The Razor in the Toolbox

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The history, use, and abuse of Occam's Razor.

There is something very weird in the sky. It's moving bizarrely at right angles and emits no sound at all. I've never seen anything like it; it's got to be an extraterrestrial spaceship, right?

I wake up in the middle of the night paralyzed with fear in close proximity to something very strange. It seems transparent and serenely floats towards me. This has got to be a ghost, right?

It is possible that an alien craft and a ghost respectively can explain these events. Who wouldn't immediately entertain these prospects? Given our cultural obsession with these phenomena it would be difficult not to immediately think about these exciting possibilities. Good skeptics know, however, that explanations aren't necessarily valid just because of their enticing nature and the ease with which they come to mind. Is there a tool in the skeptic's toolbox that will allow us to evaluate events such as these from a proper scientific and skeptical perspective? Occam's razor is a powerful rule of thumb that will do just that.

Occam's razor is not an example of the latest in shaving technology. It is a heuristic or rule of thumb used to guide the initial phases of theory building and selection. Also referred to as the principles of parsimony or economy, it obliges us to favor, among otherwise equivalent theories or hypotheses, those that make the fewest unwarranted assumptions. It is not a law or scientific principle and cannot justify a position in and of itself, yet it can be very helpful in deciding which ideas to investigate first. The razor analogy refers to "shaving off" or cutting from the theory those variables or concepts that are superfluous and introduce unnecessary complications.

Occam's razor is named after William of Ockham (Occam is a latinised variant) (c. 1285-c.1349). He was a Franciscan theologian, writer, and one of the most influential philosophers of the 14th century. His teachings were among the first to break from the medieval philosophies that preceded him including the Aristotelian Realism of St. Thomas Aquinas. William struggled against the common practice (then and now) of describing nature using abstractions that were untestable and assumed to be as physically real as any other part of the world. One quote attributed to him declares: "Pluralitas non est ponenda sine neccesitate," which translates to "plurality should not be posited without necessity." Yet another states that "non sunt multiplicanda entia praeter necessitatem" or "entities should not be multiplied unnecessarily." Modern day variations include, my favorite, "What can be done with fewer [assumptions] is done in vain with more" (Moody, 67) and even "Keep it simple, stupid." William, though, was not the first to express such sentiments. The oldest known version, attributed to Aristotle in 350 B.C., asserts "Nature operates in the shortest way possible" and "The more limited, if adequate, is always preferable." French

Dominican theologian and philosopher Durand de Saint-Pourçain (A.D. 1270-1334) also used this principle to great effect before William of Occam. Many other scientists since then have supported similar simplifying principles including physicist Nicole d'Oresme, Galileo Galilei and even Albert Einstein, who wryly stated: "Everything should be made as simple as possible, but not simpler." William, however, was such an ardent and devoted adherent that the concept became indelibly linked with his name.

Occam's Razor may not be an exalted law or a proper scientific principal or axiom, but its utility belies its lowly status as a mere rule of thumb. It is an indispensable tool for building models due to what is known as "underdetermination of theories by data" (Harnad, '87). There are always an infinite number of possible hypotheses to explain a set of data or observations of a phenomenon. To take a mathematical example, two points on a graph can be described by an equation for a straight line, equations for exceedingly complicated circuitous lines, and equations for every type of line in between these two extremes. All of these equations and their resulting lines could be made to pass through the two original points, thereby fitting all the available data. Occam's razor would recommend the simple linear relationship of a straight line as the best candidate until the additional evidence of a point off this line warranted advocating a more complex solution.

Inevitably there are times when the simplest explanation for a given set of observations is shown to be false. Often this is claimed as evidence against Occam's razor, exposing it as untenable. This strawman argument ignores the inherent heuristic nature of the razor, which never claims to determine the truth or falsity of a hypothesis. It only identifies those that, logically, should be considered and evaluated first. Occam's razor would be called Occam's law if this were not the case.

Continental drift offers an interesting example of a theory that was utterly rejected by Occam's razor (and scientists) only to be vindicated years later. It was recognized centuries ago by mariners and mapmakers that South America and Africa had complementary coastlines. Their respective west and east coasts seemed like they once fit together like a huge jigsaw puzzle. Other more tantalizing geological and fossil evidence also suggested that continents moved like flotsam over the surface of the earth. Meteorologist Alfred Wegener codified this thinking in his 1915 book On the Origin of Continents and Oceans. He proposed that all continents were, in the distant past, merged into one mega-continent he called Pangaea (Greek for "all the land"). The theory that landmasses migrated over the earth was, however, almost unanimously derided by American scientists. The geological and fossil evidence was also perceived to be not compelling since they could be explained equally well by other theories. The primary downfall of Wegener's theory, however, was his assumption of the existence of the gargantuan forces required to move continents. His attempts to account for this were unpersuasive to the scientific community and even to Wegener himself. One example invoked gravity as the force responsible for continental drift. Physicists ridiculed this possibility by showing mathematically that gravitational forces were far too feeble to power such continental wanderings. Many years passed until a plausible

mechanism was proposed, this time by Scottish geologist Arthur Holmes. He theorized that earth's crust was composed of a mosaic of rigid and fractured plates. In addition, he claimed that convection currents in the earth's mantle, powered by radioactive decay, moved these plates in different directions about the surface of the earth. These and other propositions eventually evolved into Holmes' paradigm-shattering theory called plate tectonics, which now underpins our modern understanding of geology and the evolution of the earth itself. Full acceptance still took many years but when the evidence for plate tectonics became incontrovertible, continental drift finally had a plausible mechanism for its assumption that delayed acceptance for decades.

Conversely, the early competing theories of the solar system offer a good historical illustration of the successful application of Occam's razor in astronomy. It is commonly perceived as absurd and almost comical that so many people for so long accepted as fact the geocentric model of the solar system in which the sun and planets orbit around a stationary earth. The philosopher Ludwig Witgenstein, when confronted with this attitude, is said to have commented: "Yeah, but I wonder what it would have looked like if the sun had gone around the earth" (Burke, '95). The point is, of course, that it would have looked exactly the same. Both the geocentric model and the heliocentric model (earth in orbit around the sun) make the same predictions as to the movements of the sun in the sky.

The problem with Aristotle's and Ptolemy's geocentrism involved more subtle and sophisticated observations. There were many then unexplained mysteries, including the brightening of the planets, the bizarre retrograde paths of their orbits, the apparent daily and yearly movements of the stars, including the sun, and the fact that Mars and Venus never strayed far from the sun compared to the other planets (Harnad, '87). Ptolemy had to devise a host of complex relationships in order to maintain the geocentric model, resulting in a complex earth-centered theory with the planets connected to spheres that orbited around the earth together with their attached planets. Aristarchus of Samos and later Copernicus espoused a much simpler heliocentric model with the sun at the center and a rotating earth and other planets in orbit around it. This view accounted for all of the mysterious celestial motions in a far simpler way than Ptolemy's model. Eventually, this less complicated theory with its much greater explanatory power would lead to the Copernican revolution, which ushered in the modern view of astronomy and natural science.

One application of Occam's razor presents an excellent example of its simultaneous indispensable utility with clear limitations: that of medical decision-making. Medical students learn early in their career that it is preferable to propose a single diagnosis to explain a host of symptoms with which a patient is presenting, rather than a separate diagnosis for each symptom. A patient, therefore, presenting with headache, neck stiffness, fever, and confusion is more likely to have meningitis than to simultaneously have a brain tumor, whiplash, tuberculosis and acute porphyria. This is a very practical use of Occam's razor.

However, more experienced clinicians realize that patients often do have more than one disease. As we age, the number of chronic conditions we may have tends to increase, and our susceptibility to acute ailments also increases. Further, one disease often predisposes us to other diseases and disorders. For example, patients with diabetes often develop kidney failure, heart disease, and nerve damage. Often, diseases may occur in a cascade of cause and effect, like a trail of tumbling dominoes. The end result is that Occam's razor, although very useful as a starting point, often breaks down under the complexities of reality.

Your average armchair skeptic doesn't often work on new theories of the solar system or practice medicine, but Occam's razor can be used to help with the more earthbound and quotidian mysteries we encounter in our lives. True believers in paranormal phenomena will often attempt to explain an unknown by invoking yet another unknown. For example, in an attempt to explain an apparent example of e.s.p., they will conjure brain waves as a carrier of the extrasensory information. A survivor of an NDE (near death experience) will attribute the event to an afterlife to explain the sensation of floating, moving through a tunnel, and seeing dead loved ones. Often extraterrestrial visitations are needlessly called upon to explain the engineering feats of ancient civilizations like the Egyptian pyramids. These extraordinary assumptions are simply not needed because simple and viable explanations exist for all of these examples. We could entertain these wild ideas, but it only makes sense to seriously do so when the simple explanations have been convincingly discounted. Paranormal conjectures are tailor made for Occam's razor, which slices away the unwarranted assumptions with the twin blades of parsimony and economy.

An especially irritating misuse and distortion of Occam's razor is often perpetrated by creationists to support their pseudoscientific denial of the theory of evolution. They sometimes contend that Occam's razor supports creationism over evolution since having a god create everything is much simpler than the complex mechanisms advocated by natural selection. What they miss is that by "simple" Occam's razor is really referring to the theory with the fewest new assumptions. The fact that life on earth is the product of evolution is supported by multiple independent lines of evidence. Evolution can be extrapolated from the normal functioning of life, without introducing any new physical laws or properties. In fact, it is an elegant unifying explanation for a host of observable biological phenomena. Creationism, however, requires the introduction of an omnipotent creator – a very extraordinary assumption that is not an independently established part of the natural world. Furthermore, all of the observable biological phenomena which are explained by evolution now require a separate creationist ad-hoc explanation, i.e. genetic homology just happens to follow an evolutionary pattern because god wanted it to.

Creating one theory to explain a large number of disparate phenomena is actually a common strategy of cranks and believers of the paranormal, so much so that it has engendered its own designation: "Theories of Everything." Such grandiose theories attempt to explain the actual underlying operation of the universe itself.

An example of such a theory is that proposed by Dr. Shwartz and Dr. Russek in their book Living Energy Universe (Shwartz, Russek 1999) (see The Grand Unified Woo Woo Theory, in the NEJS, vol. 3, issue 2). They propose that energy systems are living systems that are immortal due to the resonance of vibrations within the system (don't worry if you did not understand that). The end result is one big happy universe in which everything is connected to everything else, and ideas have a real physical existence. From these simple concepts they attempt to explain all apparent paranormal phenomena. They invoke Occam's razor to justify their claims; they offer one explanation for many phenomena, rather than a separate explanation for each.

What they miss is that their one explanation is completely unsupported by logic or evidence—they are simply replacing many small assumptions with one huge assumption. It is almost the equivalent of simply saying "it's magic." That is also a very simple and unifying explanation for anything and everything. Occam's razor, however, does not support such theories, because of the necessity of introducing a major new assumption—magic, living energy systems, an omnipotent deity, etc.

Unwarranted paranormal suppositions are as ubiquitous in our culture as they are unwarranted. They are examples of people essentially short-circuiting the process of science, skepticism and critical thinking in order to support a belief of how they would like the world to work. Occam's razor can help make this process of creating a better description of reality more efficient and fruitful. Less time is then spent needlessly chasing bizarre ideas before eliminating or confirming the more mundane, yet much more likely, explanations that cry out to be heard first.

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