Chapter 1: Introduction

What does the typical person know about their brain? Do they know as much as they know about their favorite sports team or their favorite celebrity? Can they describe the operations of their brain with the precision that they list the ingredients and steps in a favorite recipe or explain the nuances of playing a popular electronic game? Do they track their brain with the regularity that they follow the weather, the price of gas or how much money they have in their wallets? Yet, all that we experience, all that we know and all that we do is a direct, inseparable product of our brain.

For most of us, our brain serves as the conduit through which we experience life, but nothing more. We may have thoughtfully-devised programs for exercising our bodies and on any given day, know our weight within a couple of pounds, but we pay scant attention to the state of our brain and how we may be affecting our brain, nor how we may be affecting the brains of others, or how our own brain is being affected during the course of everyday life.

In the following chapters, our primary objective is to summarize current brain science, but most importantly, highlight and explain the practical, everyday application of brain science. Today, there may be no field that produces a larger volume of scientific papers, books and other publications than brain science, or "neuroscience." However, with little exception, these publications are esoteric and beyond the reach of those without the requisite academic training (i.e. generally, an advanced degree in neuroscience or a similar field). This occurs despite recognition in diverse fields ranging from education to engineering to marketing that brain science is highly relevant to these domains. Our goal is to make brain science accessible to a

wide array of professions, and to do so in a manner that allows readers to readily apply brain science to their own professional endeavors.

We will discuss current perspectives from brain science, as well as many recent research findings. Particular emphasis will be placed on factors that affect performance and behavior, including common vulnerabilities contributing to errors, misinterpretations and lapses in judgment, as well as factors that affect our social interactions and allow us to work more or less effectively as teams, groups and organizations. Special care will be taken to not present countless facts that would soon be forgotten. For example, basic brain function will be described without detailed descriptions of the related anatomical structures, given our belief that few readers will possess a thorough knowledge of neuroanatomy. Most of the material that would typically be covered in a college course concerning brain science will not be discussed here. This is because the bulk of current knowledge of the brain, while interesting, cannot be readily translated into insights and principles that may be readily applied to everyday activities. For instance, numerous research programs are working toward an understanding of how the cells of the brain operate, and interact with one another, at the smallest measurable scale (i.e. nanoscale, or one millionth of a meter). While important to many endeavors (e.g. engineering new drugs that have highly specific effects upon the brain), there is little insight that can be gleamed from this knowledge to help the non-neuroscientist understand why people do what they do, or how to achieve more effective outcomes.

Within the forthcoming chapters, the discussion will often extend beyond the science of the brain to encompass research and theories that might be best described as behavior science. There are

many insights arising from the broad study of human behavior, much of which the neural underpinnings are not well understood. Today, the traditional behavior sciences, which include psychology, sociology, anthropology, economics and political science, are being increasingly influenced by brain science. This is occurring partly due to the growing availability of equipment for studying brain function such as EEG, or electroencephalogram, and neural imaging such as fMRI (functional Magnetic Resonance Imaging). Additionally, there is the natural tendency for scientists to look to deeper and deeper levels, in this case the functioning of the brain, to uncover causes for the phenomena they study.

A convergence of brain and behavior science is an inevitable outcome and the two have a reciprocal interest in embracing one another. As noted, brain science provides insight into the fundamental causes of observable behavior. In kind, behavior science speaks to the mechanisms by which the environment has shaped modern humans, and particularly, our brains. As with any animal species, modern humans included, our brains are the product of our adapting in specific ways to cope with various challenges and capitalize on opportunities afforded by the environments in which we evolved. In the same way that various species have developed complex courtship and mating rituals involving sometimes tightly choreographed sequences of behavior and response, the human brain has been shaped through evolution to respond in a specific manner to certain events within the environment.

A later chapter will discuss the Ultimatum Game, which is a research paradigm in which experimental test subjects are offered real, spendable money with no strings attached, yet they regularly turn it down due to the social situation created within the context of the game (Sanfey

et al, 2003). This is not a matter of delayed reinforcement where one sacrifices a small immediate reward in favor of a later, larger award. Instead, the money is there for the taking, nothing is required of them, but they routinely say, "no thanks." Why would a test subject, most likely a college student, turn down the experimenters' money? This can happen if the situation is one that triggers disgust or anger that outweighs rational considerations. While humans are not nearly as hard-wired as other animal species, there are many curious behavioral tendencies that may be triggered by placing humans within certain situations.

The unconscious has long been a prominent idea used to explain human behavior within psychology (Westen, 1999). By unconscious, we mean that there are factors that shape our psychological experience and behavior for which we have no awareness (e.g. subtle emotional reactions, forgotten memories). The notion of the unconscious fell into disfavor due to 20th century dismissal of the fanciful propositions of Sigmund Freud and other early psychologists. However, the basic idea that our behavior is heavily influenced, and sometimes determined, by operations of the brain for which we do not have conscious awareness has undergone a modern revival due to the realization of neuroscientists that the overwhelming majority of what the brain does occurs at an unconscious level (Eagleman, 2011).

In a forthcoming chapter, there will be discussion of research showing that using brain imaging, the decisions an experimental test subject will make can be predicted 7-10 seconds before the subject is consciously aware of their decision (Soon et al, 2008). In other words, the experimenter looking at the brain scan knows what the subject is going to do 7-10 seconds before the subject knows what they are going to do. With these findings, one can better understand

human behavior that seems irrational, counterproductive and even self-destructive (e.g. over-eating or other self-destructive indulgences). Specifically, our behavior is regularly being driven by operations of the brain for which we are not consciously aware, with these brain operations being the product of the unique solution humans adopted to survive and flourish during the history of our species. Through the convergence of brain and behavior science, scientific understanding of these operations is advancing and with this understanding, principles and insights arise that may be applied in everyday life to appreciate our own behavior, counteract our vulnerabilities and more effectively engage in social interactions.

So there is no confusion, the subject of this book is not human evolution or evolutionary psychology, nor will human evolution be a component in much of the reasoning presented for understanding the brain and behavior, or applying this understanding to everyday activities. Imagine one is asked to explain the automobile and why it has come to take its modern form. Some consideration of roadways and how they have influenced and shaped certain facets of automobile design would be expected. Similarly, some consideration of human evolution should naturally be expected in discussing the operations of the human brain. Furthermore, setting aside the historical context, it should not be forgotten that all operations of the brain occur within the context of an individual's environmental surroundings and human behavior involves a continual interplay between a person and their environment, including other people, occurring at both conscious and unconscious levels.

We believe that a broadening awareness and consideration of the brain from the perspective of how knowledge, principles and practices may be applied to improve everyday life is a natural

step, even culmination, of several trends. In a thought-provoking 2011 TEDS talk, journalist David Brooks discussed the predominance of rationalism in Western thought and its misleading influence on common beliefs concerning human behavior (Brooks, 2011). It is generally assumed that people will behave in a rational manner and our institutions are organized on the basis of this belief. When we contemplate other's behavior, we assume they will behave logically, given the rules and constraints society has put in place, and we fault them, and often punish them, when their behavior does not adhere to the expectations of rationality. Furthermore, we value logical thought, and encourage and promote those who show an aptitude and propensity for logical modes of thinking. However, humans often behave in a manner that may be thought of as irrational (e.g. fearing activities for which there is little risk while ignoring the real risks associated with other activities, or investing vast amounts of time and effort in activities for which there are little or no rewards). Moreover, while rational thought has been at the core of many human engineering and technical accomplishments, it has not served nearly as well in formulating our institutions. Soviet communism offers a sterling example. Its engineers never imagined the magnitude of corruption that would emerge, and become institutionalized, in a system that relied on everyone to sacrifice for the larger good of the state.

Rising recognition of the irrational side of human behavior, often referred to as "human nature," has begun to reshape the field of economics (Tuckett, 2011). With financial investment, everyone knows that the logical strategy is to buy low and sell high. Yet, professional investors regularly disavow this most basic principle. The propensity to follow the crowd and do what everyone else is doing is so strong that software has been put in place to slow the tide, even put on the brakes, when the crowd has developed too much momentum.

Economist David Tuckett of the University College of London describes the situation in the financial industry where the information available to investors is essentially limitless, yet investors can never be certain of what will happen (Tuckett, 2011). Institutions expect that individual investors will always generate a positive return through their investment decisions, and a string of loses can quickly cause an investor to lose their job. The system sustains an illusion that individual investors, as well as the market as a whole, behaves rationally. However, investors often merely watch what other investors are doing, and then, do the same. Tuckett notes that for the individual investor, "if I'm doing what everyone else is doing, I may lose money, but at least I won't get fired." However, investors will rarely acknowledge the extent to which their decisions are being influenced by others, but instead, will assert, and most likely believe, stories that explain their behavior in rational terms.

These ideas concerning how the operations of the brain can predispose people to seemingly irrational behavior can be seen in current trends within marketing. Before launching multi-million dollar ad campaigns, many companies are now turning to organizations that specialize in "neuromarketing" to test prospective commercials (Sands Research, 2012). In these tests, high-density EEG is used to image the activity in the brain of sample viewers as they watch a commercial. The resulting images of the viewers' brains help to identify what facets of a commercial evoke the strongest responses, and particularly, where emotional responses are evoked and how strong of emotional responses are evoked. Sands Research, Inc. has been a pioneer in this area and has made numerous striking illustrations of their techniques public through videos posted to their website and to YouTube.

Another somewhat different trend arises as an extension of the public's broad interest in personal health and fitness. While physical fitness garners the bulk of the attention, there is increasing discussion of "cognitive health" and a variety of businesses and other organizations offering products and services advertised to enhance cognitive performance (SharpBrains, 2012). The range of products spans nutritional supplements to energy drinks to brain training exercises and games to educational products. In this vein, pharmaceuticals, such as Ritalin, are being used regularly in colleges and other educational settings to achieve on-demand enhancements to cognitive performance (White, Becker-Blease & Grace-Bishop, 2006). Interestingly, it was reported that the number of professional baseball players self-reporting their use of Ritalin and similar pharmaceuticals prescribed to treat Attention Deficit Hyperactive Disorder (ADHD) has increased significantly, in parallel with non-medical use of these drugs to boost scholastic performance (Schmidt, 2009). In another development, as there has been increasing use of biometric monitoring devices during physical exercise (e.g. heart rate monitors), a variety of biometric monitoring devices have been introduced for tracking brain activity, with an initial emphasis being to measure and improve the quality of sleep. These developments point to an overall trend in which large sectors of the population are now asking how they might improve their brain function and turning to various supplements, products and activities to accomplish this end.

Finally, throughout human history, whether harnessing of fire, invention of the printing press or development of the internet, it has been technology innovation that expanded the bounds of human capability. Yet, as technology, and the way of life that has resulted from technology, has

grown increasingly complex, our achievable limits are no longer determined by technology, but instead, by human cognitive and physical capacities, in concert with our abilities to cope with the ensuing stresses. There is a broadening appreciation that we have reflexively turned to technology as the solution to our problems, but time and time again, often following great expenditures of money, time and other resources, it is realized that there is a human dimension to our problems that cannot be ignored.

Today, with the Internet, despite massive investments in technologies for cyber security, the human remains the weakest link and the enabling factor for the rampant growth of criminal organizations devoted to cybercrime (Kraemer, Carayon & Clem, 2009). There exists no historical precedent for the economic commitment the U.S. has made to technology as a basis for achieving military might, yet progress in the Iraqi and Afghani conflicts only came after embracing a counter-insurgency policy that emphasized the need to form relationships with local authorities and populations (Metz, 2007). The transformations in professional and everyday life resulting from the ready availability of inexpensive, easy to use personal computers are a direct product of innovations, specifically the graphical user interface, that have minimized the specialized knowledge required to use a computer. Today, consumers expect products to be designed so they are easy to use and will complain, abandon and reject products that impose too great of demands to learn and use.

Technology has pushed us to our limits and further technological advances can only occur through thorough consideration and incorporation of the human dimension. This reality necessitates a greater knowledge and attention to how humans operate so technologies and

technological systems may be synergized with the humans that use them, and are affected by them. Consequently, we believe an understanding of the brain, and how its operations shape our capabilities and experiences will become critical to effectively designing, implementing, managing and sustaining technological systems. This sentiment is not new. It has been captured in the aspirations of the Augmented Cognition community and its founder USN Captain (Ret) Dylan Schmorrow (Forsythe, Kruse & Schmorrow, 2005) and in the thinking of George Mason University Professor Raja Parasuraman in advancing Neuroergonomics as a field of study and professional practice (Parasuraman & Rizzo, 2005).

In the following chapters, a variety of topics from brain science and their relevance to everyday activities are discussed. Little attention is focused on presenting and sorting out alternative theories. Instead, chapters focus on the science, describing the findings and the scientific studies producing these findings. Emphasis is then placed on explaining how these findings relate to everyday life and how one might integrate them into their professional endeavors. The ultimate goal is to provide usable knowledge that may be readily applied to day-to-day activities to achieve more effective outcomes based on a fundamental understanding of how the operations of the human brain produce behavior and modulate performance.

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