Questions from Prof. Grace Burton
Thursday, December 3, 2020 2:00pm EDT

Not a question, but just wanted to say how humbling and enjoyable it was to listen and learn from Professor Burton once again. Pure genius!!

Submitted: Amy V. AL '10

ANSWER. Thanks so much for coming!

Does the uncertainty triggered by the use of zero have more certainty than the certainty or lack of certainty in the use of words, in general.

Submitted: Wendy R. AL '63

ANSWER. That is a really tough question because the answer depends on the intellectual moment. Zero takes its place at the heart of modern thought by dismantling the notion of the absolute that had held sway in the West since antiquity. (There were real challenges to the Aristotelian notion of the filled universe even in Antiquity, primarily by Atomists like Democritus and Epicurus in Greece and Lucretius in Rome, but the Aristotelian position is what survived into the Christian Middle Ages.). 0 has the ability to destroy logic as we see when we try to divide by 0. When 0 then takes its place in the heart of modern thought, it becomes a locus of relationship. We can see this in the Cartesian Coordinate System, the grid with 0 at the origin that allows us to define certain geometrical figures as the relationship between x and y. So If I say that the equation for a certain parabola is $y=x^2$, I am defining a relationship between x and y that continues to hold even as the absolute values of x and y vary. So the introduction of 0 into modern thought allows us to see knowledge *relationally.* There is stability in the relationships even as the absolute values change.

Fast forward to the postmodern moment. Language is always conventional. There is no absolute relationship between a word and a thing. The word "book" only conjures up in our minds the thing that is a book because English speakers agree that "book" = book. The fact that other languages have other conventions (in Spanish "libro" = the thing we call a book in English) just proves the point that words and things are fundamentally separate realms. But what about words and philosophical concepts? In a famous essay entitled "White Mythology," the French Philosopher Derrida says in essence that philosophical concepts are really nothing more than worn-out metaphors, metaphors that we no longer understand as metaphors. The poet C. Day Lewis, for example, wrote a brief but very interesting book entitled *The Poet's Way of Knowledge*, in which he says that new knowledge is always metaphorical because we think of the new in terms of the old, we conceive of new ideas by comparing them to ideas we already understand. So, for example, in the early days when physicists were trying to understand what an atom was, some compared the structure of the atom with the structure of the solar system, with the nucleus as the sun and the electrons as the planets; that is, they compared something they could not see (the atom) with something they could (the solar system). But an atom is NOT a solar system; the solar system is merely a metaphor that allows us to conceive of things we do not yet understand. But because metaphors are comparisons, they contain within themselves a "nothing," an "is not," that threatens to undermine the very meaning metaphor seeks to elucidate. (The best book on the "is not" of metaphor is Paul Ricouerr's *The Rule of Metaphor*.) The metaphor that an atom IS a solar system

contains within itself its opposite: and atom IS NOT a solar system. What Derrida says is that the "is not" of metaphor is a turn away from proper meaning, which means that language is always leading us away from concepts and back to itself as language. Language, then, can never express real truths because language is always just playing with itself. I think that in bringing to light the in this case "nothings" philosophers like Derrida rediscovered the 0 at the heart of modern knowledge. But unlike the 0 at the heart of the Cartesian Coordinate System, which allows for relational knowledge to take hold (a knowledge that while not absolute, was stable in the sense that it allowed for stable relationships to emerge), these metaphorical "nothings" are "destructive nothings" (because as we have seen, 0 can undermine logic), which has had a real effect on our ability to know in the postmodern world, an effect that we have seen recently in the political arena.

Do you see the Quixote/Sancho dynamic playing out among our current leaders? How do you think this relates to the vanishing point principle you've described?

Submitted: Evan B. AL '09

ANSWER. I think the answer to that question depends less on the structural argument I think Cervantes is making in Book I of *Don Quixote* published in 1605 and more on the political argument he makes in of Book II of the novel published in 1615. It is in Book II that we see Sancho come to the fore as a new kind of "knight," a modern man who literally throws off the constraints of the past in order to secure liberty for himself and others. We see Sancho at his most heroic when he chooses NOT to turn his old neighbor Ricote, a man of Moorish descent who has returned to Spain after the 1609 expulsion of the Moriscos to recover the money he had hidden in his native land, even though Sancho, a man who always seems to be concerned with the pleasures of the flesh, could have benefitted materially by denouncing Ricote to the authorities. Whereas Don Quixote is always concerned with the public recognition of his deeds, Sancho comes to understand that real heroism may lie in what one chooses NOT to do. I leave it to you to decide if Cervantes has captured the contemporary moment in his 17th-century novel.

That's all ya' got?! Lol - genius. Thank you!!

Submitted: Jeffrey M. AL '90

ANSWER. Thanks for coming!

Just a comment - I loved this presentation and it's so nice to see you

Submitted: Alexandra M. AL '19

ANSWER. Thanks for coming!

This is just fascinating, Dr. Burton. I'm wondering about this idea of voids and holes and zeroes, and how it may relate to the performativity of speech acts (the enaction of something from nothing). Can you speak to that relative to the "language of science"? Thanks again!

Submitted: Christopher S. AL '09

ANSWER. I would refer you to the answer I gave above on uncertainty. I think it would be wrong to say that the language of science is not immune to the questions of metaphor that I outlined above, especially when scientists are trying to understand an aspect of the world that they have not seen or contemplated before. We all use what we know to help us think about what we don't know. I would add, however, that the "language of science" is in most though not all cases mathematics, which can reveal anomalies that cause scientists to investigate further (such as the mathematical anomalies regarding the orbit of Mercury, which were only solved by Einstein's theory of relativity). Here let me say that the development of the calculus in the 17th century was in many respects an attempt to "tame" nothing through the use of what Newton called an infinitesimal, a quantity so small that it was as if it were nothing but a quantity nonetheless. The infinitesimal allowed Newton to divide by the infinitesimal because the infinitesimal was something not nothing, but it also allowed him to drop the infinitesimal (and especially the infinitesimal squared), when he needed to add by declaring the infinitesimal to be nothing. Just a little sleight-of-hand they don't teach you in Calc I!. Statistical analysis has become increasingly more important in the study of science, not only in fields like Data Science, but also in Biology and even Physics. Statistics responds to the uncertainty endemic to statistics by measuring the uncertainty it generates through such things as confidence intervals.

Aha! never mind! I think your explanation of the Cartesian plane helped explain it for me! Forget my second question.

Submitted: Joseph C. FS

ANSWER

Also – if you have time to take two questions from the same questioner! (Obviously if there are other questions, feel free to skip one of mine): I think I might have missed a step in your narrative. How is it that the introduction of ZERO into Europe works to relativize everything? I can see the rise of relativity in the image of the Flagellation and in your analysis of Don Quixote, but why is it that Zero makes Europeans think: "Well, everything must be relative!"

Submitted: Joseph C. FS

ANSWER. I don't think that the introduction of nothing into the West relativizes everything. I think that nothing allows for *relational* knowledge to emerge. That is, knowledge becomes more systematically functional: we see x in the light of y. I think that the 0 of Hindu-Arabic numerals, which puts the meaning of numerals on the move through positional notation, is the first step. But 0 is not just a number; it is also a concept that begins to appear all over the place in such disparate fields as art (vanishing point), literature (the Sierra Morena, which completely changes the structure of Cervantes's *Don Quixote,* which is arguably the first modern novel, physics (Boyles air pump, which created physical vacuums), and mathematics (the Cartesian Coordinate System, which allowed geometry to be reconciled with numbers). "Interdisciplinarity" is not a modern concept. Once the "idea" of 0 entered the West, Western thinkers began "to see" it everywhere. Now, there were certain cultural and technological changes that, I think, helped to accelerate the incorporation of the relational thinking that 0 enabled into Western thought. One such technological advance was the printing press, which, in introducing more reading material into society, allowed human beings to start comparing texts for themselves: they started reading one text in the light of another. The history of the printing press is too long to do it justice here, but suffice it to say that the new technological advance of the

printing press coupled with the introduction of relatively new idea of nothing was an intellectually explosive combination for the West, a combination I would liken to the introduction of Mentos into a bottle of Diet Coke.

When the "invention" or the adoption of the zero came into usage, did it have independent significance (did it have independent meaning) or was it simply a modifier of some other concept?

Submitted: Wendy R. AL '63

ANSWER. That is a complicated question. I think the best approach would be to go to physics. Remember that the vacuum was an anathema in the West. The world was completely filled. Aristotelian horror vacuii ("Nature abhors the vacuum) was the order of the day. The introduction of the idea of nothing into the West led some independent thinkers to see if the vacuum were physically possible; that is, they wanted to see if nothing was *real*. Did it, in your words, have an independent existence. An Italian natural philosopher who was a student of Galileo named Evangelista Torricelli came up with an ingenious way to see if he could produce a vacuum on Earth. He upended a long glass tube filled with mercury into a container also filled with mercury and discovered that the mercury in the tube descended, leaving behind an empty space at the top of the tube that was not filled with mercury and could not be filled with air. Here before him was experimental proof of the existence of the void.

Blaise Pascal then repeated the experiment in France using different liquids like water and wine, and although these liquids reached different heights in the upended tube, the void at the top remained. Curious about why the mercury in the tube would only rise to a height of about 30 inches (76 cm.), Pascal decided to extend the scope of the inquiry. In an experiment designed by Pascal but carried out by his brother-in-law, Florin Périer, on September 19, 1648 on Mount Puy de Dome, Pascal set out to measure the effect altitude might have on what would become known as "Toricellian space." What Pascal and Périer discovered was that the mercury in the tube fell as Périer ascended the mountain.[i] Périer conducted multiple trials and took numerous measurements at different places on the mountain, and each time the results were the same. Pascal rightly concluded that not only was the void at the top of the tube real, but that the size of the void varied according to the air pressure, which, because it was greater at lower altitudes and lesser at higher, pushed the mercury to different heights depending on how high up Périer climbed. What Torricelli and Pascal had discovered was the barometer.

But Pascal does more than assert that nature does not, in fact, abhor the vacuum; he also notes the human capacity to construct "imaginary causes" or fictions to explain what we do not understand. The "horror vacui" was for Pascal one such fiction, necessary, perhaps, to explain the workings of the natural world at an earlier point in time, but completely unnecessary once the true cause of the void—air pressure—had been identified. These experiments went a long way to undermine the hold Aristotelian thought had on the West. By proving that "nothing" was a thing—that the vacuum was real and that nothing had an independent existence—Torricelli and Pascal made nothing real and relegated the horror vacuii to the realm of fiction.

Grace – thanks for this wonderful talk. I'm learning so much from your comments! I have a theological question that your talk raised for me. I'm wondering about the ancient Greek word for "god," theos, which is very close to the Greek word for running, flying, motion, movement, "theo." That word also has a close connection with "shining," which makes me think that the Greek idea of divinity has something to do with the constant movement of things, the way the demigods push the heavenly bodies around the cosmic sphere. The Greeks seemed to think the gods were forces of movement, constantly in motion, and this sounds a lot like the way you describe the Greek view of the cosmos as a fullness teeming with motion. So, I'm wondering ... Is it Aristotle's 'unmoved mover' — or maybe Aquinas? — who makes God into a constant eternal unchanging Being? Any thoughts?

Submitted: Joseph C. FS

ANSWER. What a great question. The Greeks thought a lot about stability and change. Some were more comfortable with the idea of change than others. Heraclitus, for example, famously expressed his belief in perpetual change by saying that "No man ever steps in the same river twice." Parmenides, on the other hand, argued that there existed a perfect being behind and beyond nature, the so-called the universal unity of being. In Parmenides' view, nature is all one, which renders change impossible. Aristotle also wrestled with the relationship between stability and change. First and foremost, he found stability in the idea that the world was eternal, reasoning that things have to come from other things (the substratum). They cannot come from nothing, so the world has to have always been. He also found stability in the idea that when things find their "natural place" they come to rest. So the argument that the Earth is at rest goes something like this: Heavy things fall. The heaviest thing in the universe is the Earth. The Earth has fallen to its natural place; therefore, the Earth is at rest. Aristotle then ascribes the perfect motion he sees in the heavens to "unmovable movers" that make possible celestial motion. Each of the celestial spheres emulates its own unmoved mover. The question is what is the relationship between the unmovable movers who set the individual spheres in motion and some ultimate Prime Mover or god who sets the whole system in motion? He understands these demigod unmovable movers to be in sympathy with the Prime Mover, who makes the whole system operate. Aristotle's God is not like the Christian God, however, primarily because the Aristotelian God has no interest whatsoever in human beings. The Aristotelian God does nothing but think, and he thinks only about himself. It was Aquinas who reconciled these Aristotelian ideas with Church teaching. The Aristotelian Unmovable Mover is one of Thomas's five proofs for the existence of God. The eternity of this Christian God is derived from God as an Unmovable Mover, for, as Thomas says, "Time is the measure of only those things that are moved, for time is the measure of motion, as stated in [Aristotle's] *Physics, IV.* But God is absolutely unmoved, as already proven. And so we cannot note before and after in him. In him, therefore, being does not succeed to nonbeing; neither is it possible for him to have nonbeing after being nor any succession in his being, for apart from time such things are meaningless. Therefore he is without beginning and without end, having all his being simultaneously; such is the notion of eternity" (*Summa of Christian Teaching*). Unlike Aristotle's God, who is ontologically separated and distinct from the world, Thomas's God is an infinite and eternal being who is both transcendent and immanent; that is, Thomas's God is a being who unites all things in the world to him and by extension to each other.

Interesting...not to put you on the spot, but how do we know the Greeks knew the world was round?

Submitted: Jeffrey M. AL '90

ANSWER. They would watch distant ships come into the harbor. If the world were flat, a distant ship would look smaller, but you would be able to see the entire ship. That's not what happened, however. As distant ships approached a port, the Greeks would see the mast of the ship first, after which they would see the rest of the ship gradually come into view, from which they surmised that the ship must be sailing on a rounded and not a flat surface.

Emma Newcombe emma.l.newcombe@gmail.com No question - it is just so great to be back in your (virtual) classroom!

Submitted: Emma N. AL '10

ANSWER. Thanks for coming!
