The Sparseness Adaptation Syndrome, Part I

Adaptation to low population density yields a set of traits correlated with autism and male gender.

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Abstract

Adaptation to low food and population density at inevitable frontiers yields a syndrome that plausibly accounts for major features of autism, including its defining social disconnectedness, correlation with male gender, spectrum of intensities, variety, dependence on multiple genes, rising prominence, and others. The theory proceeds from thought experiments and simple reasoning and makes testable predictions about measurable quantities.

Introduction

Autism is a neurological condition that has long defied tidy explanation. Here is a partial listing of recently proposed causes of autism:

> Vaccines, mercury, environmental toxins generally, Internet use, cold mother, older father, older mother, depressed or stressed mother, prematurity, low birth weight, high birth weight, having a big head, being a twin, smoking during pregnancy, diabetes during pregnancy, birth complications, being born in summer, being a second-born child, being a later-born child, being born close together, in vitro fertilization, childhood immune system malfunction, maternal immune system malfunction, Neanderthal genes, hyperinsulinemia and diabetes, impaired brain connections, impaired sugar metabolism, Clomid, Terbutaline, glycine, mitochondrial dysfunction, malfunctioning epigenetics, living near a freeway, too little oxytocin, too much androgen, parental wealth, Lyme disease, maternal antidepressant use, etc.

A simple Internet search easily verifies and extends this list.

Most of the proposed causes adopt a fairly narrow view of autism's origin. In what follows we see that taking a step backward to encompass a larger view resolves major questions about autism with a single hypothesis: Autism, at least in its less severe forms, is one result of adaptation to low population density at topologically inevitable and unrelenting sparse frontiers. The sparseness adaptation hypothesis does not account for all of autism, but it may account for much of it. The hypothesis forms a natural null hypothesis against which others can be tested.

The sparseness adaptation theory of autism makes testable predictions about measurable quantities: If those predictions are not born out then whatever confounds them is important in the history of brains.

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Autism

What is autism? So many varied traits are associated with this neurological condition that it is easy to become confused about what exactly defines it. Here is a list of some traits commonly associated with autism:

> Poor eye contact, monotone speech, odd gait, preoccupation with objects, preoccupation with parts of objects, echolalia, odd posture, clumsiness, preternatural physical skill, lack of empathy, extreme sensitivity to small sounds, extreme sensitivity to bright or flickering lights, not liking to be touched, lack of a theory of others' minds, lack of speech, precocious speech, talking like a little professor, social ineptitude, unusual ability to perform arithmetic or calendric computations, inappropriate interpersonal distance, liking of strict routine, blindness to social convention, inappropriate voice volume, rocking, head-banging, wrist-flapping, foot-tapping, intestinal disturbances, having frequent tantrums, lining up toys, etc.

Simple Internet search verifies and extends this list as well.

To see what does define autism we return to the original uses of the term and to the question of why the name *autism* was adopted in the first place.

Once autism had no name. It is useful to remember this when crafting a theory of autism because it underscores the obviousness of autism's central defining feature: *social disconnectedness.* The name *autism* derives from the Greek word *auto* for self, and proclaims the apparent mental involution or self-absorption of autistic people. Historically the word autism was invoked independently three times (by E. Bleuler,[3] L. Kanner,[8] and H. Asperger [1] respectively) to name clinical syndromes. In all three cases it was the startling social disconnectedness of the people described that prompted use of the term autism: The three founders clearly saw other features of autism as secondary to social disconnectedness.

Because social disconnectedness is the central, eponymous feature of autism it is the primary feature for which a theory of autism must account. A good theory of autism may also account for some secondary features. Indeed, some subsidiary facts of autism beg for explanation. As I write it is common to hear autism referred to as a mystery, and one surrounded by other mysteries, for example:
Why does autism —

- exist in the first place?
- affect more males than females? [1, 16]
- occur in so many varieties? [17]
- have a spectrum of intensities? [17]
- depend on so many different genes? [7]

Why are there autistic savants? [14]
Why is autism becoming more prominent? [18]
We shall see that the present reasoning addresses all of these questions and demystifies the origin of social disconnectedness in autism.

The Argument

The basic argument of the sparseness adaptation theory of autism is simple: Frontiers that are sparse by topological necessity constantly destroy socially adaptive genes, thus feeding social-gene-depleted genomes into the larger population and fostering autistic traits in the general population. As it stands this makes a pretty story, but there are many pretty stories. Rudyard Kipling's fanciful accounts of evolution in his renowned *Just So Stories* aptly demonstrate this.[9] Prettiness is no guarantee of validity: We want something solider than a *Just So* story.

A comment by Albert Einstein is famously paraphrased as, "An explanation should be as simple as possible, but no simpler."[4] I intend the following propositions to be almost incontrovertible, yet to be simple without being simplistic:

1. Brain parts need food to build, maintain, and use.
2. Some social abilities depend on particular brain parts that depend on particular genes.
3. Where food is sparse brain parts promote either food gathering or death.
4. The probability that social ability promotes food gathering declines with increasing sparseness of food and population.
5. Both food and population are sparse at topologically inevitable frontiers.

It follows that topologically inevitable frontiers constantly destroy genes conferring social ability, thus feeding social-gene-depleted genomes into more populous areas and fostering autistic traits in the general population.

The Argument Examined

Let's look at the propositions more closely.

1. Brain parts need food to build, maintain, and use. Without food no babies are born and no brains arise in the first place. Also, things fall apart and brain parts are no exception: Without food to maintain them brain parts decay like the rest of the body. Finally, per unit weight brains use ten times as much food energy as does the rest of the body. At every level brains and their parts — and indeed all parts of an organism — depend intimately on food for building blocks and energy.

2. Some social abilities depend on particular brain parts that depend on particular genes. People who have strokes often become abruptly acquainted with the previously unnoticed complexity of tasks like walking, speaking, and social relationship. All of these abilities depend on particular brain structures that in turn are shaped by particular genes. Stroke or other harm to particular brain parts can damage some social abilities while leaving other abilities unaffected, showing that the social abilities depend on particular brain parts.[5] Studies of identical twins separated at birth confirm that major features of personality are strongly shaped by genes.[13] Genes do not fully determine who we are. However, the present reasoning requires only that *some* genes are necessary to brain structures that are in turn necessary to *some* social behaviors.

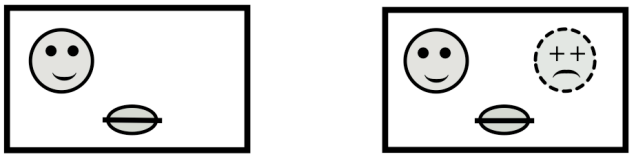
3. In sparse areas brain parts promote either food gathering or death. Where food is scarce brains must find food quickly or die. Given that all organism parts need food to build, maintain and use, any organism part that does not directly or indirectly promote the arrival of food acts as a drain on stored food reserves, and so hastens death. This applies to brain parts as it does to any other organism part.

The fourth proposition demands closer attention and we study its two parts separately.

4(a). The probability that social ability promotes food gathering declines with increasing sparseness of food. The harsh realities and social effects of scarce food at an extreme frontier are made clearer by a simple thought experiment.

The Sparse Box[ii]

Suppose that a hypothetical creature can survive on one food pellet a day, but not on less food. The creature lives in an impervious box and is fed its requisite one pellet per day so that all is well. Now suppose a second creature with identical needs is also put into the box. What happens? There is not food enough in the box for both of its inhabitants to survive. Only two outcomes are possible: Either one creature dies or both die. The only way life can persist in the sparse environment of the box is if one of the creatures prevents the other from eating. The one can do this in two ways: by grabbing food pellets more quickly than does the other or by slaying the other creature outright. Either way one creature kills the other. In the *Sparse Box* at least one creature *must* die, and compassionate behavior and camaraderie are exactly suicide.



Mobility is an essential trait in sparse regions because of the need to gather widely scattered food. Nevertheless human ancestors can move only so far in a given time and hence a sufficiently large sparse area is like a box to them: Once any carried food runs out they must find food within a short distance or perish. The limited range acts like the walls of a box and the inhabitants are forced into deadly competition for the few resources there. **Where there is food enough for one but not two no strategy can reliably transmit cooperative genes, but the genes of the deadliest competitor endure.**

When we speak of great social ability usually we mean an ability to relate socially to people regardless of who exactly they are: It is a *generic* ability. Somewhere near the opposite extreme of social ability is a tendency to indiscriminate murder: It is not socially adept to kill everyone one encounters. In the *Sparse Box* a creature that actively slays its neighbor guarantees its food supply with far greater certainty than does one that must

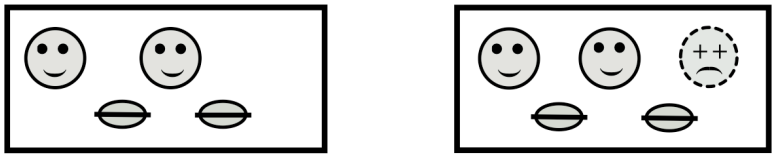
[ii] This is a *thought* experiment. Do not perform it on living creatures.

attend to grabbing every particle of food first. In fact, if the amount of food put in the box dips for a day below the amount needed to support even one creature, then life persists there only if one creature both slays and eats any neighbor. In other words, where food is sparsest active killers and cannibals prevail. Far from having anything like generic social ability, the outermost members of a population are much more likely to be predisposed to the *anti*social act of murder.

Murder is an extreme. Genes for indiscriminate murder could not survive long because the mates necessary for procreation would be killed. What *can* survive in sparse conditions are genes fostering deadly competition and callous disregard of others. Even in the absence of flat-out murder generic sociability in extreme sparseness remains fatal.

It is easy to see that social ability is a liability in an extremely sparse area. One wonders though whether social ability might be useful for food gathering in the region immediately within the desolate frontier. After all, at *some* population density cooperative behavior becomes enough of a norm that it can sustain crowds. Revisiting the *Sparse Box* shows that social ability is not as useful to a denizen of the near frontier as one might imagine:

Suppose that *two* creatures live in an impervious box and are fed the requisite two pellets per day so that again all is well. When a third creature is introduced with no additional food, however, once again at least one must die.



Obviously the original two treat a newcomer as a potential teammate at the risk of their own lives. *Any* group living at subsistence level near a frontier, and that hopes to survive intact with its genes, must treat newcomers as deadly rivals for food. Where only n can survive the n+1st is a mortal foe. Thus even near an extreme frontier genes fostering generic sociability are a liability to a group living at subsistence level. Competition does become less fierce as the sustainable number increases: If an interloper survives where exactly n tribe members can and do live, then the odds are only 1/n that any one of the original tribe will die, whereas if the interloper survives where before only one could live then that one is dead.

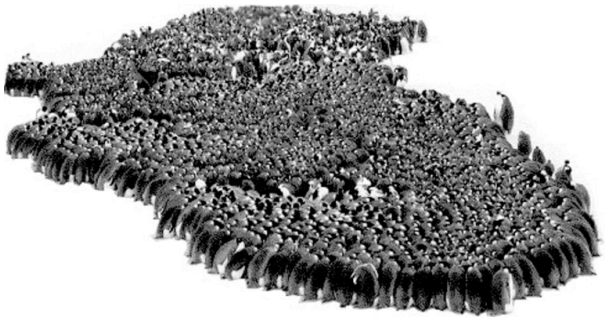
It bears noting that even if an unused or uncompetitive gene for sociability results in only a one percent decline in reproductive success in a given generation the prevalence of that gene will drop to one percent of its initial value in fewer than ten thousand years, which is not a terribly long time in the ancient history of brains.

4(b). The probability that social ability promotes food gathering declines with increasing sparseness of population. In the absence of modern technology most social abilities depend on nearby neighbors to be of any use. An ingratiating manner and easy way with words won't feed anyone marooned like Alexander Selkirk (the model for *Robinson Crusoe*).[11] At the extreme of population sparseness social ability and any brain structures dedicated to it do not bring food. This is not a matter of there being too little food: It's a matter of there being no one around to cooperate *with,* and so having to survive alone where social abilities (with underlying brain parts and genes) are simply a drain on resources.

The food-gathering value of most social abilities declines with interpersonal distance because two creatures have to be within hailing distance of each other to form, and in many cases to execute, a joint food-gathering plan. The odds of a social plan succeeding decline with distance to neighbor. If creatures near a frontier spread out uniformly then social abilities that depend on a nearby neighbor — which is to say most social abilities — are useless.

What if, however, creatures near a frontier don't spread out but travel in a *phalanx*, the ancient formation of densely packed soldiers moving in tandem? Surely, it seems, social ability is needed in the sweaty confines of a phalanx. Note, however, that near a frontier there are by definition few groups of any kind so the probability that *inter-group* social ability promotes food procurement declines with increasing sparseness. Whatever social ability is needed in a phalanx, **the ability to relate cooperatively to people *outside* of one's own small group is a social ability,** and this ability is a useless *li*ability in the near-frontier.

In fact one sees very few phalanxes in sparse areas both because scarce food cannot support many or large groups and because a phalanx is an inefficient means to track down sparse food. The reality is that human ancestors near a frontier must have lived in small bands relatively removed from other bands, and many band members must have spent significant time essentially alone in the wilderness where social ability was both useless and a deadly drain on resources.



Not every crowd is a phalanx and not every desolate place is fully sparse:
This penguin rookery does not move about and food teems in nearby Antarctic waters.[5]

A genome reflects a statistical composite of its environmental history. The more time a type of organism spends in a particular environment the more genes ill-suited to that environment are culled from its genome. Because of this **sparseness marks a population's genome even if all members constantly circulate between sparse and crowded areas.** In any case the minute a social gene moves into an area where it does not contribute to its own self-sustenance the axe of probability begins to fall on that gene: It is draining the host's resources and increasing the likelihood of the host's and its own demise. So it is with genes in ancient frontier bands.

Finally, even if teamwork does aid survival near a frontier any social bonds there are likely to be ambivalent because food levels can fluctuate unpredictably and the slightest dip in food levels turns a teammate into a deadly competitor for the remaining food.

The resounding conclusion of the forgoing reasoning is that both at and near frontiers genes favoring generic social ability are a drain on resources and an invitation to death at the hands of competitors.

We now turn to the final proposition of the argument.

5. Both food and population are sparse at topologically inevitable frontiers. This is the engine that drives the sparseness adaptation theory. From the simple fact that food and populations do not exist everywhere it follows that there exist frontiers that are sparse in both food and population. (If there is a crowd in one place and empty space in another then somewhere in between is a frontier where population is relatively sparse.) This is like having an x-ray into all past history. Without having been present we know that human ancestor populations were constantly exposed to the effects of sparse surrounding frontiers. That is why the sparseness adaptations are expected to be genetic and not only learned. It is also the practical certainty of the fact that sets the sparseness adaptation theory of autism apart from pretty *Just So* stories.

Conclusions

The logic of the five propositions is this: Social abilities depend in part on brain parts; brain parts depend in part on genes; and the lot depends on food. At inevitable sparse frontiers social abilities do not bring in food, thus lethally draining resources, and they interfere with fierce competition, so effectively courting suicide. Therefore at (and near) frontiers brains with diminished social ability thrive.

It is important to note that social ability is complex and doubtless influenced by many genes. The sparseness adaptation argument does not say exactly *which* social genes will be lost in sparseness, only *that* some social genes will be lost.

The portrait given here of life at an extreme frontier is stark but accurate. As one moves inward from the extreme, however, various influences soften the picture. Seasons change, bands migrate, gene pools mix, social and technological innovations arise, and so on. In moderate sparseness competition can take the more moderate form of gathering resources

exclusively to an individual or group, to the detriment of others. Genes promoting *simple disregard* of others are favored even where outright killing is not. There is no escaping the fact, however, that increasing sparseness selects for increasingly competitive and socially disconnected genes.

Surviving frontier organisms occasionally transmit their sparseness-adapted genes to non-frontier organisms, and in this way asocial genes make their way into crowded areas. There the axe does not fall on the genes immediately because food is more plentiful and competition less fierce. **The social disconnection expected from the inward-moving sparseness-adapted genes is the defining characteristic of autism.**

A syndrome is a set of correlated traits. The listed propositions and *Sparse Box* thought experiments show that adaptation to frontier sparseness produces a set of correlated traits. Compared to brains with long histories in lush and crowded areas, sparseness-adapted brains are:

1. Socially disconnected
2. Competitive, and
3. Mobile.

These are basic traits of the **Sparseness Adaptation Syndrome**.

One of the great attractions of the sparseness adaptation theory is that it neatly addresses the major questions about autism given earlier.

Addressing the Mysteries

Why does autism exist in the first place? We have noted that the primary defining characteristic of autism is social disconnectedness. The sparseness-adapted outlier is by heritable necessity more socially disconnected, i.e., less a generic social bonder, than a cousin from a lush and crowded place. **Generic sociability declines with increasing sparseness, and the extreme absence of generic sociability is autism.**

If social ability depends on brain structures then any damage to those structures can lessen social ability. As a result social disconnectedness, and autism, can have many causes. However, few if any other causes are as unrelenting as the sparseness of population surfaces and voids, or cause atrophy *specifically of social structures* while sparing others. When social disconnectedness is part of a general cognitive deficit it is probably more descriptive to call the condition a general cognitive deficit than to call it autism.

Autism that is adaptive is rarely noticed, precisely because it *is* adaptive: It takes a mismatch between brain and environment to bring autism to notice. However, autistic genes diffusing from the population frontier can combine in ways that are poorly adapted in any circumstance. This may account for some of the more noticeable forms of autism.

Why does autism have a spectrum of intensities? This is because population and food resources exist in a spectrum of densities ranging from sparse to lush and crowded. There are genes and gene combinations well adapted to every zone in the density spectrum.

Why does autism occur in so many varieties? The constraint that produces autism is global*:* It does not specify exactly *how* social ability will atrophy — only *that* it will atrophy. Social ability is complex and it can atrophy in many ways. It follows that autism will occur in many varieties. This is important because it shows that a search for an "autism gene" — or even only a few such genes — almost certainly is futile. Furthermore, **because of its spectrum and variety autism will always defy clear diagnosis.**

Why does autism depend on so many different genes? This is because social ability depends on so many different genes: It is the varied loss of these genes that manifests as autism.

Why are there autistic savants? In sparseness an organism has little use for generic social ability, but it has plenty of use for ability with objects and edible or dangerous organisms. Most autistic savant abilities have little to do with social bonding but some have potential value in a world of objects and alien organisms. It is likely that with increasing sparseness some brain social structures become "re-purposed" to more object-related uses, similar to what evidently happened when the legs of ancient hippopotami found new use as the fins of whales.[3,5] From the point of view of a hippopotamus a whale is a disabled hippopotamus but a swimming savant.

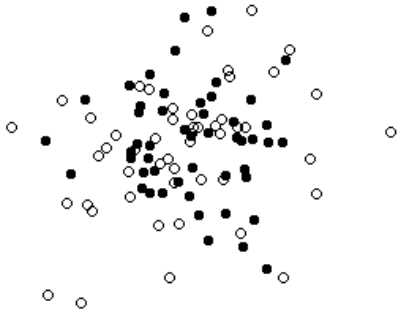
Savant abilities suggest a second and likely important origin of autism: Brains may, like computers, belong to a class of systems whose capacities are limited by finite bandwidth and storage capacity. If so then at a frontier social ability is like a computer program that steals memory and processor speed, thereby degrading brain performance on other tasks. In other words great social ability in a sparse area not only drains stored food reserves, it may also drain brain *computational* resources needed for non-social purposes like tool-building and game tracking. This would compound the destruction of social genes in sparse areas and also favor genes that re-purpose social brain structures to non-social uses.

Why is autism more prevalent in males than in females? To address this question consider the following thought experiment:

Suppose 100 identical things are dumped in a tight pile on a landscape. Suppose also that all of the things are identically inclined to move about randomly like tiny staggering drunkards. What happens? They all stagger about bumping into obstacles and each other, and the heap slowly spreads outward on the land. By sheer randomness some stagger to the margins and some stagger about near the starting point, while others travel outward and back again, and so on.

Now suppose, however, that starting at the outset half of the initial 100 things are periodically weighted as in a handicap horse race so that they cannot travel as fast. What happens then? What happens is that most of the things in the sparsest regions are the *un*burdened things, because they travel faster and so tend to move about and outward faster. The overall average distance-to-neighbor for the unburdened group will be larger

than that for the burdened. As a result **the unburdened group must be on average more sparseness-adapted, hence more autistic, than the burdened group.**



In this simulation some of the burdened (solid-colored) entities are present at the frontier, but they are in a minority there.

Half of the human ancestral line has been periodically burdened. We call the delightful burdens *babies* and they have encumbered countless generations of females during pregnancy and nursing. The physical origins of this arrangement are beyond the present scope. It suffices that in the human line **males have collectively spent far more time at greater distance from neighbors than have females** and so carry more sparseness-adaptive genes than do females. **This makes autism more prevalent in males than in females.** This brings us to the final listed mystery.

Why is autism becoming more prominent? Two explosions have occurred on Earth in the past ten thousand years: The explosion of human technology, and the resulting explosion of human population. Where each human stood several millennia ago there now stand hundreds.[10] There may be many reasons that autism is becoming more prominent, but one of them is that sparseness adaptations that accumulated over many thousands and even millions of years now have far less sparseness in which to be adapted, and adaptations with a long history are slow to disappear. As mentioned earlier, it takes a mismatch between brain and environment to bring autism to notice. **Autism is becoming more prominent because there is less sparseness to which the brain structures of autism are adapted, and burgeoning crowds expose the social limits of autistic people.** This explanation is doubtless incomplete but perhaps germane.

The specific implications of the sparseness adaptation theory of autism suggest a further question:

Given that a tendency to kill is sparseness-adaptive why is violence not a more prominent feature of classical autism? This is an excellent question, and several answers suggest themselves. One possibility is that autistic violence is heavily driven by actual food sparseness, so that it is not seen in well-fed populations. A second possibility is that the very sparseness that selects for killing also selects for killing by means that use little food energy — in other words indirect forms of violence. Beating rivals to food in a sparse box is a simple example of this and behaviors like it do not necessarily appear violent. A third possibility is that violent forms of autism do exist but are artificially separated from

the less violent forms, like separating people who are tall and plump from those who are merely tall even though both have similar foundational structures (skeletons).

A similar question could be asked about the absence of great competitiveness from the classical picture of autism, with similar possible answers. A fourth possible answer, however, is that sparseness adaptation defines a *fourth* class of autism overlapping but distinct from the classes defined by Bleuler, Kanner and Asperger: The expected traits of the Sparseness Adaptation Syndrome — including social disconnectedness, fierce or deadly competitiveness, and the ability and tendency to move about — define **Sparseness-Adaptive Autism**.

Whether or not it defines a new class of autism it highly unusual for a single simple hypothesis to squarely address so many basic questions about the condition, and this suggests that existing classes of autism are at least strongly shaped by sparseness adaptation. The sparseness adaptation hypothesis forms a natural null hypothesis against which others can be tested.

A further attraction of the sparseness adaptation hypothesis is that it yields testable predictions, the darlings of rigorous science. This section is necessarily more technical in order to establish that the present theory is more than a *Just So* story.

The Hard Science of Prediction

A rigorous scientific theory makes testable predictions about measurable quantities. The present sparseness adaptation theory of autism has its roots in measurable quantities like distance to neighbor, organism and population persistence times, population densities, genetic composition and details of environment and brain structure. These quantities can be measured in different ways, but overall the theory makes the following predictions:

• **Autism-associated genes are more prevalent in lineages with long histories in sparse areas.**
• Autism is more prevalent in males: The observed gender difference is not a bias artifact.
• Autistic people and men spend more time at greater distance from neighbors than is average.
• Autism is pervasively polygenic.
• Autism correlates with distinct brain structures, but these exist in great variety.
• Brain scans will show that brain parts activated by social tasks in most neurotypical people are activated by non-social tasks in some autistic people.
• Maladaptive autism often results from or is compounded by a *concentration* of relatively common sparseness-adaptive genes.
• Language in sparse areas differs radically from that in lush areas and disproportionately concerns objects, techniques and strategies of rapid food acquisition, and subduing competitors. Sparseness also favors language that conserves time and energy.
• Autism correlates with an ability to hunt animals and survive alone in wilderness (this likely seen more clearly in relatives).
• Autism is a feature of brain history in all extraterrestrial biospheres.
• Density gradients are not restricted to human populations and so corresponding trait gradients will be observed in many if not all species. To the extent that they are *not* this gives valuable clues to gradient moderation and secondary effects in humans.

There are many other predictions and the ones given can expand into more technically detailed predictions. The lineage history predictions will become testable as gene sequencing becomes more common. Significantly, gene sequencing should make it possible to construct accurate histories of gene flows and mixing in populations, thereby establishing how strongly stirring effects influenced sparseness adaptation. Random proximity and communication measurements — e.g. checking how far autistic and non-autistic people (or men and women) are from neighbors at random moments — can begin to test the behavioral predictions. Some predicted correlations will be more clearly observable in *relatives* of very autistic people because extreme autism can be disabling in ways that lead to confounding compensations imposed by neighbors.

As complex as life is, it is much harder to fashion strongly predictive theories in the realm of biology than it is in, say, atomic physics. By the standards of biological theory, then, the sparseness adaptation theory of autism is remarkably predictive, particularly when compared to pretty and beguiling *Just So* stories.

In Sum

That then is the gist of the theory that a Sparseness Adaptation Syndrome gives rise to autism. To deny the conclusion is to deny at least one of the five propositions leading to it. In constructing counterarguments it is not enough to show that there are moderating influences: That is obvious from the existence of crowds. A proper counterargument must show either that unrelenting sparse frontiers leave no genetic trace or that such traces cannot underlie even in part a syndrome of social disconnectedness.

Doubtless there are flaws in this essay's reasoning, and it does not pretend to account for all of autism. However, if something even remotely *like* the story happened in the history of human brains, the result would be that autism- or autism-like genes diffused from sparse areas into the larger human gene pool, bringing with them something very like what we know today as autism.

NOTE

The sparseness adaptation hypothesis does not support the view that any group of brains is globally superior to others, and any attempt to distort the reasoning to that end is an abuse of the hypothesis and associated theory.

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