The Neurochemistry of Science Bias

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The doctor who discovered the preventative power of hand-washing was shunned by the nineteenth-century medical establishment when he tried to spread the word. One hopes this could not happen today because the scientific method keeps us focused on replicable data. Yet Dr. Semmelweis's critics believed they were defending evidence-based science. They invoked the greater good as they ridiculed his assertion that dirty hands carry invisible disease-causing agents. How is it possible for people intent on objectivity to dismiss essential information?

Two familiar answers to this question are *confirmation bias* and *paradigm shift,* but neither explains it completely. Confirmation bias is incomplete because it typically omits the investigator's bias. As such, it could be used to "prove" that Semmelweis was biased without addressing biases of his critics. Paradigm shift is incomplete because it doesn't explain how a brain chooses information that fits a prevailing explanatory framework and ignores information that doesn't fit, even as it believes in its own objectivity.

Brain chemistry offers a new way to understand information-processing biases. Brain chemicals cause a person's positive feeling about one chunk of information and negative feelings about another. Feelings are presumed irrelevant to empirical analysis, but the brain chemicals that cause feelings are integral to human information processing whether we notice them or not. Neurochemicals work without words. They do not report themselves to your verbal inner dialogue. That makes it easy to dismiss them as a factor in your own inferences, though you clearly see their power in others. Our brain chemicals were inherited from earlier mammals, and when we know what they do in animals, their impact on humans is obvious. This paper shows how neurochemicals influence empirical science, with examples from modern social science.

Nature's Operating System

Natural selection built a brain that is focused on survival. It scans constantly for information relevant to its survival needs, and responds with a positive- or negative-feeling chemical. Survival is defined in a quirky way by this brain we've inherited: it cares about the survival of its genes; and it relies on neural pathways built in youth. Conscious concern for survival is not needed for the brain to release a positive feeling when it sees something it has linked to survival. Neurons connect when a chemical is released, which speeds their release in the future. Though neurons connect through life, the pathways myelinated in youth speed electricity so efficiently that they feel more reliable, even when they conflict with new knowledge.

All mammals have the same basic brain chemicals, controlled by the same core brain structures (such as the amygdala, hippocampus, hypothalamus, pituitary). This core operating system does not process language, but it has allowed mammals to meet their survival needs for two hundred million years. It works by tagging inputs as reward or pain, which motivates approach or avoidance. A pleasant-feeling chemical motivates an organism to go toward a reward, while an unpleasant-feeling chemical motivates withdrawal from potential threats.

The chemicals are activated by pathways that develop from experience. The brain's electricity flows like water in a storm, finding the paths of least resistance. The cortex can define rewards and pain in complex ways with its huge reserve of neurons, but it can only process a limited amount new information at a time. Thus we are heavily influenced by the pathways we already have. We are not aware of these pathways, so it's easy to presume our declarative reasoning is our entire thought process.

No one consciously sifts new inputs through an old filter, but this is how the brain is equipped to work. We have ten times more neurons going from the visual cortex to the eyes than we have in the other direction. This means we're ten times more prepared to tell our eyes what to look for than we are to process whatever happens to come along. Our ancestors survived because they could prompt their senses to find information relevant to their survival. Neurochemicals are central to the prompting mechanism. The mammal brain evolved to honor its neurochemical signals as if its life depended on it, not to casually disregard them.

Here's a closer look at the chemicals of reward (dopamine, oxytocin, serotonin) and pain (cortisol) and their role in our inferences about the empirical world.

Dopamine

The brain releases dopamine when a reward is at hand. A person may think they are indifferent to rewards because they do not respond to rewards that others value. But each brain scans the world with pathways built from its own past dopamine experiences. When it sees an opportunity to meet a need, dopamine produces a great feeling. This motivates us to do things that trigger it, and to lose interest in things that do not trigger it.

Dopamine releases the energy that propels a body toward rewards. We humans experience this as excitement, but the physical sensation makes more sense when viewed from an animal perspective. A lion cannot get excited about every gazelle that crosses its path because its energy would be used up before it found something it could actually catch. A lion survives by scanning the world for a reward it realistically expects based on past experience. When a lion sees a gazelle within its reach, dopamine! That releases the energy needed for the hunt. Most chases fail, so a lion's brain constantly re-evaluates its course of action. If it succeeds at closing in on the gazelle, dopamine surges, which tells the body to release the reserve tank of energy.

We are designed to survive by reserving our energy for good prospects, and dopamine guides these decisions. Our hunter-gatherer ancestors scanned for evidence of food before investing energy in one path or another. A modern scientist meets needs in different ways, but the same operating system is at work. The good feeling of dopamine motivates us to approach rewards, as defined by the neural pathways we have.

Dopamine is metabolized in a few minutes, alas, and you have to do more to get more. This is why we keep scanning the world for new opportunities to meet our needs. The brain habituates quickly to old rewards, so it takes new reward cues to turn on the dopamine. When berries are in season, they stop triggering dopamine in a short time because they no longer meet a need. Then, protein opportunities turn on the good feeling…until nuts are in season. Dopamine focuses our attention on unmet needs by making it feel good. Today's scientists seek new discoveries because it stimulates dopamine.

Social rewards are as relevant to a mammal's survival as material rewards. Once physical needs are met, social needs get the brain's attention. The brain makes predictions about which behaviors will bring social rewards in the same way that it predicts which path is likely to lead to a berry tree: by relying on the neural pathways built by past experience. One may believe they are indifferent to social rewards, but anything that brought social rewards in your past sends electricity to your dopamine, which motivates an approach.

When we see others get rewards, our mirror neurons activate. Thus we wire ourselves to turn on the dopamine in ways that work for others. Our brain promotes survival by observing the patterns of rewards and pain around us, which helps us create a better hunting tool or a better grant proposal.

Repetition builds pathways, and repetition during the myelin years (before age eight and during puberty) builds the ultra-fast and enduring pathways known as "white matter." These myelinated neural networks are powerful whether or not we have specific event memories.

Big rewards build big pathways. The relief of threat is a huge reward to the mammal brain because it promotes survival immediately. Escaping a predator promotes survival more than any one reward, so the brain builds a big reward pathway whenever you avert a threat. Social recognition is a big reward from the mammal brain's perspective because it's so relevant to the survival of one's genes, so anything that brings social recognition builds a big pathway. That brain interprets data with acute awareness of potential threats and potential social rewards.

Oxytocin

Social alliances help a mammal survive, and natural selection built a brain that rewards you with a good feeling when you build social alliances. Oxytocin causes the feeling that humans call “trust.” Oxytocin is not meant to flow all the time because trusting every critter around you does not promote survival. The mammal brain evolved to make careful decisions about when to trust and when to withhold trust. It releases the good feeling of oxytocin when there’s evidence of social support.

Safety in numbers is a mammalian innovation. Reptiles avoid their colleagues except during the act of mating, when they release an oxytocin-equivalent. Reptiles produce thousands of offspring and lose most of them to predators. Mammals can only produce a small number of offspring, so they must guard each one constantly in order to keep their genes alive. Oxytocin makes it feel good. It causes attachment in mother and child, and over time it builds pathways that transfer this attachment to a larger group.

A mammalian herd or pack or troop is an extended warning system. It allows each individual to relax a bit as the burden of vigilance is spread across many eyes and ears. This only works if you run when your herd mates run. A mammal who insisted on seeing a predator for themselves would have poor survival prospects. We are descended from individuals who trusted their herd mates. We humans are alert to the risks of herd behavior, of course. But when we distance ourselves from our social alliances, our oxytocin dips and we start to feel unsafe. Even predators feel unsafe without a pack: a lone lion’s meal gets stolen by hyenas and a lone wolf cannot feed its children. We have inherited a brain that constantly monitors its social support.

But life with a pack is not all warm and fuzzy. Trust is hard to sustain in proximity to other brains focused on their own survival. And the social alliance that protects you today can embroil you in conflict tomorrow. Yet mammals tend to stick with the group because the potential pain of external threats exceeds the potential pain of internal threats. Common enemies cement social bonds, and oxytocin makes it feel good. Each brain turns it on with the pathways of its unique individual oxytocin past. Each scientist recognizes the rewards of social alliances and potential threats to those alliances, whether they put it into words or not.

Serotonin

An uncomfortable fact of life is that stronger mammals tend to dominate weaker group-mates when food and mating opportunity are at stake. Violence is avoided because the brain anticipates pain and retreats when it sees itself in the weaker position. Yet an organism must assert itself some of the time for its genes to survive. Serotonin makes it feel good. Serotonin is not aggression but the nice calm sense that you can meet your needs. When you see an opportunity to take the one-up position, your mammal brain rewards you with the good feeling of serotonin. We can easily see this in others, even though we re-frame it in ourselves.

The mammal brain evolved to compare itself to others, and hold back if it’s in the weaker position. Avoiding conflict with stronger individuals is more critical to survival than any one meal or mate. When a mammal sees itself in the stronger position, the safe feeling of serotonin is released. But it’s metabolized in a few minutes, which is why the mammal brain keeps scanning for more opportunities to be in the one-up position. You may insist you do not compare yourself to others or enjoy a position of social importance. But if you filled a room with people who said that, they would soon form a hierarchy based on how much disinterest each person asserts. That’s what mammals do, because each brain feels good when it advances its unique individual essence.

Cooperation is one way to gain a position of strength, and larger-brained mammals will cooperate when it meets their needs. They work together to advance their position in relation to common rivals, and serotonin is stimulated when they succeed.

Each serotonin spurt connects neurons that tell you how to get more in the future. The serotonin of your early years builds myelinated pathways that play a big role in your social navigation through life. These pathways generate expectations about which behaviors are likely to enhance social power and which behaviors might threaten it. Every researcher has expectations about which actions might bring respect or lose respect. One research outcome might trigger the expectation of social reward while another set of data might trigger social pain. It’s easy to see why people go toward one slice of information and avoid another without conscious intent. And it’s easy to ignore one’s own efforts to compare favorably even as we lament such efforts in others.

Cortisol

The mammal brain releases the bad feeling of cortisol when it encounters a potential threat. Bad feelings promote survival by commanding attention. For example, a gazelle stops grazing when it smells a lion, even if it is still hungry. Cortisol motivates an organism to do what it takes to make the bad feeling stop.

Cortisol is the brain’s pain signal, but waiting until one is in pain is not a good survival strategy. That’s why the brain is so good at learning from pain. Each cortisol surge connects neurons that prepare a body to respond quickly to any input similar to those experienced in a moment of pain. The brain evolved to anticipate pain because your prospects fall quickly once a lion’s jaws are on your neck.

Social pain triggers cortisol. In the state of nature, social isolation is an urgent survival threat. Cortisol makes a gazelle feel bad when it wanders away from the herd, even when it is enjoying greener pastures. Cortisol creates alarm in a monkey who experience a loss of social status because that’s a threat to the monkey’s genetic survival prospects. Conscious concern for one’s genes or one’s status is not needed to get the cortisol flowing. Natural selection built a brain that warns you with a bad feeling when your prospects encounter a setback. You may try to ignore it, but if you don’t act to relieve the perceived threat, the alarm is likely to escalate.

A big brain brings more horsepower to the task of identifying potential warning signals. Cortisol turns on when we see anything similar to neurons activated by past cortisol moments. It's not surprising that people are so good at finding potential threats, and so eager to relieve them. And it's easy to see how social threats can get our attention as much as we presume to disregard them.

The Survival Urge in Science

The hand-washing Dr. Semmelweis got a bad reaction from his colleagues. It would be easy to accuse them of greedy preoccupation with their own needs at expense of others. But the germ theory of disease had not been established yet, so Semmelweis's allusion to invisible disease carriers was superstitious nonsense in the science paradigm of his day. Leading doctors claimed the public needed protection from such dangerous misinformation.

Information that does not fit one's existing neural network requires a significant investment of energy to interpret. There's little motivation to make that investment when there's no expectation of reward (from the old paradigm's perspective), and real expectation of pain (because sympathizers could be tarnished with the same labels applied to Semmelweis).

Curing a major killer of the day, "childbed fever" (septicemia), may seem like a huge reward, but without a perceived link between hand-washing and health, there's no expectation of that reward. The expectation of pain is reasonable because a scientist has invested heavily in credentialing, so any threat to their credentials is significant. Semmelweis's findings could give doctors a bad feeling that was not offset by a good feeling. The urge to retreat from those findings can easily be explained with polysyllabic abstractions unrelated to neurochemistry.

If we're angered by that retreat today, we must hold ourselves to the same standards. We must invest our own energy in new information that conflicts with shared expectations, even when that threatens our social support. Quite often we don't. To avoid pointing fingers, I'll offer two personal examples.

I taught International Management for 20 years at a time when Japanese management was widely admired. My course focused on the superiority of Japanese over American methods, and I was convinced that "the data" supported this conclusion. But one day in 1995, while lecturing to 150 students, I had the horrifying awareness that Japan had been in a deep depression for the past five years and I had not adjusted my rhetoric at all. US productivity was booming at the time, and I still spoke of American management in the derisive tones I had learned in my past. Hearing myself in that way forced me to confront my belief that I'm motivated by "the data." My cortisol surged as I struggled to finish the sentence. The cortisol paved a pathway that reminds me of this moment, and alerts me to my potential for bias instead of just pointing to the biases of others. As I grappled with the problem, I realized it could not be solved by adding a few facts to my course because the critique American management was the very core of the course. I had learned his habit from my social alliance because it put us in the one-up position. I feared the social pain that could result from any negative inferences about another country or any positives inferences about the United States. My survival was not really at stake because I was a tenured full professor. But as much as I hated to admit it, neurochemistry could shape my empirical "knowledge."

When I had children in the 1980s, I was interested in "the data" on daycare. I put my children in daycare with the belief that "studies show" a neutral or even positive impact. But I now realize I was not open to all data, and I suspect researchers were not either. If a researcher happened to find negative effects of daycare, would they have reported those findings? Or would they have repeated the study with adjustments until they got results consistent with expected rewards? And if negative findings had been reported, would they get published and mass communicated? Would such findings get replicated, or be dismissed as an aberration? Despite aspirations to empirical objectivity, each brain generates expectations about actions likely to bring rewards and actions likely to risk a setback. I might have gone on mirroring the biases around me, but the welfare of one's children is the highest reward there is in the brain built by natural selection. This motivated me to invest energy in information processing instead of relying on answers that flowed effortlessly from shared frameworks. I could not necessarily find a simple truth, but I could accept my own observation, from decades in the social science world, that negative findings about daycare could not become "data" because they'd be dismissed as "anti-woman." So if I relied on "the data," I would inevitably be biased.

Research is conducted by brains that seek rewards, respect, and the safety of social alliances. In the long run, realistic interpretations of the empirical world bring rewards, but not necessarily to the individuals who risked a new interpretation. Semmelweis came to a very bad end.

Science Bias Today

A bias is hard to notice when it's shared by those around you. Yet shared perceptual frameworks are inevitable because:

- the credentialing process requires a professional to absorb the explanatory framework held by respected members of their discipline;
- information overload forces us to sift for relevance based on past experience, and that includes social experience.

Even as we aspire to objectivity, we end up seeing the world through a lens built from social experience. This makes it easy to overlook the limits and biases of that lens. For example, let's examine the Rousseauian lens so widely shared in social science. Rousseau asserted that nature is good, and "our society" is the cause of that which is bad. A social scientist who finds evidence to support this presumption can expect rewards. The result is an accumulation of evidence that:

1. animals are good (they cooperate and nurture each other)
2. children are good (they grow to perfection automatically unless miseducated by society)
3. pre-industrial people are/were good (in harmony with nature and each other)

A reader may think these assertions are indisputable facts because the effortless flow of electricity through well-developed pathways gives us a sense of truth. No one notices the neural network they built from repeated experience. No one accounts for their natural anticipation of rewards and pain as they process each new input. We can only have realistic information if researchers feel safe reporting what they find and we feel safe receiving it. Here are some simple examples of data being shaped to fit the Rousseauian framework despite the shared presumption of objectivity.

1. **Animals are naturally good**

Mountain lions are endangered in the hills around my home town, and measures to protect them are in effect. Every effort is made to rehabilitate a injured mountain lion; but the animal cannot be returned to the wild when it recovers because it would be killed instantly by the lion that dominates the territory it is released into. This raises an uncomfortable problem. No one wants to admit that animals routinely kill intruders. "Only humans kill" is a widely shared belief, and a person is likely to get ostracized from a social alliance if they violate such a core belief. Just thinking of that risk is enough to trigger a neurochemical alarm that discourages a person from stating obvious facts. So animal rescuers struggle to do the necessary without acknowledging the reasons.

For most of human history, animal conflict was observed first hand. It's true that animals rarely kill their own kind, but that's because the weaker individual withdraws to save itself. Animals are at the edge of conflict a lot because asserting promotes their genes. Today's researchers "prove" that animals share and empathize by crafting "studies" that ignore all behavior except that which supports the message of animal altruism. Every researcher understands the reward structure, and no researcher wants to invalidate their prior investments of effort. Researchers believe they are motivated by the greater good rather than the urge to seek rewards and avoid pain because those words are part of the learned framework and people tend to believe their verbal explanations of their motives. If no one will risk reporting animal conflict, then we can say there is "no evidence" of animal conflict, and it will be true.

2. Children are naturally good

Children flourish if left to their own impulses according to widely held beliefs in social science. Any developmental problems that occur are quickly explained as a failure of "our society." The agreed solution is to let a child do what feels good. Credentialed professionals point to "proof" that fun is the core of learning, and they know they will suffer rebuke if they expect a child to do something un-fun. If the student hasn't learned, the teacher hasn't made it fun.

For most of human history, survival depended on children pulling their weight. Each child carried water, firewood, or a younger sibling as parents deemed necessary, whether the child thought it felt good or not. A child would look for ways to make it fun, but adults did not substitute children's fun-meter for their own judgement. Children learned survival skills not by following their bliss but by being accountable for essential tasks, often harshly. By experiencing the repetitive, back-breaking un-fun labor of their parents (that challenging concept is explained in #3 below), they built core self-management skills, such as focusing attention on steps that meet needs.

We have been trained to believe that children were constantly frolicking in the past. If you violate this shared presumption, it's hard to survive as a member in good standing of a social-science profession. Just taking a step toward information that violates a shared framework is difficult because one's neurochemical alarm signals the risk. It's not surprising that people step where rewards are expected, without consciously telling themselves that in words. The result may be more research on how to make things "fun," and more children who don't learn basic survival skills.

3. Pre-industrial societies were/are good
The accepted view in social science is that traditional people met their survival needs with only a few hours of effort per day, and spent the rest of their time making art, making love, and making their group mates feel valued and understood. Research that enhances this paradigm gets recognition. Research that conflicts with it gets ignored, ridiculed or attacked. A researcher makes choices about where to invest his or her energy.

More rewards go to the more advanced form of this paradigm: the idea that no one ever worked in the past, because work is defined as something you have to do, and our ancestors survived by only doing what they felt like. Researchers support this assertion with data from the time period before recorded history but after the separation between humans and apes– the time when no evidence is available except data that comes from social science professionals. Researchers generate data by defining the labor of prehistory as "creativity" or "fun." Of course food-seeking feels good when you live with hunger, and it allows you to get out in nature. So the premise is true as long as you ignore all the facts that don't fit.

A researcher has no reason to investigate the pain and suffering of the past if there's no expected reward. They have reason to fear social pain if they step toward evidence that our ancestors did mind-numbing labor in service to tyrants in hopes of getting protection from endless attackers. The result is the prevailing belief that life is sheer hell today compared to past times. One wonders how those aggrieved by modern society would feel about vermin-infested open-pit toilets and neighboring tribes stealing their food stocks and their daughters.

The Greater Good Tautology

No one likes to imagine themselves sifting data for opportunities to meet their own survival needs. It feels better to imagine one's self serving the greater good. It's easy to do that if one defines the greater good in ways that also advance one's own survival prospects. Semmelweis's critics invoked the greater good without acknowledging their own survival motives. Today's science community focuses on verbal abstractions about the greater good, and overlooks the role of neurochemical survival responses in their thinking. This makes it hard for individuals to recognize biases that may occur. The brain is designed to go toward things that feel good. It feels good to believe in the superiority of one's ethics. But no one is indifferent to rewards and pain because that information drives our operating system. If we want good data, we are better off understanding our brain than masking our biases with abstractions about the greater good.