for these controversial topics surrounding what theories are common amongst technically trained people, an interview was conducted among twenty-one individuals. Of these people, all but one person are in pursuit of or hold an Engineering degree. The other person has a Mathematics degree. Brewer and Chinn categorize people with technical degrees as scientists. Therefore, all of these individuals would be categorized as scientists.

The information gathered from the survey helped to expand on scientists' responses given an anomalous situation. Brewer and Mishra explained how studies need to be expanded beyond undergraduate responses. Therefore, this survey captured an audience of working scientists. The survey questions were categorized to represent the general scientist responses of Chinn and Brewer. It was evident from the results that other philosophers such as Kuhn and Feyerabend were incorrect in their theory that scientists do not change their theories in the face of anomalous data. Figures 2, 3 and 4 show the responses of the group, when given different circumstances of anomalous data within test results. When one anomalous data point was found out of one hundred, people tended to retain their original theories. Whereas 52.4% or more would change their theory entirely based upon half the data being anomalous. Figure 5 displays how drastically those choices changed with each independent scenario. It was identified that each person's response changed dependent on the circumstances involving the anomalous data points within the entire data set.

All in all, there are some similarities and some contrasts in thinking processes amongst technical and non-technical individuals. Additional studies would need to be made to accurately conclude a given theory. Still, psychological and cognitive factors affect everyone. One way to address these factors is to have awareness of the negative outcomes that might occur and try to promote ideas to create opportunities from those situations.

TECHNICAL FIELD APPLICATIONS

Technical Arena

Cognitive science has become an inherent aspect of engineering and technical related processes and procedures. The relation between cognitive science and technology is remarkably intertwined. It's a wonder why the study was not explored in depth earlier. In serving the public, professionals are placed in a position of public trust. In particular, the engineering and technical role in society becomes very critical. "However, given the important role of science in modern society, it seems that the cognitive science of science has not received adequate attention" (Brewer and Mishra 749).

Many guidelines have been put in place to mitigate growing concerns for societal and professional responsibilities. One example is the Texas Engineering Practice Act (TEPA). The Texas Board of Professional Engineers has implemented the TEPA to maintain professional conduct and ethical behavior with regard to engineers and engineering based companies. The "Texas Engineering Practice Act and Rules Concerning the Practice of Engineering and Professional Engineering Licensure," Chapter 137 contains information on professionalism and compliance of the TEPA rules. The General Practice section 137.51 reads, "In order to safeguard, life, health and property, to promote the public welfare, and to establish and maintain a high standard of integrity and practice, the rules relating to professional conduct in this title shall be binding on every person holding a license authorized to offer or perform engineering services in Texas" ("Texas Engineering Practice").

Cognitive science is a very important aspect of technology and is a crucial topic to understand. Many technical professions bound by guidelines such as the TEPA know that cognitive science has become more evident in today's workplace. The TEPA addresses professional conduct and establishes a list of rules that every engineer should follow. Guidelines and established processes are ways to address cognitive science in the workplace. With established practices, a business can minimize negative effects of human behavior. Human error is one of the most common grounds for the basis for litigation. It is evident that, if performing or providing engineering or technical services, a person should consider cognitive science in all aspects. This paper will describe the relation between technical fields and human behavior in the paragraphs that follow.

Cognitive Technology

In order to effectively create opportunities from ambiguity and minimize hindrances or human error, one must continue to study cognitive science. A strong understanding of cognitive factors will help to identify strengths within an organization and team. By applying that foundation of cognitive science with technology, society can delve deeper into the understanding of the mind and create greater interactive technology. Cognitive technology creates an opportunity in itself by allowing the mind to be explored in terms of technology. Things that humans consider second nature, such as merely speaking, have become a crucial part of technological developments. Natural language (human speaking) is used as a cognitive technology. Dascal explains the various projects being explored to allow man and machine to communicate naturally with each other. The projects are being described as revolutionary, "comparable to those achieved by the introduction of the computer and the internet" (Dascal 38). MIT's Oxygen is one of the references described as having a built-in application to recognize speech (Dascal). Technological advancements that are available today were only mere concepts a few decades ago. Bach and Beethoven made musical masterpieces with the instruments available to them. If presented today with new cognitive technology, "being great minds, not merely great composers and/or performers, these cognitive geniuses would have recognized the tool for what it was: an extension of the mind, not an impediment to its development" (Gorayska and Mey 18).

There are endless possibilities of computational models in relation to the mind including programming, robotics, and artificial intelligence (AI). "The primary research methodology used by AI and Cognitive Science researchers is the computational modeling approach" ("Emotion Research"). This approach investigates how to model the mind in a computational model. In short, the mind becomes analogous with a computer. The sections covering medical cases and artificial intelligence will discuss the uses of the computational models in cognitive science and the many applications of robotics using similar human modeling techniques.

The identified medical situations demonstrate ways where medical practices have been assisted or replaced with robotics to create less hazardous environments for humans while creating more efficiency and effectiveness. As mentioned in the organizational behaviors section, one of the vital methods of understanding human behavioral limitations is to learn from mistakes. In the sections that follow, technical cases will be discussed that describe lessons learned from human error and common biases. These sections will go through history from 1915 to current day technological advancements.

Molassacre

With the United States Industrial Alcohol (USIA) Company as its parent company, the Purity Distilling Company in Boston, Massachusetts (MA) was contracted to construct a storage tank that was completed in 1915. The same tank was soon destroyed in 1919 when nearly 2.5 million gallons of molasses burst out of it sending its' rivets shooting out. The molasses that exuded from the tank came rushing out at speeds of 35 miles per hour, creating molasses waves 15 feet tall in height. The force was strong enough to destroy the structural steel girders of the Boston Elevated Railway.

Buildings and lives were crushed at the north end neighborhood of Boston, located at 529 Commercial Street. The aftermath included a total of 21 killed and 150 injured, which led to the largest class action suit in Massachusetts at that time. The suit combined 119 separate legal claims against the United States Industrial Alcohol Company (Puleo). This horrible incident occurred on January 15, 1919. It is an appalling engineering catastrophe that is seriously under told. Other names it has come to be known by are the Boston Molasses Disaster and the Great Boston Molasses Tragedy. In recent references, it's also been dubbed the "Molassacre."

The tale explains many possibilities that may have contributed to the ultimate demise. The person, who was in charge of the tank's testing and construction efforts, went by the name of Arthur Jell. In this scenario, this man demonstrated characteristics of the overconfidence and hindsight biases that fall into the confirmation heuristic. Although he had no relevant background in overseeing this project, he continued to do so, with haste. "…Jell had spent his entire professional career as a financial administrator, …he had no technical or engineering training, and …he could not read building plans or specifications" (Puleo 199). His lack of experience led him to make multiple mistakes that led to this negative outcome. Simple tests were not conducted, such as filling the tank up to check for leaks. No water test was made of the tank "except by putting in six inches of water" (Puleo 202). Jell stood by his decisions, even after the event, stating that there was no time and not enough supply of water to perform a test with more than the six inches. Not only that, he testified that he considered a water test to be an unnecessary expense. Other people later testified to the leaks that they had witnessed that had subsequently been covered up by paint to be hidden (Puleo).

During testimony, other witnesses were called to discuss the circumstances that led up to this event. One of the tank's destruction theories was that there was dynamite placed there by anarchists. However, the state police chemist was called to testify about the "common explosion scene" that would have been observed had this occurred. The shattered windows found in the area did not fall into the correct category of properties to be considered an explosion. The chemist also described the fermentation properties that the molasses would have experienced by combining a warm batch of molasses with cool layers of molasses that occupied the tank. Although there was no definitive cause to this catastrophe, human error and biases were clearly involved.

The sites that mark this disaster have become recreational landmarks in Boston where a small plaque at the entrance to one of its parks, Puopolo Park, placed by the Bostonian Society, commemorates the disaster. The historic marker is titled Boston Molasses Flood and reads: "On January 15, 1919, a molasses tank at 529 Commercial

Street exploded under pressure, killing 21 people. The initial onset created a 40-foot wave of molasses that buckled the elevated railroad tracks, crushed buildings and inundated the neighborhood. Structural defects in the tank combined with unseasonably warm temperatures contributed to the disaster" ("Historic Markers: North"). The small plaque may not seem like a large enough commemoration to the disaster, but other long term requirements took place that changed engineering practices altogether. Fortunately, lessons were learned from this event where construction safety standards improved, engineering calculations were required to be filed with plans, and drawings were to be reviewed and signed by an engineer.

Medical Cases

As previously mentioned, another cognitive science factor is concepts. The concepts theory describes many terms that can be considered vague or contain multiple interpretations. Some words that can fall into that category are quality and value. Still, others surround general objective measurements such as success. For this horrid example, quality is in question yet again. Here is a medical case that led to the worst possible outcome, death. While performing a normal task, a nurse flushed a patient's arterial line incorrectly. The nurse used insulin instead of heparin. The patient, Mrs. Grant, suffered from multiple symptoms including "severe hypoglycemia, seizures, coma, and, ultimately, death" (Spear and Schmidhofer).

How could this patient have received better quality in medicine? It is hard to say what contributing factors occurred on this given day that could have been changed. One thing for sure is that if the nurse was in doubt, she could have asked for assistance. In

Congo, in December 2008, a volunteer surgeon was able to perform an operation he had never performed. The surgeon knew a colleague in London who was an expert in the operation, and he decided to text him. A response was received right away with lengthy step-by-step instructions on how to perform the operation. This operation saved a 16-year old boy's life ("Surgeon Saves Boy's"). "It goes to show that if a clear message is given to the team and patients get the best treatment that could be offered then one would expect the best results" ("Congo: Caught in the crossfire"). A true indicator of quality was demonstrated in this miraculous surgery by simply incorporating text-messaging services that were unavailable in Africa in the past (Ambler).

One train of thought is that robots are meant to aid and evolve humans to another level (Engelberger). It seems that robots and robotics technology are under constant development and will be a part of mankind's future. Even more so now that cognitive technology is being practiced to create more advanced robotics and AI. Understanding the possibilities of robotics and technology is important because they will affect everyone's lives in the future. Cognitive science in technology is becoming a more critical focus to aid in understanding human behavior as well. "You're using AI to understand the human mind - Herbert Simon" (Simon).

Well-known advocates, such as Engelberger, have described robotic technology as a four-stage life cycle. The first stage is single functional robots that can only perform one task. The second stage is where robots can perform numerous functions while being conditioned to avoid dangerous situations. Improvements of the second stage from the first stage would be, for example, where a robot would pick something up and move it.

The first generation robot would bump into the box next to it while the second-generation robot would feel the box, or see it, and avoid it so that it did not drop or jostle the item that it is carrying. That is an example of being able to condition the robot. The third stage of robotics would be multifunctional robots that could see where they were going and simulate where possible dangerous obstacles and impediments might be and avoid them. The fourth and final stage of robotics has been described as artificial intelligence where a robot could interact with a human on a day-to-day basis (Engelberger).

This paper will be focusing on the advancements of robotics in relation to cognitive science and therefore, will not be touching on the first stage of robotics. "Recently, the computer technology has suggested the very powerful and popular metaphor of the brain as a computer" (Pfeifer 124). A general medical practice robot will be described that performs tasks and laboratory tests. After covering these general applications, the use of robotics with artificial intelligence and advanced programming will be described in more detail. Various robotic and artificial intelligence developments have taken place by combining cognitive science with technology. Robots are being used to perform daily activities, dismantle threats, and even act as autonomous surveillance vehicles.

A combination of second and third stage robotics is used in medical practices such as robotic nurses. Tired nurses scramble back to their feet as another patient enters the doorway. The nurses have many chores on a daily basis. They are usually the first and last people someone sees at a medical facility. At Loyola University Medical Center, one might catch a glimpse of something else processing the specimens or the prescriptions. In

Maywood, Illinois, where this medical center is located, robots are now helping with some of the daily routines throughout the laboratories.

In 1998, Loyola was the only academic institution that contained a robotic workstation (Paxton). By 2000, Loyola went on to integrate a processor program to its existing analyzer tools. Through a computer, the robotics can determine positive patient identification through bar code labels; the robot also sorts and processes specimens for further analysis or category placement. The tubes are placed on a rack depending on the order of testing procedures. After the specimen is tested once, if further testing is required, the robot receives the proper commands, which essentially tell it which testing rack to return it to next. If all tests have been completed, the robot simply retrieves it and places it in the correct spot ("NCCLS Guideline Adds"). Loyola has also incorporated new pharmacy prescription robotics to help minimize human related medical errors. Another new technological breakthrough now being incorporated is a bacterial badge reader to help minimize bacterial infections that might spread from lack of health care worker cleanliness. The badge reader lights up to indicate whether or not the health care provider is allowed to treat the patient based on the sensor reading (McFadden). These new technologies will be a significant aid in the laboratory. Not only will the robotics help eliminate some of the strenuous, labor-intensive work, but it will also help minimize biohazard risks. Still, other developments are taking place that involve protecting military personnel and this country. "There is no better testbed for both researching and teaching AI than real-world, autonomous systems" (Kortenkamp, Bonasso, and Murphy). Robots and autonomous vehicles are becoming very crucial to society.

Artificial Intelligence

The future of robotics is determined by what humans want from robots, whether it is to aid us in medicine, aid us in hazardous situations, or entertain us in games and movies. The entertainment industry is a measuring stick of the needs and desires of humans. Science-fiction movies provide a look into the future of robotic technology. Advances in robotic technology depend heavily on Artificial Intelligence (AI) and the understanding of cognitive technology. "Cognitive technology is concerned with the relationship between humans and machines, in particular how the human mind can be explored via the very technologies it produces" (Pfeifer 109). AI is the science and engineering of making intelligent machines.

Artificial Intelligence (AI) has been the basis for movies throughout history such as Stanley Kubrick's *2001: A Space Odyssey* and Steven Spielberg's movie *AI*. The possibility of robots with the ability to have emotions and make decisions on their own depends entirely on AI. In the movie *2001: A Space Odyssey* the space ship's computer named HAL controls the entire ship's vital control systems. HAL's name originates from its creation, a **h**euristically programmed **al**gorithmic computer. HAL, with its advanced AI, communicates in a human voice with the ship's astronauts and is programmed with genuine emotions. HAL even adjusts and learns new ways to prevent the crew from stopping its pre-programmed mission. Steven Spielberg's movie *AI* concentrates on the possibility of robots with the ability to feel emotions, specifically love. A child robot named David is given to a family whose son is in a coma. David fills the emotional gap for the family left by the son. Throughout the movie, the mother bonds with the child robot. The idea of such an advanced AI in a robot is amazing. A robot that feels such a complex emotion such as love thins the line between an actual human being and a robot.

At the MIT Humanoids Robotics Group, AI is being researched and implemented into robots. These robots are being developed to learn and react from human actions (Adams et al.). The MIT research group believes that in order for AI to be as human like as possible, a robot must also have a body that is human in form and function. Just as HAL had a natural human tone to his voice, having a robot with a humanoid body will allow humans to better interact with human level intelligence robots (*2001: A Space*). Cog is a robot made up of sensors and actuators to emulate a human's motor skills. Cog's arms, legs, torso, and head are able to move just like its human counterparts. Video cameras make up Cog's eyes. A humanoid face, biochemical subsystem, and mind are currently in development (Adams et al., Cog). Using cognitive science surrounding childhood developmental stages, Kismet was also created. Kismet is a robot modeled after a child to capture human emotions and expressions. The robot has at least seven expressions for different types of emotions. Kismet expresses an emotion in relation to its social interaction with a human. The sound and visual recognition system of the robot determine Kismet's reaction to a situation (Aryananda and Varchavskaia).

These examples are all technological breakthroughs, which have promising potential in national defense products, keeping humans out of hazardous situations. Since national defense is crucial for a nation, the quality of the product becomes scrutinized at an exponential level. Robots are currently part of the military today. Many robots are used for hazardous situations in order to prevent loss of human life. However, the future of robotics in the military goes far beyond bomb retrieval or entering contaminated buildings. Less than a decade ago, there were prohibitions on the use of robots or systems that could operate on their own initiative in combat. In the past, the military robots were limited to bomb-disposal, reconnaissance and surveillance.

Ideas currently in development are military robots resembling insects, birds or plants. Insect-like robots with the ability to enter enemy compounds can collect intelligence information without being noticed. The robots can carry bombs and detonate themselves with pinpoint precision. Crab-like robots can walk the surface of the ocean and search for mines. Bird-like robots can patrol the sky for years with support from the sun for energy and attack enemy aircrafts with missiles when the opportunity arises. Plant-like robots can be dropped across a wide area of land and collect information on ground troop movement. In a recent news release, BAE Systems has announced a team of scientists that will expand on this leading technology. "The alliance will create an autonomous, multifunctional collection of miniature intelligence-gathering robots that can operate in places too inaccessible or dangerous for humans" (Spiller and Lenover).

Still, these are not the first technological advancements in autonomy. Our country has been using autonomous unmanned aerial vehicles (UAVs) in military combat for some time now. A 2003 Report for Congress defined UAVs "as powered, aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or non lethal payload" (United States. Congressional Research Service). In order to create any autonomous technology, programming has to be heightened to multiple levels of the mind and responses. UAVs cannot respond to every situation without fully understanding what a human would do in a given situation first. Operators are still used to assist in the operations of these aircrafts or vehicles. In aviation environments, an operator can be overwhelmed with decision-making processes and cognitive factors. Wilson mentions the overload or complacency that can occur with UAV operators. Due to this fact, operator assessment programs are being developed to assist in the limitations of these situations (Wilson).

"The first artificial intelligence program was the Logic Theorist" (Thagard 43). The program was written in 1956 based on performing proofs from formal logic (Thagard). Today's current cognitive technology is more advanced than it has been in decades. Still, there are obstacles to overcome and further cognitive science understanding to apply to reach the level of such advanced AI as seen in Spielberg's *AI* and Kubrick's *2001: A Space Odyssey*. Reaching such an advanced form of AI is certainly an exciting and challenging goal that scientists will continue to try to achieve.

RECOMMENDATIONS

To expand on the advancements of technology, one must continue to research cognitive science in technology to gain a solid foundation and understanding of inevitable cognitive factors. Recognition of cognitive science is a huge factor in developing any new technological breakthrough in relation to artificial intelligence and human interaction with robotics. By considering cognitive science in technological applications, one can minimize human errors and hindrances and create more opportunities from ambiguity or miscommunication. Minimizing negative results in human behavior directly impacts multiple organizational functions such as litigation, management, human resources and engineering. Several methods can be used to proactively address cognitive factors in technology: selection, checklists, training, feedback, reinforcement and incentives.

Personnel selection is a way of addressing errors that might develop in the workplace. During the hiring process, leaders should look for people to satisfy the criteria for skill set and capabilities in a particular occupation. If reliable and valid tests are used to satisfy a job and measure the required skills and abilities of a person, fewer errors should result. Some ways of promoting positive behavior after the selection process are to instill checklists, training, and communication for providing feedback and reinforcements. Checklists have become a standard practice amongst aviation and military operations, especially in the cases involving unmanned vehicles that were described earlier in this paper. The checklist method provides a guide to the user that ensures the basic necessary steps are performed, it allows the organization to have a record of compliance that the minimum steps were performed, and in some cases, it relieves the user of the cognitive limitations that are imposed upon them in hazardous situations.

As with checklists, personnel must be trained to use the available tools properly. Proper training must be provided for the entire team so that they are aware of how to approach different situations that they may encounter. Team members should be comfortable and aware of situations where they can seek advice or make decisions without repercussion. Management should also help identify development opportunities for growth and confidence to minimize complacency. Feedback and communication become crucial in engineering or technological processes such as these. In order to establish an open environment, a manager or leader must communicate with the team to better understand the strengths and weaknesses of each individual. This will allow for better team relations and a better understanding of both team and individual motivations. The leader should also promote a sense of community within the team to allow each individual to feel a sense of safety and security in knowing that support will be available if necessary or that support will be available despite what decision is made. This can encourage team interaction and communication within a constructive climate. In cases of ambiguity, the leader must be able to recognize the leadership mode characteristics when assigning a team lead. Otherwise, the leader must identify which mode to lead their team with. For others that do not reflect any of the positive ambiguity characteristics, the leader should not tolerate room for ambiguity and provide feedback directly to the team member.

The feedback should be bi-directional, from the leader to the team and from the team to the leader. Continual feedback from the entire team will help in maintaining and improving processes and procedures that are outdated or incorrect. The explicit/tacit knowledge transfer here is an important aspect as well. Although tacit knowledge is hard to capture in documentation, team members should try to capture as much information as possible from the experienced individuals to incorporate into their processes and procedures. Many times, this information is assumed to be obvious or implied, but in actuality, only the experienced individuals can perform the task without the additional information provided. Providing clarity to unknown information will help to provide continual knowledge transfer amongst the different levels of experienced personnel.

Feedback following positive behavior and desired outcomes are another way of minimizing negative behaviors. In this case, the feedback is used as a reinforcement method to motivate the individual or team to continue to demonstrate the same behavior, as described in the organization behaviors section in this report. The reinforcement theory goes hand in hand with incentives where management can provide rewards in order to instill and encourage the same positive behavior. For sales teams, bonuses are normally given as part of an award for meeting a sales quota. In general, promotions, increases in salary, or stock options are normally offered in today’s society to demonstrate an appreciation of work output and contribution to the company.

Along with the methods described, management and leaders should continue to promote cognitive awareness within the workplace. Decisions or judgments affected by cognition may happen at an unconscious level, and in those cases, may not be predicated by logic. By understanding common biases related to heuristics, people can help others collaborate past the negative ideas. By recognizing cognition in the workplace, bi-directional feedback should help team members and leaders de-bias their own judgments as well.

CONCLUSION

Cognitive awareness is an important aspect of embracing the positive affects of cognitive factors in a technical field. There are several human behavioral theories to consider. The important thing to take away from cognitive science is to not ignore the fact that human behaviors exist. After recognizing this, the important step becomes understanding how to minimize negative effects and how to optimize the outcomes. Humans are adaptive. Therefore, as leaders and managers, people should create opportunities for their teams in order to minimize incidents. It is critical for managers to convey information that may be unclear or ambiguous. Communication in engineering and technical fields is very important between organizations. Meanwhile, the average engineer or scientist is not known for his/her communication prowess. "Computers are getting smarter all the time. Scientists tell us that soon they will be able to talk to us. (And by 'they', I mean 'computers'. I doubt scientists will ever be able to talk to us.)" ("Dave Barry Quotes").

As an engineer, a person is trained to find the right answer. Unfortunately, in industry, people are also taught to meet a schedule under pressure, and as noted previously, this can lead to misleading results, incorrect sample data or even death. In order to minimize the negative impacts of cognitive factors in a technical field, communication and cognitive awareness are key. "Understanding the limits of human cognition allows leaders to create structures in which these limits will do less harm" (Bazerman and Watkins 94). By gaining awareness of common heuristics, biases, and psychological factors, steps can be taken to improve employee relations, create positive work environments, and create established processes and procedures to help minimize negative outcomes and litigation.

This paper has captured the general outline of cognitive science theories to provide the reader with a better understanding of the general aspects that impact human behavior. From there, those theories were applied to technology and explained to demonstrate the major impacts that cognitive science has had on technology. After reading this paper, it should be evident that human behavior affects everything in the workplace. It is a de-emphasized subject in general engineering studies that needs to be better understood in order to improve organizational practices and to promote positive human behavior. Although cognitive science and technology impact each other so drastically, it is hard to find information related to cognitive technology when researching cognitive psychology and vice versa. Cognitive science has bridged human thinking and behavior with technology. Humans have used the general concepts of cognitive science to create great technological developments through history. Now, technology has evolved to a point where the role is now reversed, and the technology is now helping humans to better understand human thinking and behavior as well.

By understanding the fundamental concepts surrounding cognitive science in technology, negative biases can be addressed, and leaders can promote cognitive awareness and better decision-making from understanding the foundations for human behavior. "[Good leaders] stay with ambiguity, explore it for possibilities, discover decisions, and are comfortable altering those decisions and making new decisions in light of new information and/or new thinking, while positively influencing the thinking and actions of others” (Wilkinson 122).

APPENDIX

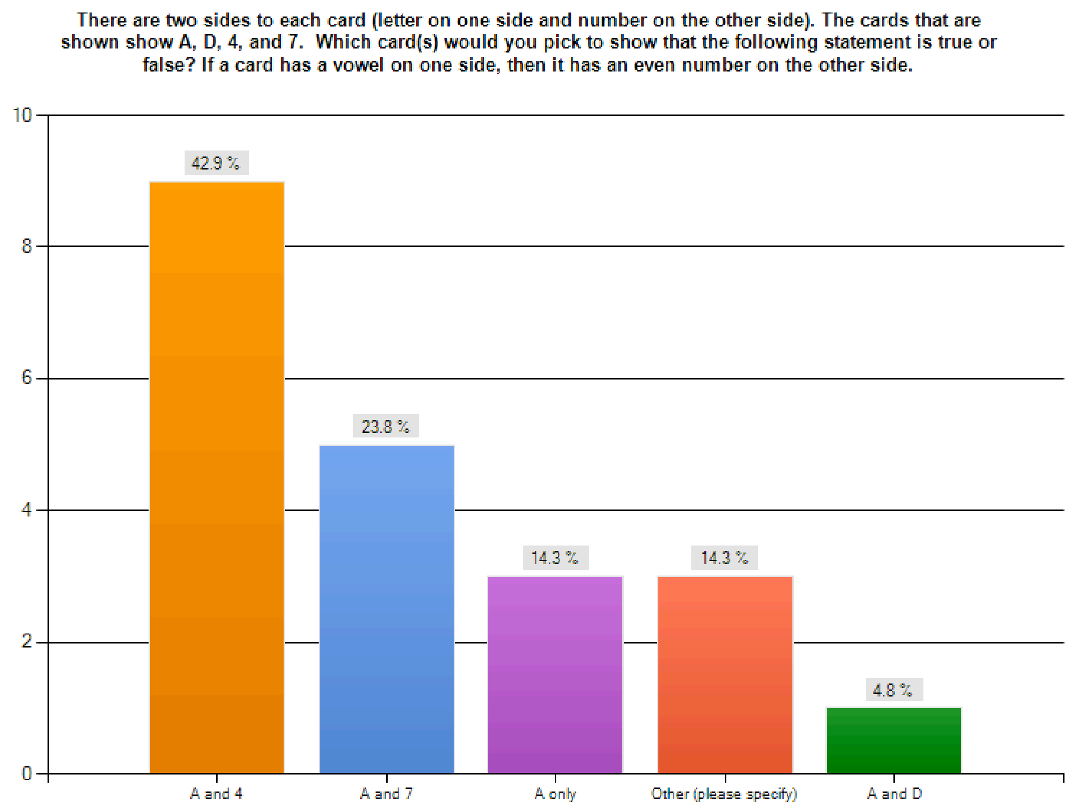

Figure 1: Wason Card

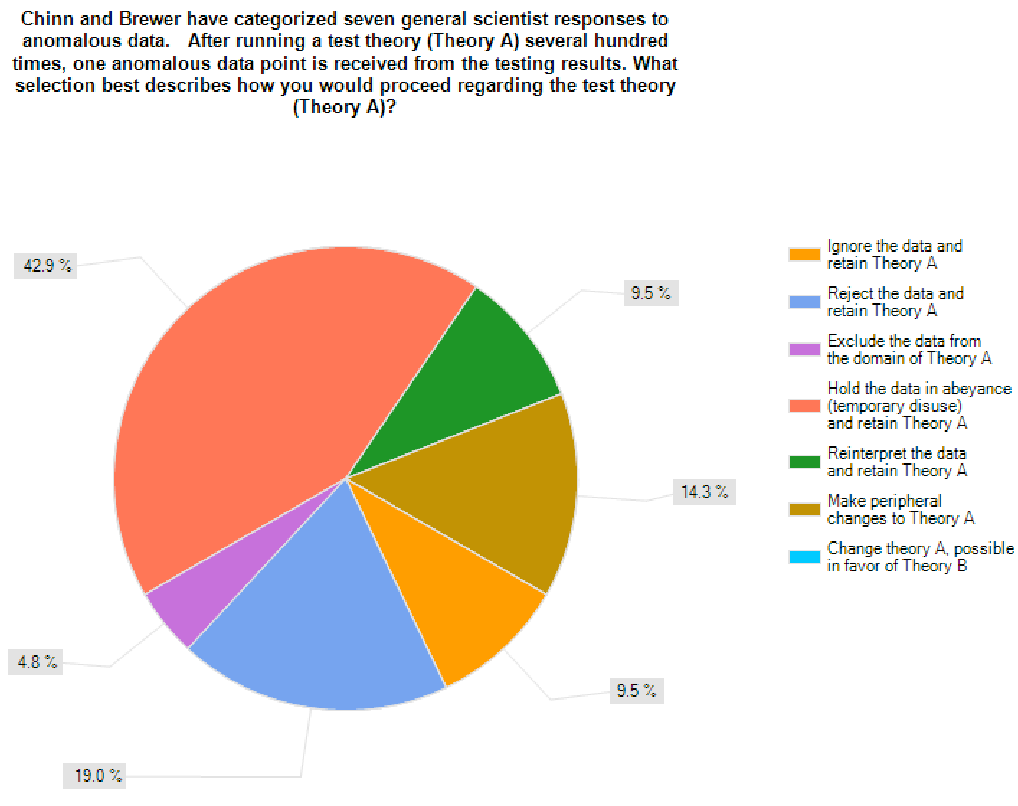

Figure 2: Given One Anomalous Data Point

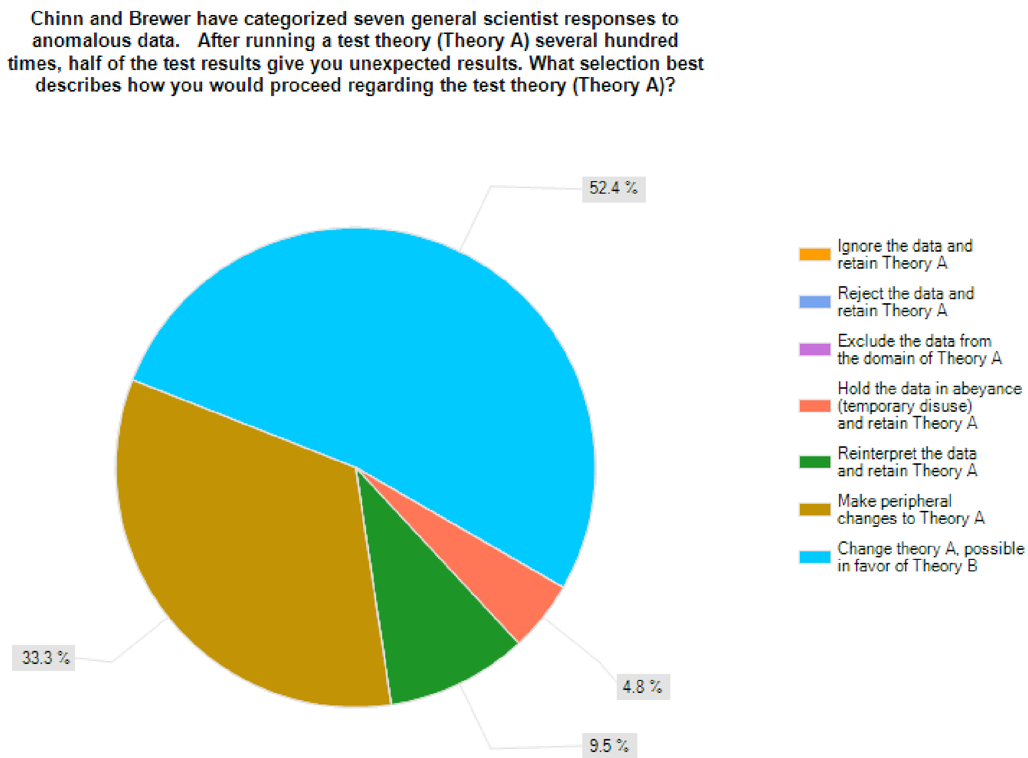

Figure 3: Given 50% Anomalous Data

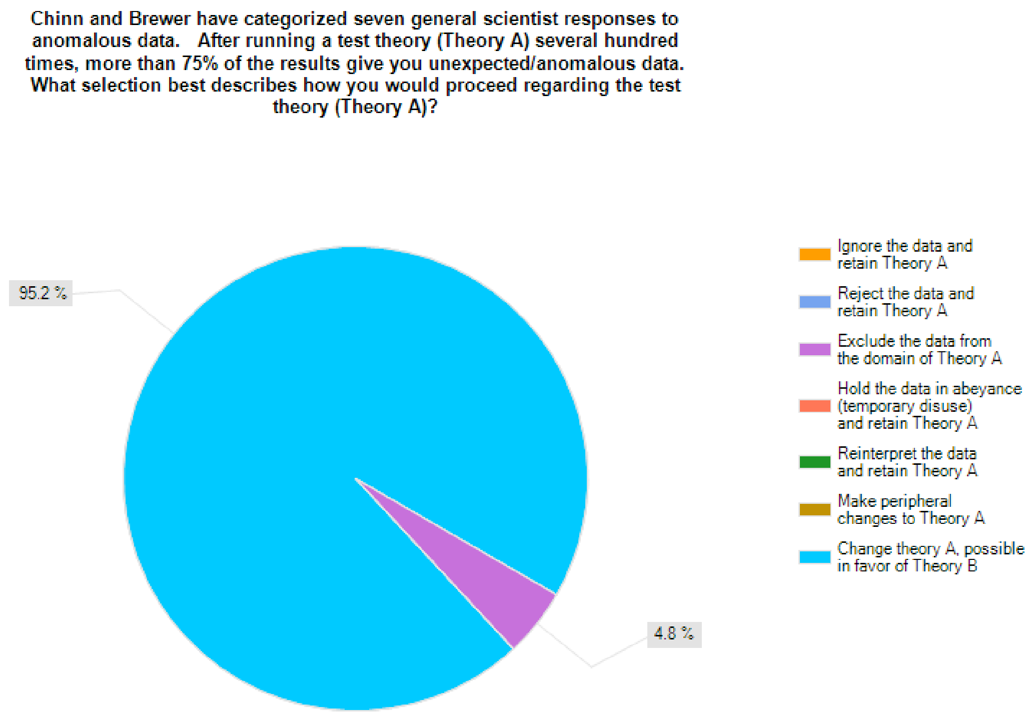

Figure 4: Given 75% Anomalous Data

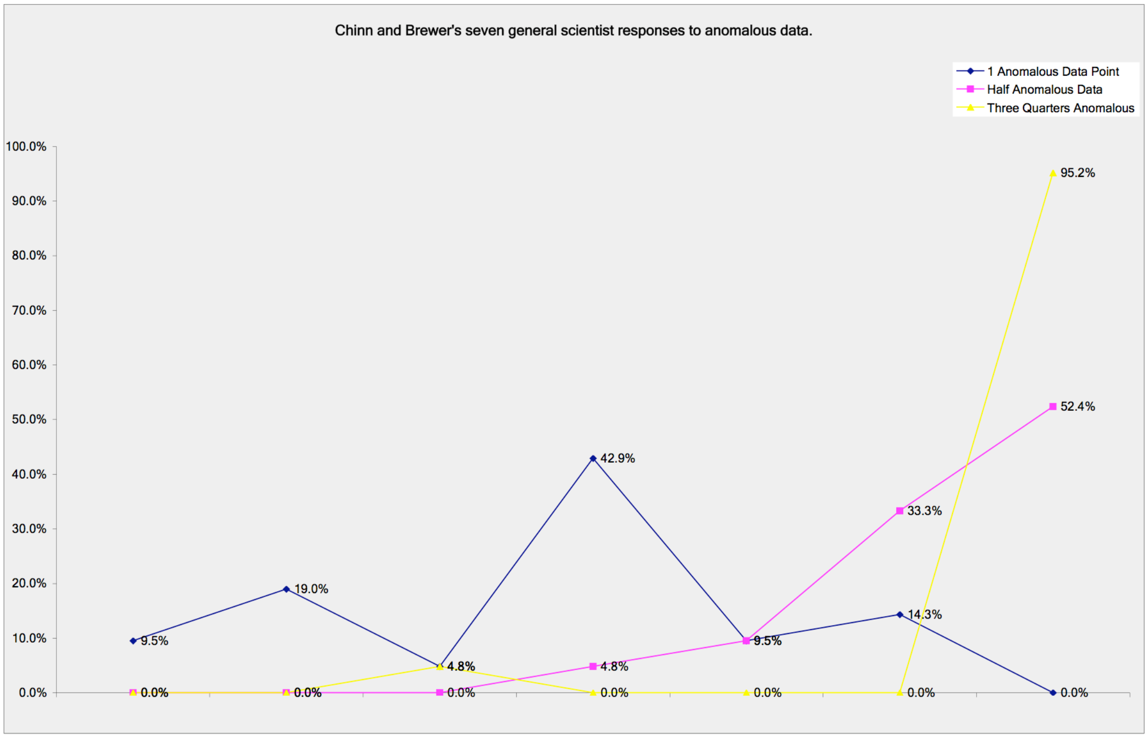

Figure 5: Combined Group Responses

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