5-2023

Personal Equation

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Personal Equation

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Fine Arts in Art

by

Nicholas Hobbs
Louisiana Tech University
Bachelor of Fine Arts in Studio Art, 2020

May 2023
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

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Abstract

The body of this paper is a formatted version of text which exists natively on the web and is accessible at *www.personalequation.art*. Its non-linear narrative is meant to accompany and mirror, not describe, the artwork in the exhibition. The following two paragraphs are copied from the exhibition statement accompanying *Personal Equation*, which is on view in the Reading Room at the Fayetteville Public Library from April 3 to June 30, 2023:

A personal equation is one that attempts to account for the inevitable role of subjectivity in scientific observations. The term was coined by astronomers in the 18th century who, upon noticing inexplicable differences between their measurements, realized that the accuracy of an observation is influenced as much by the observer as it is by the instrument being used. In 1877, for example, Giovanni Schiaparelli noticed dark lines on the surface of Mars that he believed to be channels of water criss-crossing its arid surface, causing a frenzy of speculation about the potential for life on the distant world. Only decades later, after many failed attempts to reproduce the finding, was it realized that Schiaparelli had probably seen the shadows of the blood vessels in his own eye.

With these drawings I explore and embrace my own personal equation, grappling with the hyper-specificity of looking out into the cosmos as a human being trapped on the surface of the Earth. Through quiet scale-shifts and implied comparisons, drawings of widely disparate subjects are interwoven in an alchemic dance of familiarity and ambiguity. References for these drawings are pulled thoughtfully from thoughtless drifts through astronomical archives, photographs of my everyday life, and the depths of the internet where, just as in science, many contradicting realities are forced to co-exist. Like Schiaparelli, I'm trying desperately to find meaning in the noise with imperfect instruments and narrowly limited senses.

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Honey-Moon

I am in pursuit of a romantic genesis story. All sincere science and soupy seas and sardine's soft salamander sleep. In this story, my life begins like any other: At an invisible origin point envisioned variously as a spark, as a flame, as warm and all-encompassing, as if described by the cautious hand of a pink, maternal glow.

The origin point of an incomprehensible click-click-click of dominoes.

I don't need this story to explain it all, I just want to know what that thing is at the back of my head. The thing that never seems to get comfortable, even in brand new sheets. It was born with me but it knows something I don't.

The thing that drops into my stomach straight from my head and slams into the wall at every turn of my intestines. The thing I can't name but, there it is. In the eyes of my dog. Deep in her eyes. Behind her cataract, behind her cerebellum. Something deep between her neurons. Between molecules of sappy cell goop. Between atoms of molecules. Between particles of atoms. Between particles of particles. The thing we all feel in our own way. Something we share. That's all I need to know, and what else we're asking.

Car body

There is a specific, full-body discomfort that accompanies road trips. It is stiff and unnatural like a bedsore, resulting from the misuse of organic machinery designed for running and climbing and crouching – anything but the long duration sitting endured in the car. Moving great distances and not moving at all can feel quite similar.

With remarkably little energy I can travel from the northern border of Mexico to the southern border of Missouri just by giving my uninterrupted, if restless, focus to driving. Fourteen hours with no movement other than the flexing of leg tendons to modulate the speed of the car, and the gentle sway of my arms as they track the road with the steering wheel. My car is designed with me in mind, so effort is minimal.

My eyes track with my arms, informing them. Bold lines of pristine white and lemon yellow make it an easy, often pleasant thing to do. Like a game. Lines, weaving the landscape and inviting drivers to do the same. I trace these lines as diligently as I can, leaning forward into them, clinging to them like I cling to the unbroken strands of sentences that propel me through the pages of a book.

Thrummmmmm. The conversation between road and tire is a soft daybed for my thoughts. Thoughts which come quickly because the task of driving is effortless after so many years of daily practice. It requires only some of my brain-space. It can be fully automatic if I want. I can be relieved of the task, kick it down the chain of command to some reptilian ancestor, a creature of reflex and instinct, dwelling below the surface of my mind.

This is where my best thinking happens. Encased in a machine hurtling across the surface of the Earth at fatal speeds, its disposable tires sacrificing ablative rubber to friction with every mile. Where does all that rubber go?

The Moon like skin

For most of history, the planets were only what the naked eye sees. That is, featureless pinpricks of light dancing seasonally across the vaulted dome of the sky, weaving between fixed stars and occasionally changing directions. Few imagined they might be physical places that could, at least in principle, be visited. The telescope changed this dramatically. It was a shock when in 1610, Galileo peered through a primitive teleportation device and found himself floating above rich, textured worlds rather than the Platonic forms imagined by his ancestors.

On the Moon he saw a surface as varied and uneven as the face of the Earth. Blotchy patches of an indiscernible nature can easily be seen with the naked eye, but granular details that would betray the idea of a perfectly polished surface are invisible. In the telescope, Galileo saw mountains and valleys and thousands of circular craters.

He looked down on this mysterious landscape as if floating above. Looking at the Moon with the naked eye feels like looking up, but in the telescope, it feels like looking down. The eyepiece is a long, dark tunnel that opens into a cavern at the bottom, and the sky is contained in that cavern. And so, Galileo was the first to see the Moon as a landscape and, informed by real visual information, imagine walking on it.

Anticipating vistas that would be held by Apollo astronauts nearly four centuries later, he imagined standing in the long shadows he saw stretching across the lunar plain from above:

> And we have an almost entirely similar sight on Earth, around sunrise, when the valleys are not yet bathed in light but the surrounding mountains facing the Sun are already seen shining with light. And just as the shadows of the earthly valleys are diminished as the Sun climbs higher, so those lunar spots lose their darkness as the luminous part grows.[1]

These observations were supported by rich drawings made at the eyepiece which take only a small mental leap to accept as real because they are so familiar from experience with

[1] Galileo Galilei, *Sidereus Nuncius*, trans. Albert Van Helden (Chicago: Chicago University Press, 2015), 43.

terrestrial geography. Those drawings served less to reveal something entirely undetectable by the human eye, and more to bring an already familiar mystery into sudden focus. It was, primarily, a shift in resolution.

A similar revelation occurred in biology when naturalists looked at organic tissue under microscopes and saw that familiar surfaces broke down into intricate structures invisible to the unaided eye. Skin is not the solid object it seems to be, but an illusion that emerges out of the collective interaction of many tiny creatures called cells.

Like skin, the Moon is not a singular and featureless object, but an emergent property of the geological forces that once rumbled in its core, the accumulation of planetary detritus, of mountains and canyons and rolling hills and rocks upon rocks upon rocks piled up in the beating sun of an airless world.

Inter-state

Anywhere I drive the lines stay the same. So do the signs, even if the language changes. Organization is a common denominator of all human societies and, in my day, laws have spread the influence of this fundamental impulse to every corner of the planet. My car is designed for navigating only one narrow environment and it does so comfortably wherever I want because that environment – the road – has wrapped the sphere of Earth so thoroughly in its black tendrils. While only a few meters across, the lanes of the road reach out unbroken for thousands of miles.

Outside my window, rolling toward and then away from me like a global mudslide, the landscape undergoes drastic changes. It falls past horizontally. Slowly at first, then quickly. I'm sure the transition is gradual on foot, but in the car a forest springs up around me in a blink. Dusty, then lush. Towns barely exist unless I'm hungry enough to notice them, and then only the parts that serve me. Landscapes large enough to hold countries contain only windmills. Dallas traffic gets a wide berth. In Oklahoma I hit a wall called the Ouachitas. I scale its switchbacks, then I fall off just as quickly. Soon I'm in familiar territory.

The road tames the undulating landscape. The road lets me ignore it. That landscape was for some reptilian ancestor, now buried under the surface of my mind. I can look out the window at the landscape untouched by road, past the *whooshing* effects of parallax turning litter into colorful smears, and feel an itch. But only an itch.

Naming Nabu

Asteroid 101955 Bennu is not a monolithic body of rock, like the mountains of Earth, but a collection of pebbles, rocks, and boulders bound together by their collective gravity. A primordial rubble pile accumulated from the leftover debris of planet formation. Fragile, volatile, and only the size of the Empire State Building. As humans explore the solar system more deeply and more broadly, even the most mundane assumptions are turned on their head. For so long we imagined asteroids like solid boulders, but time and time again this has proven not to be the case.

In 2012, there was a nation-wide contest name Bennu, known at the time as 1999 RQ36. The detritus of the solar system is so numerous that proper names are awarded only to the most interesting and important. 1999 RQ36 was bestowed the honor of a name due to its selection as the target of an unprecedented sample collection mission. It could no longer endure the indignity of being nameless. Of being, like most celestial objects ever will be, a collection of measurements. So, it was named Bennu by Michael Puzio, a third-grader in North Carolina.[2]

Telescopic observations of Bennu, combined with existing knowledge of asteroids, led scientists to believe that Bennu is largely smooth with, perhaps, a handful of large boulders. A perfect candidate for a mission requiring a delicate touchdown.

When our robotic emissary arrived, our little metal insect, it reported an immediately surprising finding. Bennu was not smooth and, in fact, is so strewn with sharp-edged boulders that the carefully planned touchdown would need to be re-thought entirely. Meticulous mapping revealed only four landing sites safe enough by the standards of its conversative engineering team.[3]

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[2] Bruce Betts, "That Asteroid Has a Name: Bennu", The Planetary Society, last modified May 1, 2013, https://www.planetary.org/articles/that-asteroid-has-a-name-bennu.
[3] "OSIRIS-REx", NASA Solar System Exploration, last modified July 7, 2022, https://solarsystem.nasa.gov/missions/osiris-rex/in-depth/.

Extending a long, sterile proboscis it gingerly drifted toward its target like a shiny mosquito hovering toward a blood source in super slow motion.

All things, maybe, are universal and all things, maybe, converge. At the very least, my home has asteroids, too. Dirt, skin cells, clothing fibers, food crumbs, and hair float through the interplanetary medium between couch and kitchen, colliding with each other and merging in accordance with the laws of gravity. On a monthly basis, these planetesimals gather in larger and larger numbers until they form asteroid belts of their own. Grey and fuzzy, like Bennu.

Other moons too

Despite the immediate acceptance of his detailed Moon drawings, Galileo's discovery of four previously unknown satellites orbiting Jupiter took longer to be accepted by the philosophical communities of his time.[4] Though his descriptions of his observations were meticulous, they were accompanied only by simple diagrams indicating the relative positions of the moons as they danced around the disc of Jupiter. Illustrated timetables, essentially. As far as visualization goes, it was the best he could do. In his crude telescope, the little Jovian moons appeared, like the planets viewed with the naked eye, as featureless pinpricks of light.

Unlike the realization of the Moon's imperfect nature, this discovery did not benefit from a similar grounding in intuition. With the Moon, direct comparisons could be made to familiar analogues on Earth – mountains on a celestial body visible with the naked eye are not hard to imagine, and the rich sensory experience they invoked was beautifully communicated through Galileo's drawings. Not so for the invisible Jovian satellites.

Delaying the implications that would have to be drawn out from the existence of such satellites, many speculated that they were artifacts of a defective lens, optical illusions, or wishful thinking. This period of doubt did not last long, as the finding was easily verified by other astronomers making their own telescopes, but it anticipated the importance of vision in a new era of astronomy.

Before Galileo, astronomy was a field of pure mathematics. Tables of numbers tracking and predicting the movements of featureless dots across the sky, and diagrams of circular orbits and epicycles defined the first of the sciences. But with the introduction of the telescope – even before it was combined so impactfully with photography in the 20th century – astronomy came to be associated more strongly with vision than any other science.

[4] Stillman Drake, *Galileo at Work: His Scientific Biography* (Chicago: University of Chicago Press, 1978), 211.

Point source collapse

Everything is a star from a sufficiently great distance.

For an observer standing on Earth, the planet fills the visual field. It is so large and so close that not even its shape can be determined. Moving away from Earth, curvature slowly appears – the observer doesn't even need to leave the atmosphere to see it. In low orbit, it becomes clear that the planet is a sphere. In high orbit, not quite as far as the Moon, the Earth starts to register as a distant body and compress into a disc as the effects of foreshortening fade.

And so on, farther and farther until the Earth is just a pale blue sesame seed suspended among a scattered field of stars. And farther until a threshold is crossed and the image collapses into a point source no different from the surrounding stars. No longer a projection but a beam, shined directly into the eye of the observer. Beyond this threshold, the Earth no longer shrinks—there is no more shrinking to do—but dims in apparent magnitude.

Smaller objects will collapse faster. My heart skips a beat every time I see one of the thousands of communications satellites drifting overhead because, for just a moment, it looks like a star falling abruptly from its fixed position in the sky. I quickly realize my mistake, but I'm left wondering about what immense forces the universe would have to contain to make that illusion reality.

The phenomenon of point source collapse is rarely observable on Earth, usually only with luminous objects. A lighthouse on the horizon is a star to me, but a building to someone else. Maybe a home. A star is a star to me, but a sun to someone else. Maybe even a home.

Unreachable neighbors

Intuition fails me at the scales needed to understand our place and origin in the universe. The horizon always recedes. Even before humans were finally able to escape the atmosphere and break the illusion of the horizon by witnessing the whole sphere of the Earth in one view, it was found that yet another horizon places hard limitations on our perceptions.

It seems that light fades.

As it travels across space, the violent trauma of the Big Bang is pushing every galaxy away from each other in a mutually compounding effect. On small scales, the ones I am familiar with, the effect is negligible. But most galaxies are so unimaginably far away that gentle bubbling and churning, small perturbations in a vast sea, expands more powerfully than gravity can condense.

So light fades, is stretched into deep red-orange hues. Soft amber memories dissolving at the edges of the universe. The light than can reach us from deep space is fatigued from a journey not unlike walking backwards up the escalator. Light from the farthest edges barely makes it at all, having been stretched into the deepest, bloodiest red and then even more, into invisibility. Below vision, lost to human eyes, into infrared. Long wavelengths, reporting evidence that nothing lasts.

Sun worms

I wonder if the image of the road could burn itself into my retina, as so many sights that fatigued my vision before. Surely. Looking at anything long enough will create a trace afterimage that is visible with closed eyelids, and I stare at road lines like nothing else.

I shut my eyes and look for a long time at the back of my eyelids after a long road trip, but I see only the quiet vibration of vision. Within just five minutes of being home, the amount of time it took me to remember to check, the image is gone. I can conjure my own image from memory, of course, but that original image, the one created from direct experience, closer than a photograph in degrees of separation, is gone.

I'm surprised, as my eyes have always seemed particularly sensitive to afterimages. Looking up from a book means peering out at the world through a shimmering field of horizontal bands. If I blink hard while watching a movie, I can retain a fuzzy still in my mind for minutes at a time and, sometimes, recall it with perfect clarity hours later.

I played a game with myself as a child in which I would capture an image of something with my eye and carry it around with me. My favorite object to capture was the Sun. It didn't take long, just a fraction of a second, but an afterimage that bright takes a few minutes to fade.

But despite my careful efforts, I never captured the perfect circle I desired. Like a camera stuck on a slow shutter speed, the image was always streaked by the fearful aversion of vision that immediately accompanied my forbidden glance. The luminous paintbrush of the Sun was dragged across my vision along an escape trajectory, creating a long tail.

Like a worm. A vibrating sun worm wriggling in front of me, pulsing violet, cyan, and black. I carried the worm around, watching it dance an electric dance through my house. I placed

it on green bushes and beige cabinets and the intricate patterns of my parents' carpet. Through all the backdrops of my world it followed me. It had a life of its own.

Visual desperation

Two-hundred fifty years after Galileo first published his findings in *Sidereus Nuncius,* another Italian astronomer named Giovanni Schiaparelli pointed a telescope at Mars during opposition, the closest point in its orbit to Earth. For him, as for amateur astronomers across the world today, Mars would have appeared as a soft red disc vibrating violently in the undulating convection of the atmosphere. Looking through the atmosphere is not dissimilar to looking through water, or a thick pane of vibrating glass.

Moments of clarity occur in fractions of a second – the fuzzy ghost of Mars snapping into brief focus, teasing some hidden detail to its eager viewer, then continuing to dance in the waves of hot air. Drawings, the main currency of truth in the post-Galilean age of visual astronomy, had to be made from the memory of those brief moments of stillness. Astronomers wanting to describe the planets would stare for hours waiting for pockets of calm air to pass, then record as quickly and faithfully as possible what they saw in that atmospheric peephole before returning to the eyepiece to wait again.

Clinging desperately, as astronomers do, at the limits of human vision, Schiaparelli noticed something new and surprising on Mars: A network of dark lines criss-crossing the surface. He called them *canali*, which most precisely means "channels" in Italian, but American astronomers interpreted the word to mean "canals" and it stuck. Given the recent completion of the monumental Suez Canal, the latter term carried a strong implication of artificiality and an air of sophisticated engineering, which fed into an inevitable fervor of speculation about life on the distant world.[5]

[5] George Basalla, *Civilized Life in the Universe: Scientists on Intelligent Extraterrestrials* (New York: Oxford University Press, 2006), 56.

Schiaparelli's drawings of the strange lines, like Galileo's drawings of mountains and craters on the Moon, lent credibility to the discovery. In his colossal *A History of Astronomy*, Anton Pannekoek recounts the frenzy of astronomers seeking to verify the discovery and claim some second-hand prestige. Henri Perrotin and his assistant Louis Thollon were among the first astronomers to do so, and Pannekoek notes "it was curious that, at first, these observers saw nothing of this for weeks and then at last [with opposition ending] produced drawings entirely similar to Schiaparelli's." [6]

Schiaparelli used a telescope with a 9-inch aperture to make his initial discovery of the *canali* and Perrotin and Thollon had reproduced the observation, apparently with some difficulty, with a 15-inch telescope. So when the newly installed and much anticipated 36-inch telescope of the Lick Observatory was trained on Mars during the 1888 opposition, it was expected that new drawings would be made showing the canals in greater detail than ever before. When Lick Observatory reported seeing nothing of the supposed megastructures, their results were met with disappointment and criticism from many in the astronomical community.

The cause of their failure to see the canals was credited to two main factors. First, Lick Observatory was primarily used for stellar observations, and its resident astronomers were thought to be lacking in the necessary experience to conduct planetary observations. The drawings they published were widely considered to be unreliable and of sub-par quality. Second, it was decided that larger telescopes must be—counter-intuitively—inferior for planetary astronomy. Pannekoek explains the logic:

> Faint differences in shade, extending over wide surfaces, are more difficult to distinguish than when contracted to small dimensions. Moreover, air striae in the broad bundle of light entering a large objective will smooth the image more than in the narrower pencil of a smaller instrument.[7]

[6] Anton Pannekoek, *A History of Astronomy* (Ontario: General Publishing Co., 1961), 377.
[7] Pannekoek, *A History of Astronomy*, 378.

So belief in the canals prevailed, and with it a dogma that prioritized the observer over the instrument. Astronomy during this period was uniquely and intimately tied to the individual in a way almost unrecognizable in the sciences today.

Fear of heights in a place without direction

I have a recurring nightmare of falling into Jupiter. At first, I am floating freely among its many satellites, and I feel serene. Jupiter is a perfect Platonic sphere – dazzlingly bright against the black sea that suspends us both. But as I float, which feels like not moving at all, I notice Jupiter filling my field of view at an alarming rate. Soon, it is no longer a sphere. Edge slips silently into horizon and, faster still, the horizon disappears. What was smooth reveals itself to be textured, scattered with clouds as large as countries, and a thousand storms more powerful than any I've ever known. As I am pulled ever closer to this alien world, I'm helplessly overwhelmed by megalophobia. I turn around, in horror, and watch as the universe outside is swallowed by clouds. The darkness I experience now is interrupted only by vicious lightning. Sound returns with a vengeance as I leave the vacuum of space behind, and the cacophonous roar of an entire planet reverberates through my skeleton. The pressure is too much, then I'm dead.

Looking through a telescope

For Galileo, using a telescope was an arduous task. His was small, with a narrowly fixed field of view that made it possible to observe only a quarter of the Moon's diameter at any given time. While this made observing granular details possible, it also required constant repositioning to keep the Moon in view as the Earth rotated underneath it. The quality of the optics, cutting-edge as they were for his age, would have provided soft, fuzzy views plagued by chromatic aberrations.[8]

Today, most professional telescopes would be completely unrecognizable to Galileo. Lenses have been abandoned in favor of mirrors, segmented into dozens of smaller surfaces and individually controlled by a computer to cancel out the vibrations of the atmosphere. But in amateur astronomy, the spirit of those initial observations endures.

My first telescope was small and cheaply manufactured. It suffered from many of the same problems as Galileo's, but for entirely different reasons. Spindly tripod legs barely supported a compact optical assembly, so when observing at high magnification even the gentlest touch would cause the field of view to shake wildly. In the dark cave of the eyepiece, which cups my eye like a horse blinder, minimizing the intrusion of external sensory input, even my breath could send the luminous pinprick of a star or planet into a frenzied seizure, drawing afterimages across my vision like a marker.

There is a specific symbiosis that grows between observer and telescope that, at its best, makes it an extension of the perceiving body – an extension of my consciousness. But it is not the same me that reaches symbiosis, it is a version of me altered by the telescope. It forces me to slow my breath and hold my body as still as possible. I strain my neck, shut my non-dominant

[8] Horst Bredekamp, *Galileo's Thinking Hand: Mannerism, Anti-Mannerism, and the Virtue of Drawing in the Foundation of Early Modern Science*, trans. Mitch Cohen (Berlin: Humboldt University, 2014), 102-103.

eye, and lean deep into the eyepiece. I have to stand steady and strong, as if encouraging the telescope to do the same. I have to be slow and look slow. Calm atmospheric peepholes come only once a minute, and under high magnification the telescope has to be repositioned at least as often.

And seeing nothing at all

But of course, there are no canals on Mars. This fact was not confirmed with absolute certainty until Mariner 2 performed the first robotic flyby of the planet in 1962, but the idea fell out of favor soon after photography became intimately tied with astronomy in the early 20th century. Telescopic photographs of Mars were not of a sufficient resolution to completely rule out structures as thin as canals, but evidence against civilization on Mars quickly mounted and the need to explain and falsify the canal hypothesis remained.

In 1903 a famous experiment that, by today's standards, represents a basic demonstration of gestalt principles, school children were shown a six-inch diameter drawing of Mars and seated at distances of 15-60 feet. The drawing included the known albedo features on Mars, but no canals. The children were also not told what the drawing was meant to represent. Remarkably, a significant portion of the students, especially those seated father away, connected features in the drawing with straight lines of their own invention.[9]

Human vision is complicated and the image received by the mind has a more tenuous relationship to the external world than might be comfortable to admit. Shortcuts for processing information are extensively utilized by the brain and, especially when confronted with sights outside of normal experience, those shortcuts can break down or lead to false conclusions. Many of these shortcuts, slippery as they are, have now been categorized by psychologists as gestalt principles like "continuation" and "closure".[10] Schiaparelli and his contemporaries, just like the school children in the experiment, and through no fault of their own, may have been subject to one or many of these illusions.

[9] J.E. Evans and E.W. Maunder, "Experiments as to the actuality of the 'Canals' observed on Mars", *Monthly Notices of the Royal Astronomy Society* 63 (June 1903): 488-499.
[10] Bang Wong, "Gestalt Principles (Part 1)", *Nature Methods* 7, no. 11 (November 2010): 863.

It has also been speculated, in a more poetic explanation for the canals, that those 19th-century astronomers could have, at times, seen the shadows of the blood vessels in their eyes. In 2003, a retired optometrist named Sherman Schultz noticed that some of the drawings of Percival Lowell, the most prominent advocate of the canal hypothesis after Schiaparelli, looked remarkably similar to the vein structure on the human retina.

The specific drawings in question were of Venus, in which Lowell claimed to have discovered yet more alien megastructures resembling a spoked wheel with a large central hub, bearing a superficial resemblance the internal structure of the eye. Investigating further, Schultz found that because Lowell was in the practice of stopping his 24-inch telescope down to a smaller effective aperture for planetary observation—sometimes to just three inches—he was inadvertently simulating the conditions used by contemporary optometrists to examine patients for cataracts.[11]

He may, in short, have been seeing a projected image of his own eye on the surface of the planets. It is impossible to know, of course, what the truth is. And the truth is likely somewhere between these illusions and astronomer's overwhelming desire for these observations to be true.

[11] William Sheehan, "Venus Spokes: An Explanation at Last?", *Sky & Telescope*, last modified July 23, 2003, https://skyandtelescope.org/astronomy-news/venus-spokes-an-explanation-at-last/; William Sheehan and Thomas Dobbins, "The spokes of Venus: an illusion explained," *Journal for the History of Astronomy* 34, no. 114 (February 2003): 53-63.

Letter to anyone in need of advice

I keep my car clean. If you take pride in anything, it ought to be your car. Really, think about it. You spend so much time in your car. I once had a job with a two hour commute each way, with traffic. Why would you spend so much of that time surrounded by trash? Dusty, dirty, brimming with fast food bags, grey but it used to be black, crumbs in every crevice like sand in folds of skin after a day at the beach. Lived-in.

I know you've been down lately. We all have. Something in the air, I guess. It would give you something to rely on. Keeping your car clean. One thing you can control every day. Maybe it would make a difference. It does for me.

My car has six windows. I like it because I can be cozy in my driver seat, sealed off from the exterior world, in my private domain, and yet I can still enjoy the benefits of panoramic vision. But like my eyes, my car has a few blind spots to be aware of.

The A-pillar, which does much to keep me and my passengers safe, blocks a significant portion of my vision. Like the blind spot caused by my optical nerve, I've learned not to see it.

How did I get so comfortable moving such a large machine? I remember not understanding how anyone could get used to such a thing. The extend of my new metal body seemed an unsolvable mystery. Where is my rear bumper, anyway? The concrete barrier looked so close, but it was still eight feet away.

Personal equation

The case of canals on Mars points at a problem in astronomy known as the "personal equation". The term was coined by astronomers in the late 18th century who discovered inexplicable differences in high-precision stellar measurements between different observers. During this period, astronomy served an important role in celestial navigation and some of the most well-funded observatories were specifically tasked with cataloguing the positions of stars for that purpose. Using a telescope precisely aligned with the axis of the Earth, astronomers would time as accurately as possible the exact moment a star crossed the meridian.

A target star would be observed crossing a hair-thin reticule while a pendulum clock or metronome ticked in the background. The observer would note the position of the star in relation to the meridian at one second, watch it cross, note the position of the star at the next second, then determine, to the tenth of a second, when in that intervening silence it crossed the meridian – all without looking away from the eyepiece. Illustrating the intimate connection between this method and the body of the observer, it was often called the "eye and ear" method.[12] It seems simple enough, or maybe insane, but it worked. Until astronomers realized it didn't.

Individual astronomers were capable of remarkable consistency, but when cross-referenced with each other, disagreed with equal consistency. In the most famous case, Britain's Astronomer Royal Nevil Maskelyne dismissed his assistant, David Kinnebrook, because his measurements differed systematically from his own by 0.8 seconds across months of recorded measurements. The concept of the personal equation would not be put into words for another twenty years, so Maskelyne assumed his assistant incompetent. Analyzing the meticulous records kept by the Astronomer Royal years later, in 1888, the psychologist Edmund Sandford

[12] Edmund Sanford, "Personal Equation," *The American Journal of Psychology* 2, no. 1 (November 1888): 3-6

determined that Kinnebrook's discrepancies could not be explained merely by a subtle difference in technique, as Maskelyne cited during his assistant's dismissal.[13]

The conversation this problem instigated required astronomers, for the first time, not to look to their instruments in the pursuit of greater precision, but themselves. Potential explanations were numerous, and entirely dependent on the individual in question. To make the problem even more complicated, physiological sources like astigmatism could compound with subtler psychological explanations, like reaction time, which has been shown experimentally to vary wildly among human beings.[14]

Lowell's personal equation could, perhaps, be said to include susceptibility to gestalt principles, blood veins in his retina, an active imagination, and personal ambition. More broadly, the personal equation is the tip of an iceberg rearing its head at the threshold of the human capacity for precision. The submerged portion of the iceberg is the hyper-specific experience—a complex cocktail of physiological, psychological, social, and spiritual qualities—of trying to describe the external universe as a human being trapped on the surface of a small planet.

Just by looking, even Galileo was subject to the personal equation, because to look is to relate to something in a uniquely human way. Most of the universe, ostensibly, is not and never will be seen or perceived in any way. To see the Moon as a place is to relate to it as a creature with legs and a desire to live. To see canals on Mars is to relate to it as member of a civilization rapt by the colonial impulse, and maybe, the desire not to be alone in the universe.

In the context of science, the personal equation offers a way of articulating the desperation of human beings to know the universe as intimately as the soft computers in their skulls will allow. Looking beyond this context, the personal equation is synonymous with the

[13] Sanford, "Personal Equation," 8.
[14] Alfred Baumeister, "Intelligence and the 'personal equation,'" *Intelligence* 26, no. 3 (1998): 255

human condition, and there is a reason the phenomenon originates in the field of astronomy. On this Earth, humans can alter the world to fit their needs, to more closely align with some shared personal equation that compels the taming of the landscape and the organization of the amorphous natural world into a tidy, comprehensible system of information. In the universe beyond, humanity is helpless to enforce its structural will. It is left only to confront the limitations of its collective intuition.

Beringia / generation ships

How did the bodies of my distant ancestors age differently, having never wriggled like an earthworm into the Z-shaped cockpit of an automobile? We have modified ourselves irreversibly with our tools. I'm struck often—with the force of interstate speeds—by how rare my experience of living is when considered in its global and deep-historical context. I was born into incredible circumstances, amongst the minority in space and time with easy access to, among many things, a car. My car alone makes my life drastically different than most people who have ever existed.

The first humans to travel could only do so with legs, and their eyes would see very little of the world. Even with a tendency toward the nomadic that has spread our species to every ecosystem, a Pleistocene individual would come to know only a portion of a continent or two. And with no way (yet) of knowing the true scale of their world, or that it is far stranger in structure and origin than they could possibly imagine. No way (yet) of knowing that they crawl about the surface of an organic spacecraft, shielded by a gossamer sheath of air from a bottomless sea of nothing.

I know this to be true not because I possess a sharper intuition or more inherent wisdom than my ancestors did, nor due to direct experience, but because of the unprecedented connection of human minds that I take part in. The brain power of a typical nomadic group in the Pleistocene was, maybe, 150 minds – as slippery as determining a number like that is.[15] The potential brain power our globalized industrial civilization, by this simple logic, is like 50 million tribes working together. And to a large extent this is a true enough picture of the global economy, co-dependent, fragile, and brittle as it is. It allows this network of minds to exist at an

[15] Douglas Bird, et al. "Variability the organization and size of hunter-gatherer groups: Foragers do not live in small-scale societies," *Journal of Human Evolution* 131 (June 2019): 105-106

unprecedented scale. Mediated at first by speech, then symbols, then written word, then radio transmission, and now, the internet.

The internet is where all the information that has survived the gauntlet of time is preserved. Where instead of wandering the surface of my planet—my documented, my known planet—I wander, in a subdued but tangible awe, compulsively, hungrily I wander the bottomless library of experience, knowledge, broad and narrow, of my species. From my terminal on the threshold of this web, I am allowed a tiny and imperfect peephole into deep time.

When I hear about the great and important milestones in human history through the narrative voice that history takes on, tending to focus on and mythologize individual stories in the way this paper often has, it is tempting to imagine them as singular events. After all, my life tends to unfold in a braided sequence of singular events. But in deep time, in the terms of geologic timescales, this is seldom the case.

Learning about the Bering Land Bridge as a child, I imagined a treacherous, tightrope-thin stretch of ice holding Alaska and Siberia together like a fraying rope, ready to snap. And brave explorers: husky, strapping cavemen, savage as they are fearless, walking the slippery balance beam between landmasses, between worlds, in pursuit of migratory prey. As soon as their feet touched solid ground on the New World, I imagined, the Bridge was swallowed by the frigid sea, never to re-emerge.

Reality, as always, does not fit into so neat a story. For the men and women and children who did make the trek, there was no “Alaska” to go to nor “Siberia” to come from. There was not a “North America” or “Eurasia”. It was just the land by whatever names it was adorned with in paleolithic tongue. And the term “land bridge” implies an insignificance that underplays to

role played by that land– it conjures the image of a thin, barren isthmus walked upon only in transition from one destination to another.

In fact, Beringia, by its posthumous title, was a destination of its own. A region of land that was itself continuously inhabited. That was, itself, just a seamless continuation of the land that was not (yet) perceived as shapes, chopped up and painted the rainbow of pastel hues needed to trace the messy histories of our borders. Nor was it perceived as I perceive it, through the veil of history that condenses eras into singular events.

The "land bridge" was "open" for over ten thousand years in its latest iteration.[16] Those nascent peoples probably had no sense of the significance that would later be applied to lives they lived in their unforgiving and beautiful homeland. No sense of the continental division that would only later cause their lives to be viewed as "transitional". No sense that their lineage would populate an entire hemisphere of the globe.

Did the world seem big or small to the Beringians?

Theirs is arguably the better way to live – to know one place so deeply that it is an extension of yourself. But to have this new and strange ability that comes with my life, in my time, to flex a tendon and roar across the surface of the planet at lethal speeds is thrilling and unique and mine. A ground-based guided missile, heavy metal rhinoceros grinding down rubber hooves on asphalt. How rare my fragile and privileged perspective is when compared against history.

Do astronauts get stiff after long voyages around and around in the black sea of space the way I get stiff on road trips? I can only imagine. No gravitational anchor constantly squashing and stretching their vertebrae, barely enough room to fully extend four limbs. I wonder how they

[16] Dan O'Neil, *The Last Giant of Beringia: The Mystery of the Bering Land Bridge* (New York: Basic Books, 2004) 15

can ever satisfactorily put words to such a strange and dramatic experience. The measurable health effects of space travel, at least, are well documented thanks to stays on the International Space Station that often last the better part of a year. Will we all modify our bodies one day in the void between planets? Between stars?

In the shower—home from my own voyage—I can think of my hypothetical descendants, generations removed, cramped in their own metal miracles on interstellar missions of pilgrimage, colonization, proliferation, or exodus. I think of them as scalding water sanitizes my skin and relaxes my mistreated muscles. The residues of travel melt away and disappears in the thick, fragrant steam. The smell of fast food eaten at the wheel; sweaty back and sweaty thigh; wrinkled, lived-in clothes. Clean, soft water pours—erupts—hot like blood from pressurized pipes snaking the wall like veins.

Expecting too much and missing what's there

There is a faceless, formless voice I yearn to hear, drifting through the cold to say, if only in a whisper, *I am here too. I struggle, suckle, hustle like you.* Or, *I did, anyway*. Here in the dark I wait, then I see something, but is it really you? Or were you here with me, all along, waiting too? Head cocked, eyes up, I am surely seeing nothing. I turn around and round again, inward like a spiral to meet whatever waits there. The frog in my throat croaks over my affirmations. What can I expect to hear when I neglect to call out?

Bibliography

Basalla, G. (2006). *Civilized Life in the Universe: Scientists on Intelligent Extraterrestrials.* New York: Oxford University Press.

Baumeister, A. (1998). Intelligence and the “personal equation”. *Intelligence, 26*(3), 255-265.

Bird, D., Bird, R., Codding, B., & Zeanah, D. (2019, June). Variability in the organization and size of hunter-gatherer groups:. *Journal of Human Evolution, 131*, 96-108.

Bredekamp, H. (2014). *Galileo's Thinking Hand: Mannerism, Anti-Mannerism, and the Virtue of Drawing in the Foundation of Early Modern Science.* (M. Cohen, Trans.) Berlin: Humboldt University.

Evans, J., & Maunder, E. (1903, June). Experiments as to the actuality of the "Canals" observed on Mars. *Monthly Notices of the Royal Astronomical Society, 63*, 488-499.

Galilei, G. (2015). *Siderius Nincius, or The Sidereal Messenger* (Second Edition ed.). (A. Van Helden, Trans.) Chicago: University of Chicago Press.

O'Neil, D. (2004). *The Last Giant of Beringia : The Mystery of the Bering Land Bridge.* New York: Basic Books.

Pannekoek, A. (1961). *A History of Astronomy.* Ontario: General Publishing Company.

Sanford, E. (1888, November). Personal Equation. *The American Journal of Psychology, 2*(1), 3-38.

Sheehan, W. (2003, July). *Venus Spokes: An Explanation at Last?* Retrieved from Sky & Telescope: https://skyandtelescope.org/astronomy-news/venus-spokes-an-explanation-at-last/

Sheehan, W., & Dobbins, T. (2003, February). The spokes of Venus: an illusion explained. *Journal for the History of Astronomy, 34*(114), 53-63.

Stillman, D. (1978). *Galileo at Work: Scientific Biography.* Chicago: University of Chicago Press.

Wong, B. (2010, November). Gestalt principle (Part 1). *Nature Methods, 7*(11), 863.