Measuring the Stuff of Thought: Psychology and its Discontents

Brendan J. Morse

The human brain ranks among the most complicated biological machines in the known universe. Trillions of wet-wired synaptic pathways carry electrical and chemical information at a paradoxically slow speed but with such massively distributed processing, we can function seamlessly in our environment. No computer has yet achieved this level of open, dynamic functioning and the brain-as-a-computer analogy is a misnomer on nearly all fronts. Renowned British science writer Arthur C. Clarke (1917-2008) once remarked that any sufficiently advanced technology is indistinguishable from magic, an apt description for the human brain and our state of understanding how it works.

Researchers who study the brain from basic neuroscience to applied psychology are striving for unambiguous measures of cognitive functions. Although the capability exists to listen to individual neurons and map the circuitry of the brain and its neurotransmitters, we still cannot make direct links between basic brain activity and the stuff of thoughts. We can classify how the constituent parts of the brain function, but something is missing between the neuro-activity and our conscious experience. This gap is known as the ambiguity of measurement and it lies at the heart of our understanding of our biological and experiential selves.

When studying cognition, we do not measure anything directly. There is no litmus, scale, or thermometer that measures psychological phenomena with anything near objectivity. Intelligence, depression, creativity, psychopathy, and a host of other constructs that define the human experience are simply semantic short-cuts for characteristics that we can hold in our hands no more than we could a wisp of smoke. These phenomena are assumed to exist and cause variations in our thinking, feeling, and behavior. We can liken the study of psychological constructs to that of dark matter – we are reasonably certain it is there because we see its effects but it is not within our observable sphere.

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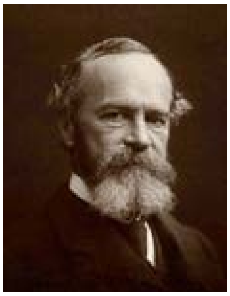
A New Science, a New Discipline

In the 19th and early 20th centuries, the field of psychology had an academic identity crisis, and the heart of the matter quickly focused on how psychological phenomena were measured. Most psychological researchers at the time were located in philosophy departments. William James (1842–1910), the father of American experimental psychology, headed Harvard's philosophy department for lack of a more aptly suited post (and if you want to really needle Harvard philosophers, point out that the first Ph.D. conferred by the Harvard philosophy department was actually granted in psychology in 1887 to G. Stanley Hall [1844–1924], who studied under James' direction).



William James (1842-1910): Father of American experimental psychology

In Germany, pioneering psychologist Wilhelm Wundt (1832–1920) felt that psychology should be the experimental arm of philosophy, but James was strongly opposed. His was a new science that required its own discipline on par with the established natural sciences. James argued that psychologists ask scientific questions and utilize scientific methods to answer those questions. At the time, nascent psychologists were primarily investigating psycho-physiological phenomena such as sensation, perception, and reaction times; mental-health researchers and pure cognitivists had yet to enter the fray. The exceptions to this general characterization of the field included individuals such as French scholars Théodore Simon (1872–1961) and Alfred Binet (1857–1911), who were engaged in measuring the mental capabilities of French schoolchildren, and Englishman Sir Francis Galton (1822–1911), who forwarded intelligence as a heritable trait and subsequently grandstanded for the eugenics movement. Regardless, for many psychologists in these years, the mind was still a mysterious entity. James himself was deeply interested in studying consciousness with the liberal use of nitrous oxide as an experimental catalyst (he served as his own subject). The important point was that their methods of experimentation were performed with scientific rigor.

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In time, a group of physicists, speaking for many early 20th-century scholars, attempted an intellectual take-down of the new discipline based on the tenets of measurement and calculation. In the 1920s and 30s, British physicists such as J. Guild and N. R. Campbell (1880–1949) reasoned that any field of research that does not achieve *fundamental measurement* is not a science. This reasoning naturally stemmed from their position that physics was the science of measurement. Haughty debates at meetings of scientific academies ensued. All measurement can be generally defined as the application of a system of numbers to some phenomenon of interest—the intersection of

The new *Connectome* scanner… can follow individual water molecules along a neural pathway and creates stunning three-dimensional spaghetti maps of the brain.

White Matter Fibers, HCP Dataset Red Corpus Callosum (Courtesy of Connectome Project, Institute for Neuroimaging and Informatics, Keck School of Medicine, University of Southern California).

mathematics and reality. Fundamental measurement was held as the complete lack of ambiguity between the numbers used to describe a phenomenon and the phenomenon itself. For example, a physical property of an object such as height has fundamental measurement. There is no way to manipulate the physical reality of an object's height by using different measurement methods. Additionally, the number zero holds a special meaning in fundamental measurement such that it implies that the object no longer exists (at least in our dimensional reality). Further, and perhaps most importantly, mathematical calculations can be performed with those numbers and the results can be readily interpreted. Stretching and squeezing the numbers themselves does not result in any ambiguity about the empirical nature of the object or phenomenon. For Guild, Campbell and others, psychology was measurement deficient and not worthy of scientific status. Ironically, fundamental measurement as the paragon of physics falls on its face in Niels Bohr's strange quantum universe that defines our subatomic selves.

Measurement and Meaning

Definitions about what makes a science aside, these criticisms of psychology and measurement were true during the earliest volleys of this debate and they remain true today. Numbers that are used in any measurement context exist along a continuum of ambiguity, and psychology dabbles in the deep, murky end of that spectrum. No one has ever physically held intelligence or happiness, either in their living states or post-mortem. Some general conclusions can be drawn about differences in the depth and density of the grooves and fissures between the brains of, say, Einstein or Yo-Yo Ma and the masses, but these do not give us objective ways of measuring individual differences in a meaningful (or practical) way. Ours is a science of probabilities. We use a wide array of measurement "instruments" from self-report surveys (How much do you agree/disagree with the following statements?) to timed perceptual or logic tests to high-tech imaging and then draw conclusions about what most people would do, most of the time, under a certain set of conditions. It is hardly a recipe for objectivity.

This lack of objectivity gave way in the middle part of the 20th century to the dominance of behaviorism. Well-known researchers such as Americans John Watson (1878-1958) and B. F. Skinner (1904-1990) envisioned and promoted a science sterilized to overt, quantifiable behaviors, eschewing the "black box" of the mind and its invisible properties. These middle ages of psychology elevated the primacy of the scientific method above what its proponents saw as superfluous assumptions. In his last public address at the Boston convention of the American Psychological Association in 1990, Skinner accepted a lifetime contribution award and took the podium to opine that there is no room, or need, for the mind and self in a scientific account of behavior. "Cognitive science is the creationism of psychology," he stated. "It is an effort to reinstate that inner initiating, originating creative self or mind which, in a scientific analysis, simply does not exist." In this statement, the mechanisms of thought and the ambiguity of measurement inherent in its understanding were denounced by perhaps the most famous living psychologist at the time in his inimitable, pithy oratorical style.

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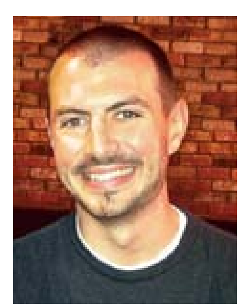
However, this ambiguity has spawned further inquiry. Researchers in the field of psychometrics have been steadily working to define the mathematical and logical properties of psychological constructs and the instruments that are used to measure those constructs. Psychometricians work as theorists and statisticians who attempt to define a mathematical representation of everything from decision-making to anxiety. Although technologies such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) have given us glimpses into the activity in the brain while participants in the lab are doing everything from math exercises to having an amorous encounter with their lovers, they have still not brought us much closer to having an objective, unambiguous assessment of math ability or attraction. In fact, a recent spate of articles in *Perspectives on Psychological Science*, a leading experimental psychology journal, point out that many statistical results attributed to brain scanning research had serious flaws, some the result of mathematical impossibilities. These results escaped peer-review scrutiny because of the over-generalized assumptions that have become commonplace with regard to the mathematical properties of our measurements and the quantitative skills of many researchers. Nonetheless, there are still promising waves of excitement and innovation in the measurement of psychological phenomena. The new *Connectome* scanner at Massachusetts General Hospital can follow individual water molecules along a neural pathway and creates stunning three-dimensional spaghetti maps of the brain. Further, President Obama's April 2013 announcement of the Brain Initiative promises to infuse much needed resources into exactly this type of research. In these efforts, it is important to keep in mind that purely objective measurement is the wrong way to define science. Working along the ambiguity of measurement spectrum is a driver of innovation and discovery about what makes us sentient beings.

The entire issue boils down to complexity. The brain is an enigmatically complex organ in which our consciousness and higher-level processing arise from a dense web of protein chains. It is there, in the embodiment of this emergence, where the combination of chemical reactions creates our perceptual experiences. Trying to connect this neural activity directly to an experience or a thought is complex and difficult. It involves many levels of analysis and the connection may not be possible to capture in one instance. It is our Heisenberg uncertainty principle. Multiple features cannot be observed directly and the very act of observation changes at least one of those features. All scientific disciplines are creatures of their methodology and all sciences make assumptions in their process and measurement. Here, in Arthur C. Clarke's parlance, lies the magic of the interaction between our brains and ourselves. No matter how far our technology advances, we may not be able to measure and comprehend the ephemeral path from neurotransmission to thinking, feeling, and behavior. We are, ironically, beyond our own ability to fathom.



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