This article was originally published with the title On the Trail of the Orchid Child.

On the Trail of the Orchid Child

One genetic variant leads to the best and worst outcomes in kids

By Wray Herbert

Scientific papers tend to be loaded with statistics and jargon, so it is always a delightful surprise to stumble on a nugget of poetry in an otherwise technical report. So it was with a 2005 paper in the journal*Development and Psychopathology*, drily entitled "Biological Sensitivity to Context," which looked at kids' susceptibility to their family environment. The authors of the research paper, human development specialists Bruce J. Ellis of the University of Arizona and W. Thomas Boyce of the University of California, Berkeley, borrowed a Swedish idiom to name a startling new concept in genetics and child development: *orkidebarn*.

Orkidebarn means "orchid child," and it stands in contrast to *maskrosbarn*, or "dandelion child." As **Ellis and Boyce** explained in their paper, **dandelion children seem to have**

the capacity to survive—even thrive—in whatever circumstances they encounter. They are psychologically resilient. Orchid children, in contrast, are highly sensitive to their environment, especially to the quality of parenting they receive. If neglected, orchid children promptly wither—but if they are nurtured, they not only survive but flourish. In the authors' poetic language, **an orchid child becomes "a flower of unusual delicacy and beauty."**

Sensitive Souls

Inside the small world of scientists who study **genetics** and **child development**, the notion of the orchid child was stunning. The idea of resilient children was hardly new, nor was the related idea that some kids are especially vulnerable to the stresses of their world. What was novel was the idea **that some of the vulnerable, highly reactive children—the orchid children—had the capacity for both withering and thriving**. **They appeared to be extremely sensitive to home and family life, for better or worse.** Is it possible, scientists wondered, that **genes underlie this double-edged childhood sensitivity?**

Ellis and Boyce's paper launched a **search both for those genes and for the risk pathways** that might lead to bad outcomes such as delinquency, substance abuse and mental illness. Most of the work initially focused on the genes that

behavioral geneticists call the "usual suspects"—and it paid off. **Studies soon showed that genes linked to particular enzymes or brain chemical receptors, if combined with family stress or maltreatment, can lead to a slew of behavioral problems or mood disorders. These links have now been verified again and again, and scientists are searching for additional genes that might play a role in this exquisite childhood sensitivity.**

But where to look? If one is looking for **genes that might be linked to unhappy lives**, the **genetics of heavy drinking** is a place to start. That was the reasoning of behavioral geneticist **Danielle M. Dick of Virginia Commonwealth University**, who, with 13 other scientists from around the world, has been exploring a gene called ***CHRM2*.** *CHRM2* has already been **implicated in alcohol dependence**, which is in the same **group of disruptive behaviors as childhood conduct disorders and antisocial behavior.** What's more, the gene codes for a **chemical receptor involved in many brain functions**, such as learning and memory, so the gene might also be involved in behavioral disorders. Dick and her colleagues recently decided to test the idea.

The team of researchers took DNA samples from a group of more than 400 boys and girls who have been part of a larger child development study since before kindergarten and analyzed **variations in their *CHRM2* gene**. These kids did not have

behavioral problems at the start; they were a representative sample from communities in three U.S. cities. The youngsters have been studied every year since kindergarten, and they were around age 17 at the time of this new study. The scientists collected information on the **teenagers' misbehavior—delinquency, aggression, drug abuse,** and so on—from both the mothers and the kids themselves. They also **asked the teens how much their parents knew about their lives**—such as their whereabouts, who they hung out with, what they did with their time, and how they spent their money. They wanted to get a general idea of how closely these kids were monitored by their parents in their daily comings and goings as a way of measuring parental nurturing, indifference or neglect.

Withering or Thriving

As reported in the **April *Psychological Science***, the genetic and behavioral data are consistent with the **orchid child model of susceptibility.** That is, **certain variations in the children's *CHRM2* gene appear to interact with parental negligence to produce the most undesirable teenage behavior.** But the nature of that interaction is what is most important: **the genetic variant that combined with lousy parenting to produce the worst aggression and delinquency also combined with the most attentive parenting to produce the *best* teenage outcomes.** Put another way, **the kids who ran the highest risk of**

developing bad behaviors in bad homes were least likely to struggle when living in healthy, nurturing homes.

Although the scientists studied **parental monitoring or awareness**, this measure is most likely a proxy for a teenager's environment more generally. That is, adolescents **who scored low on parental involvement are probably more likely to live in unsafe neighborhoods and to hang out with friends who tend to get into trouble.** Some kids—the dandelion children—might do okay in such a world, but these stresses may be enough to tank the genetically sensitive orchid children.

If ***CHRM2* does turn out to be an orchid child gene**, some earlier findings might now begin to make sense. For example, the gene has also been linked to serious depression in some studies and to cognitive ability in others. But the gene does not appear to code for these outcomes directly, nor do all these outcomes necessarily show up in all genetically at-risk teenagers. Indeed, *CHRM2* may not be a gene "for" anything—other than the tendency to follow life's fortunes or misfortunes.

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Orchids and Dandelions: The Emerging Science of Emotional Sensitivity

by Michael A. Jawer

Anyone who is highly sensitive must often wonder, *Why am I the way I am?* Is it nature, nurture, or both? A number of recent scientific findings and popular theories indicate that the answer is undeniably both.

A **British study** from the **University of Essex** shows how an important **genetic variant** makes some people more sensitive than others to their **emotional environment**—and thus **more susceptible to anxiety disorders.**[1] This research focused on the **serotonin transporter gene.** Serotonin itself is a neurotransporter, a chemical released into the gap between nerve cells. The serotonin transporter is a protein that plays an important part in that cross-nerve signaling. Once a signal has crossed from one nerve cell to another, the serotonin transporter removes serotonin from the gap and transports it back into the initial nerve cell, where it can be reused for the next signal.

The gene that encodes the serotonin transporter varies across the human population. Some people carry a **"short" version of the gene**, which means they have fewer copies of the serotonin transporter and therefore higher concentrations of serotonin in the gaps between neurons. Other people have a **"long" version of the gene**, which leads to more copies of the serotonin transporter and lower levels of serotonin in the cross-neuron gaps. Previous studies found that people with a short version of the gene tend to pay more attention to negative or potentially threatening information. This negative bias is characteristic of many anxiety disorders, such as depression, post-traumatic stress disorder, and irritable bowel syndrome.

Remarkably, the University of Essex team found that **people with the short version of the serotonin transporter gene were not only more sensitive to negative information but also to positive information.** According to the lead researcher, **Dr. Elaine Fox,** such people "are likely to

be far more reactive to both very negative situations, such as a car crash, and very positive ones, such as a very supportive relationship." The short version of the gene, Fox says, can be viewed as *providing enhanced adaptability as well as greater vulnerability in the first place.* In contrast, people with the long version of the gene are likely to be less influenced by negative stimuli but also less able to benefit from a highly positive emotional environment—since their reactivity in the different experimental conditions barely changed.[2]

Orchids and Dandelions

The serotonin transporter gene—and others like them—can be characterized as an ***orchid gene*****,** like the flower whose bloom is spectacular but requires great care to cultivate. If the environment is supportive, a person with orchid genes will probably thrive and possibly succeed in spectacular ways. But if neglected or subjected to negative emotional input, such a person may develop any of the anxiety disorders and wilt (to stay with the flower analogy). Those who are more resistant to the vicissitudes of life and aren't quite so subject to the relative quality of their nurturance are *dandelions*. They are more numerous and more hardy.

The orchid-dandelion hypothesis has been expressed principally by University of Arizona development psychologist **Bruce Ellis and University of British Columbia developmental pediatrician W. Thomas Boyce** and has been presented in a more popular vein by author **David Dobbs.[3]** People who are orchids, they point out, have a heightened genetic sensitivity to ***all*** **experience**, but their **environment plays an equally important role.** They call this ***biological sensitivity to context.*** Although orchids are more susceptible to stress and tumult, whether they go on to develop various health conditions ultimately depends upon their emotional environment.

Incidentally, humans aren't the only species with variations in reactivity among individuals. The same has been found in mice. The ones who seem most vulnerable to stress are also more likely to fall ill.[4] This variability may eventually be disclosed as a feature of all mammals.

Just as the divide between mind and body is disappearing—thanks to all manner of discoveries in the field of psychoneuroimmunology (the discipline that studies connections between the nervous, immune, and endocrine systems)—so too, clear and fast distinctions between nature and nurture are on the way out. The latest findings indicate that environmental stimuli can be as deterministic as genes were once believed to be and that the genome can be as malleable as only environments were believed to be. To discriminate between nature and nurture in this way seems as futile as asking which feature of a rectangle—length or width—makes the most important contribution to its area.[5]

The **University of Essex** findings are important in many ways. First, we can discern a mechanism behind some people's pronounced sensitivity. Second, we can see how off base the "nature versus nurture" debate is (or was). Third, there are significant implications for personal health. Quoting Dr. Fox again, the lead researcher: "This opens the door to the idea of personalized treatments for anxiety disorders. Information about the genotype... of a patient could be used to inform decisions about which treatments... are likely to be most effective."[6]

The prospects are actually more intriguing and potentially more useful than that. All we need do is consider a particular framework for sizing up this most salient distinction between people—that is, how much "gets" to them and how they handle it. This framework, known as boundaries, opens the door to a whole different way of viewing health care and assessing both individuals' vulnerabilities and the treatments most likely to help them.

The Boundaries Concept

Because we are bound within our bodies, we are enabled to have distinct minds and personalities. The "boundaries concept," developed by Ernest Hartmann, MD, of Tufts University, is an especially useful way of looking at personality differences and understanding why one person may develop a chronic illness that is distinctly different from another.

Boundaries are more than a measure of introversion or extroversion, openness or closed-mindedness, agreeableness or hostility, or any

other personality trait. Boundaries are a way to assess the characteristic way individuals view themselves and the way they operate in the world based on how they handle the energy of feelings. To what extent are stimuli "let in" or "kept out"? How are a person's feelings processed internally? Boundaries are a fresh and unique way of evaluating how we function.

According to Hartmann, each of us can be characterized on a **spectrum of boundaries from "thick" to "thin." In his words:**

> There are people who strike us as very solid and well organized; they keep everything in its place. They are well defended. They seem rigid, even armored; we sometimes speak of them as ***"thick-skinned."*** Such people, in my view, have **very thick boundaries**. At the other extreme are people who are especially sensitive, open, or vulnerable. In their minds, things are relatively fluid... Such people have particularly thin boundaries... I propose thick and thin boundaries as a broad way of looking at individual differences.[7]

Hartmann first came to his conception in an interesting way. In the 1980s, he was studying people who have nightmares and noticed that they could also readily recall vivid or colorful dreams that didn't qualify as nightmares. These people seemed to him especially "sensitive," "vulnerable," or "imaginative," in contrast with other people who came across as more "stolid," "stoic," or "persevering." He suspected real brain and body differences between thin- and thick-boundary people, and he developed a questionnaire to gain more insight.

Since the 1980s, at least five thousand people have taken Hartmann's Boundary Questionnaire (BQ) and more than one hundred published papers have referenced it. Scores on the BQ are distributed across the spectrum of boundaries in a bell-shaped curve. Women tend to score significantly thinner than men, and older people tend to score somewhat thicker than younger people.[8]

Thick and Thin Boundaries

The accumulated evidence shows that thin-boundary people are highly sensitive in a variety of ways and from an early age:

- They react more strongly than do other individuals to sensory stimuli and can become agitated by bright lights; loud sounds; particular aromas, tastes, or textures.
- They respond more strongly to physical and emotional pain in themselves as well as in others.
- They can become stressed or fatigued by an overload of sensory or emotional input.
- They are more allergic, and their immune systems are seemingly more reactive.
- They were more deeply affected or recall being more deeply affected by events during childhood.

In a nutshell, highly thin-boundary people are like walking antennae, whose entire bodies and brains seem primed to notice what's going on in their environment and to understand more precisely what it means.[9]

Thick-boundary people, on the other hand, are fairly described as stolid, rigid, implacable, or thick-skinned:

- They tend to brush aside emotional upset in favor of simply "handling" the situation and maintaining a calm demeanor.
- In practice, they suppress or deny strong feelings. They may experience an ongoing sense of ennui, of emptiness and detachment.
- Experiments show, however, that thick-boundary people *don't actually feel their feelings any less.*Bodily indicators (such as heart rate, blood pressure, blood flow, hand temperature, and muscle tension) betray their considerable agitation despite surface claims of being unruffled.[10]

In sum, highly thick-boundary people don't take in nearly as much in their environment and are much slower to recognize what they're feeling. However, they are affected by what's happening within them just as much as thin-boundary people.

Parallel Approaches

Several other researchers have traversed similar territory over the last two decades. Psychologist **Elaine Aron** has illuminated various facets of what she calls the "highly sensitive person" or **HSP.**[11] Harvard professors **Jerome Kagan and Nancy Snidman have studied the differences between "high reactive" and "low reactive" individuals.**[12] Educator **Mary Sheedy Kurcinka** has profiled what she terms the "spirited child" (one who exhibits high energy as well as sensitivity).[13] Researchers **Sheryl Wilson and Theodore Barber** have profiled the "fantasy prone" person.[14] **Psychologist Sharon Heller** has examined what makes someone "sensory defensive," and physicians **James J. Lynch and Gabor Maté have chronicled "Type C"** people, those who seem unwilling or unable to acknowledge their feelings.[15]

Researcher **Susan Cain'**s book on introversion has grabbed popular attention. In *Quiet: The Power of Introverts in a World That Can't Stop Talking,* she draws an important distinction between shyness and introversion: shyness is the fear of social judgment, whereas introversion is "really a preference for less stimulation."[16] This interpretation is consistent with what Elaine Aron has found, that high sensitivity is not the same thing as shyness. Indeed, approximately 30 percent of highly sensitive people are gregarious. But, as they still tend toward being careful and deep thinkers, highly reactive, and easily overstimulated, they need much more downtime than do extroverts to recover.[17]

Value of Knowing Your Boundary Type

All of these conceptions are helpful, and all point to the same basic kind of person, the orchid, someone who can thrive or wilt based on the quality of her or his emotional environment. Hartmann's boundary concept goes to the heart of what actually drives the formation of that particular personality. In a word, it's *stimulation*—what kind (positive or negative), how much (not enough, just right, too much), and most important, how the person *handles* stimulation (acts as if it's not happening, reacts immediately, stores it away for future rumination). The person's boundary type—thick or thin or any degree in between—mediates with the outside world and the internal world of feeling.

That flow, that characteristic style of processing emotional stimuli, has a direct bearing on what kind of illnesses a person will experience. At the beginning of this article, we noted that highly sensitive (thin-boundary) people are especially susceptible to anxiety disorders. This class of chronic illnesses can be seen to reflect a “hyper” style of feeling. Similarly, highly thick-boundary people, who aren’t nearly so sensitive to environmental changes, are much slower to recognize what they’re feeling, so it stands to reason that they would manifest different forms of chronic illness. According to our research, ulcer, hypertension, and phantom pain are examples of thick-boundary conditions.[18]

The implications are quite remarkable. Based on where you fall on the boundary spectrum, you’ll have a sense for what forms of chronic illness you’re most susceptible to. And you don’t need a genetic workup to determine boundary type. All you need is Hartmann’s Boundary Questionnaire—of which there is an 18-question short form. The benefits of knowing your boundary type don’t stop there. Since specific forms of complementary and alternative medicine (CAM) are known to alleviate the symptoms of particular kinds of chronic illness, you could conceivably develop a “menu” of therapies that would be most appropriate for the chronic condition you are susceptible to or have. This brings the concept of “personalized medicine” down to earth, making it more immediately accessible than any genotype assessment could be.

Chronic Illness Is Different from Disease

It’s important to realize that the health conditions mentioned above are distinct from *diseases*. A disease is an illness (even a run-of-the-mill illness such as a cold) that is not conditioned by personality type and the way a person registers feelings. Anyone can catch a cold, and everyone wants to get rid of it. The most serious diseases—such as AIDS, leukemia, smallpox, malaria, cancer—are something our bodies fight precisely because they are alien and threaten our survival.

In contrast, science is showing that a variety of chronic conditions are more directly related to our thoughts and feelings.[19] Rooted in our emotional biology, these types of illness include the following:

- allergies
- asthma
- chronic fatigue syndrome
- depression
- fibromyalgia
- hypertension
- irritable bowel syndrome
- migraine headache
- post-traumatic stress disorder
- rheumatoid arthritis
- skin conditions (such as eczema and psoriasis)
- ulcer

These conditions—call them the Dozen Discomforts—are far more constitutional than a disease. They affect a person, yes, but they are also *of* the person. They are rooted in how we handle stimuli, the most important kind being emotional, and they won't be resolved through standard medical interventions, such as drugs and radiation, for the simple reason that they are not really "alien" to us.

Allopathic medicine, which fundamentally views sickness as originating *outside* the person, fails in many cases to successfully treat chronic pain and illness. However, CAM can often do so, because complementary and alternative approaches are *psychosomatic* in the literal (and appropriate) sense of the term.They address the whole person: the emotional/mental (psyche) as well as the physical (soma). Distinct from conventional practices that treat a given symptom or set of symptoms, CAM treatments proceed from a holistic perspective that considers the entire patient—mind and body.

CAM Treatments: Complimentary Alternative Med.

There are, of course, many CAM therapies, but seven of them stand out by virtue of being well established, safe, and effective. Indeed, based on our analysis of boundary type matched against CAM therapy type (a true first), the relative merits of these seven become clear.[20] The Super Seven are

- acupuncture

- biofeedback
- guided imagery
- hypnosis
- meditation
- relaxation/stress reduction
- yoga

These therapeutic approaches have been extensively studied over many years. They are not “off the wall” or in an early stage of development. They have helped millions of people already and saved them a substantial amount of money in the process. I am not arguing against conventional medicine, but I *am* advocating sound, safe, cost-effective treatments that have a reasonable chance of improving your health based on your boundary type.

Progress in Science and Health

Medical science is making huge strides in discerning how closely connected nature and nurture are in shaping individual personality. Likewise, there is more evidence than ever before that mind and body are not separate but more appropriately viewed as two sides of the same coin. Emotion seems to underlie all of this—since, clearly, feelings go on inside of us but are inevitably linked to what goes on outside too (what people say to us, how well or poorly we’re treated, what shifts or changes we’re subjected to).

Science is also coming to realize that everyone is different. Some people are thin-boundary—orchids, high reactors, HSPs, call them what you will. Thick-boundary types, on the other hand, are more staunch and perhaps more resilient, but everyone is affected in her or his own way by emotional ups and downs. Some of us may be more “in touch” with what we’re feeling at any moment, others less, but all of us are feeling something all the time (or we wouldn’t be alive).

Hartmann’s boundary concept provides a truly useful framework to capture this most salient personality difference and relate it to health. Despite the fact that conventional medicine is moving toward a model of personalized medicine that relies on genetic testing, the short-form Boundary

Questionnaire (BQ) offers unprecedented insight into who you are and the sorts of illnesses you may be prone to. [Take the BQhere; it typically requires less than ten minutes to complete and score.] Furthermore, a range of cost-effective CAM therapies has now been evaluated against boundary type, so a menu exists that allows you to select the treatments most likely to benefit *you.*

Information on Jawer and Marc Micozzi's new book, *Your Emotional Type: Key to the Therapies That Will Work for You* (Healing Arts Press, 2011), can be found at www.youremotionaltype.com. Information about their previous work together is at www.emotiongateway.com.

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Orchids and Dandelions Abloom – Best of Neuron Culture, #10

- BY DAVID DOBBS06.08.138:00 AM

Below find #10 in my Best of Neuron Culture Moving Party here at Wired — the final of run of 10 of my favorite posts from the blog's stay here, posted on the eve of my departure to more homegrown pastures at my own site. (Details on my move are at bottom of the first post in this series). This piece, originally posted in May 2012, visits the topic of the book I am now writing, working title **The Orchid and the Dandelion***, which explores how genes, experience, and culture shape temperament — and, in particular, the idea — the orchid hypothesis — that some of the genes and traits that underlie our greatest foibles and miseries also help generate our finest strengths and pleasures. (For a deeper exploration of this subject, see my feature about it in The Atlantic.) The book will be published by Crown just as fast as I can finish it in a way that does it justice.*

Finally: As noted below, this is my last post at the WIRED iteration of Neuron Culture. But Neuron Culture. five years old now and running, will live on at a new home. Please drop by.

Can Genes Send You High or Low? The Orchid Hypothesis A-bloom

by David Dobbs

Originally posted March 2012

A few years ago, Arial Knafo, a psychologist at Jerusalem University, wanted to see if three-year-olds would share their bonbons. Snack time would come amid a bunch of other activity at Knafo's lab — drawing, games, doll-making — whose real purpose was to disguise tests of prosocial behavior in these toddlers. The researcher, saying it was high time for a snack, would bring out two packages of Bambas, peanut-butter-flavored corn puffs much coveted in Israel. The child's pack, like every pack, would hold 24 of the little treats. But when the researcher opened *her* pack, she would cry out in dismay, dump the bag out on her plate, and say, "Ohhh, mine has only three!" Which it did, because the researcher had earlier removed the rest. Would the child share her bigger treasure without being asked?

Most did not. This was expected. "The average child," says Knafo, "will help or share without being asked less than one in three times. Self-initiated sharing is a difficult task — they have to detect the need, then decide to do it." A few 3-year-olds, however, will do it far more often than their counterparts. And in Knafo's study, the ones who tended to share more were kids carrying what is generally considered a risk gene for *anti*social behavior: DRD4-7R, a variant of a dopamine-processing gene called DRD4. In a pile of previous studies, 7R kids, if they had harsh or distant parents, were far more likely to develop attention, social, conduct, and school problems. These studies had given the DRD4's 7R variant a reputation as a "vulnerability gene" — bad news. People had dubbed it the ADHD gene, the drinking gene, the bully gene, even the slut gene. Now Knafo, in effect, was calling it the Bamba-sharing gene.

Why the difference? Simply that Knafo, unlike most prior investigators, looked at the interaction between 7R and all parenting, good and bad, rather than focusing on the bad. And when he did,

he found that the gene didn't just create greater vulnerability to problematic parenting; it created greater response to any parenting.

Knafo's study supported a bold reconception of the vulnerability-gene hypothesis — the view, dominant for more than a decade, that certain heavily researched genes create risk for mood and behavioral problems. These include not just DRD4 but the serotonin transporter gene (also known as SERT or 5HTTLPR), the short variant of which is often blamed for depression and anxiety disorders, and a variant of MAOA, the monoamine oxidase A gene, that some studies associated with aggression or violence. In the conventional vulnerability- or risk-gene model (also known as the diathesis-stress model), these genes create specific vulnerabilities that stress can reveal. Knafo's research supported a view recasting those problems as merely the downside of a genetically shaped higher sensitivity to experience — the upside being enhanced function and happiness. The evidence for this revision lies not only in Knafo's studies but, embedded but overlooked, in the data of the very studies that created the risk-gene view of these variants.

This revisionist hypothesis is known variously as the sensitivity hypothesis, the differential susceptibility hypothesis, or the orchid-dandelion hypothesis — a term that Thomas Boyce and Bruce Ellis coined based on the vernacular Swedish term "dandelion children," who seem to grow up okay in almost any environment; to that they added "orchid children," who thrive under good care but wilt under bad. It is a young hypothesis, hatched 15 years ago and obscure for most of that time. But in the last two or three years it has gained enormous traction, spreading through behavioral genetics, child development, and anthropology.

"This thing is just exploding," says Jay Belsky, a developmental psychologist at the University of California, Davis, who helped pioneer the idea with a seminal paper in 1996.

In a special issue of *Development and Psychopathology* this past February, Belsky and researchers W. Thomas Boyce and Bruce Ellis, who had independently forged a parallel view rising from physiological reactivity studies, reconciled their approaches into a more comprehensive framework. A dozen papers tallied the growing evidence. The orchid hypothesis is now a staple at child development conferences, and the upside/downside paradigm is

becoming common in behavioral genetic studies. It offers to radically rework our conceptions of mental illness — and of how genes shape our behavior, our moods, and even our evolution.

Yet the orchid hypothesis faces new obstacles as the vulnerabilty-gene paradigm out of which it grew comes under closer scrutiny. With genetics moving toward sophisticated whole-genome studies using data from thousands of people, researchers can no longer rely solely on the kind of small-scale, individual-gene studies that led to the orchid hypothesis. (Such studies are called candidate-gene studies, since they study a gene already suspected of having an effect.) If the orchid-gene hypothesis is to hold up, researchers must broaden and deepen their evidence. Will it prove just a pretty story — or will the orchid hypothesis show the flexibility and strength to adapt among changing conditions of proof?

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To Elaine Aron, a psychiatrist and researcher who has written since the mid-1990s about what she calls highly sensitive persons, or HSPs, the sensitivity granted by "orchid genes" starts with a heightened attention, followed by deeper processing and, ultimately, response.

In a review paper now in press[1], she draws on several lines of animal and human research to describe a sensitive creature who typically pauses in the face of a new or ambiguous situation. "This can look like anxious inaction," says Aron. "But it's actually a time to gather information and take things in." When her own child, for instance, hung back quietly on the first day of preschool years ago, the teacher asked Aron if the child was scared. "But he was just taking it in," says Aron. "Soon enough he engaged quite fully."

This pause suggests a third mode supplementing the classic behavioral choice between approach and withdrawal: a pause to read cues and await opportunity. Aron cites studies showing this mode in animals from fruit flies to a freshwater fish called a pumpkinseed[2]. Some animals measure a new context more carefully before either exploiting the new environment more fully or, if the new situation looks unpromising, moving on to a different arena. The more sensitive creature's heightened emotional state, says Aron, burns the experience more deeply into psyche and memory, creating valuable lessons for future choices.

Belsky, meanwhile, is trying to broaden the empirical base with both larger studies and multigenic ones that gauge additive effects of purported plasticity genes. Late in 2010 he and Kevin Beaver published a study of 1,586 adolescents* representative of the 26,000 in a major national U.S. longitudinal study. The environmental variable was maternal involvement in the children's lives, such as how emotionally engaged they were and how much time they spent with their boys. The behavioral outcome measured, by both interview and testing several times over a 12-year period, was self-regulation of attention, emotions, and behavior, such as whether the youths had trouble paying attention, whether they used an organized way of making decisions, and how well they controlled their temper. Once tabulated, the results were analyzed according to how they were influenced by five genes that have variants previously associated with effects on behavior or mood: three genes affecting dopamine availability and processing (DAT1, DRD2, and DRD4); the serotonin transporter gene, 5HTTLPR (or SERT); and the two variants of the MAOA gene.

Strangely, the researchers found no significant effects on the girls in the study. "We've no idea why," says Belsky, "and can only guess, really: Maybe girls self-regulate better than boys. Maybe they're less sensitive to maternal engagement at that age. But these are only wild guesses."

The boys did react, however, with additive effects showing in boys who carried more than one of the plasticity variants. Those with just one variant reacted about the same to maternal involvement as did the boys with no variants, which is to say they reacted very little: To boys with no or just one variant, it seemed to make little difference whether their mothers were engaged — a true dandelion effect.

Boys with two or three plasticity variants, however, showed a steeply sloped sensitivity, with self-regulation scores dropping sharply from the mean among those with distant mothers and rising sharply among those with more engaged mothers. To these kids, mothering style was a big deal. The effect was even greater for boys with four or five plasticity variants.

This is just one study. But the additive effect seems to argue well for the orchid hypothesis. And the absence of significant effect in boys with just one plasticity variant may suggest why studies on individual candidate genes produce such varying results: The effect of any one plasticity gene may depend heavily on whether a person also carries a second.

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Individual studies like Knafo's, meanwhile, are revealing some interesting wrinkles.

Knafo, as earlier described, tested 3-year-olds and, confirming the orchid hypothesis, found that kids with the more plastic DRD4-7R variant and warm, engaged parenting were more prosocial than even warmly parented kids with the gene's more common 4R form. These 7R kids with good parents not only shared their Bambas; they were more likely to pick up pencils a researcher had "accidentally" knocked onto the floor, express sympathy when a researcher bumped her knee on the table, or help find and then comfort a missing doll.

But a layer down, Knafo found a surprise. He had rated the kids' mothers not only on warmth and engagement but on whether they sometimes punished without explanation. Earlier studies — studies that didn't look at genotype — generally found that unexplained punishment produces little prosocial effect or creates a contrarian pushback. This held true for most of Knafo's kids. But in a subset of his kids, unexplained punishment created sharply higher self-initiated prosocial behavior — and that subset, paradoxically, were those carrying the 7R plasticity variant.

What on earth was that about? Possibly it's a fluke that other studies won't replicate. But Knafo thinks it might be a sort of inverted consequence of sensitivity, an overreaction. He thinks these 7R kids, cue-alert and eager to make an unpredictable world less so, may exercise what psychologists call pathological altruism: they try to stave off disapproval or harsh treatment by being proactively helpful.

One final finding that impressed Knafo was that the prosocial edge held by 7R kids with good parents grew over the three years he followed these children. Possibly it simply reflected a cumulative effect. It may also refflect a positive feedback loop, as a sensitive, responsive child

and a sensitive, engaged parent each responds to the growing good chemistry developing between them. Some of these mothers were almost surely 7R themselves, since at least one parent had to be. Knafo hadn't genotyped them, so he can't say. Studies that genotype both parent and child are on the short list for additional ways to test these effects.

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One of the strengths of gene-environment studies is that they can find specific responses to particular environmental influences. Yet critics of these studies have seized on exactly this sort of response-specific focus because it can lead researchers to unintentionally manipulate responses to show a result— or, if they measure enough responses, focus on those that show the greatest result, even if that result came by chance or artifact.

"It's not necessarily that anyone is trying to game a study," says Daniel MacArthur, who just opened a lab at Massachusetts General Hospital that will use whole-genome studies to investigate rare and complex diseases. MacArthur prefers whole-genome studies because they avoid some of the bias problems that can creep into candidate-gene studies. Rather than start with a hypothesis and a candidate gene, as gene-by-environment researchers do, whole-genome researchers choose a disease, then examine the genomes of hundreds or thousands of people who have the disease to see if they have genes or gene variants that don't appear in people without the disease. "There's no massaging of data or decisions about what environmental conditions to look at," says MacArthur. Associated genes either show up or not.

In candidate-gene studies of the sort used in orchid-gene studies, however, MacArthur worries that "understandably, someone convinced that a dynamic exists might throw a bunch of different filters at the data — different definitions of environment, different measures of behavior — until they find the relation they're convinced is there." Parse enough measures of environment and behavior, in other words, and you'll eventually find a pairing that shows that some environment seems to lead to some change in behavior. In addition, such studies are often be fairly small, since they require a lot of data collection, and this increases the odds that an effect that is actually a statistical fluke will be snatched up as proof of principle.

Such criticisms were central in a withering attack on behavioral candidate-gene studies in 2009 from a team led by whole-genome researcher Neil Risch, of the University of California, San Francisco. The team essentially conducted a brisk strip-search of a 2003 study by Avshalom Caspi and Terrie Moffitt that established the short SERT variant as a risk gene for depression — perhaps the single most foundational paper in gene-environment studies of mood and behavior. Risch collected a selection of papers that purported to replicate the Caspi and Moffitt findings and concluded they essentially proved it false. A feud ensued as Caspi allies accused Risch and colleagues of gaming their meta-analysis by doing some cherry-picking of their own.

"They picked just the papers you'd pick to disprove Caspi and Moffitt and left out the ones that would support it," says Belsky. Another researcher said, simply, "That Risch paper is bullshit."

Caspi and Moffitt responded a bit more diplomatically in a major 2010 paper in the *American Journal of Psychiatry*. Analyzing what they said were all the replicating papers rather than a selection, they argued that not only did those studies confirm a gene-by-environment interaction for the serotonin transporter gene and depression, but that human studies showed that the short SERT produced distinctive sensitivities in studies of brain waves, brain imaging, hormonal response, and inflammation, while tightly controlled animal studies showed that short SERT variants created similar physiological sensitivities as well as a more sensitive temperament.

This debate will continue. MacArthur, meanwhile, acknowledges that the agnostic, a-theoretical approach that whole-genome researchers prefer can't readily test the orchid hypothesis. For one thing, if an orchid gene has both upside and downside effects — which is the orchid hypothesis's central assertion — those effects might cancel each other out, leaving no significant "disease" effect visible. In addition, whole-genome approaches don't generally compare genetic effects by environment — and even in conventional candidate-gene studies, the candidate genes such as DRD4-7R or the short SERT rarely produce measurable effects unless the study group is split according to environmental measures. Standard whole-genome surveys built for detecting disease, in other words, simply aren't likely to reveal the bidirectional sensitivity that orchid genes purportedly create, since positive and negative measures of, say, depression, would cancel one another out.

To remedy this, Caspi and Moffitt, in their 2010 paper, call for whole-genome studies[1] that include environmental measures. If done well, such studies might go a long way toward proving or disproving the hypothesis. Meanwhile, some orchid-hypothesis researchers are looking for physiological effects of orchid variants, including heightened gene expression and other epigenetic changes.

There is also, finally, an evolutionary argument for the importance of these polymorphisms: These variants, Belsky and others note, appear to have emerged and then rapidly expanded through humankind over the last 50,000 to 100,000 years. Of the leading orchid-gene variants — the short SERT, the 7R DRD4, the more plastic version of the MAOA gene — none existed in humans 80,000 years ago. But since emerging through mutation (or, possibly, through interbreeding with other hominids), they have spread into 20 to 35% of the population.

"That's not random drift," says evolutionary anthropologist John Hawks. "They're being selected for."

They may not spread much further. For most of these variants, the adaptive edge gained would likely hold only as long as the trait didn't spread too wide in a population — a dynamic known as negative frequency-dependency. The cost of aggression, for instance (such as someone hitting back), rises with the trait's frequency in a population. Likewise, an extra taste for novelty or exploration — both of which are "expensive" in evolutionary terms, requiging time, energy, and risk — would become nonadaptive if everyone had it. This makes such traits self-regulating in a population, for if they become too common they become disadvantages and are selected out.

Yet such plasticity genes serve a group well if they remain in a minority, since they create a populace of steady do-ers (dandelions) mixed with individuals of more volatile temperament but greater range of behavior (orchids). Thus some evolutionary anthropologists have argued that some of the traits associated with these variants, such as the high sensation-seeking and risk-taking found in 7R carriers in many DRD4 studies, may have helped drive human expansion around the globe;[2] and in fact the 7R variant is found in its highest rates in populations[5] that migrated fastest and furthest from Africa and Arabia. The sensitivity to cues and flexibility of

response that orchid genes provide, at both the individual and group levels, may well have been essential to our human success.

It may seem odd to link such communal achievements to bits of behavior such as a toddler's willingness to share Bambas. Yet if the orchid hypothesis is right, the genes and genetic dynamics that help create some of our most grievous frailties and foibles — anxiety and aggression, melancholy and murder — may also underlie our greatest strengths and successes. Something to ponder next time you're offered a sweet.

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Note: The piece above is an expansion of a feature I published a few weeks ago in New Scientist. This version adds material that wouldn't fit in the New Scientist space, most notably on caveats, complications, and other conundra, and I've moved a few things around to make room for those. It draws from research for a book I'm now writing, The Orchid and the Dandelion (Crown; ETA 2013). I originally explored this subject, at more length (and with monkeys) in a November 2009 Atlantic article, "Orchid Children."

Photo by Bitman, via Creative Commons license at flickr.

Figure from Belsky and Beaver 2011, cited below.

Notes

[1] Elaine Aron, Arthur aron, and Jadzia Jagiellowicz, "Sensory Processing Sensitivity: A Reivew in the Light of the Evolution of Biological Responsivity," *Personality and Social Psychology Review*, in press [as of 12/5/11]

[2] Summarized on pp 201-203 of Wilson, DS. 1998. "Adaptive individual differences within single populations." … *Transactions of the Royal Society of …*.http://rstb.royalsocietypublishing.org/content/353/1366/199.short.

[3] As related by Belsky in interview, 12/5/11. Study is Drury, S.S. et al. (submitted). Genetic sensitivity to the caregiving context: The influence of 5httplor and BDNF val66 met on indiscriminant social behavior.

4 Caspi, A, a R Hariri, A Holmes, R. Uher, and T E Moffitt. 2010. "Genetic Sensitivity to the Environment: the Case of the Serotonin Transporter Gene and Its Implications for Studying Complex Diseases and Traits." American Journal of Psychiatry 167 (5) (May 3): 509–527. doi: 10.1176/appi.ajp.2010.09101452. [4]

[5] Matthews, LJ. "Novelty-seeking DRD4 polymorphisms are associated with human migration distance out-of-Africa after controlling for neutral population gene structure." … journal of physical anthropology (2011).

*Belsky, Jay, and Kevin Beaver. 2011. "Cumulative Genetic Plasticity, Parenting and Adolescent Self-Regulation" (April 6): 1–8. doi:10.1111/j.1469-7610.2010.02327.x.

[1] See note 137 in Caspi and Moffitt 2010

[2] See Harpending and Cochran, *The 10,000-Year Explosion.*

Orchids and Dandelions: Parenting the Flowers and Weeds

August 1, 2012 by Kelly Grooms

My seven year old daughter has a necklace I made her that says "Dandelion Girl" . I made it for her because she remains enamored with these cheerful yellow flowers despite other people's best attempts to disillusion her. To her they are not weeds, but pretty flowers that turn to a white puff ball that a nature-made toy. Imagine my surprise when I came across an article referring to the genetics of "Dandelion Children".

The name come from a Swedish expression describing dandelion children as those who can survive and thrive in whatever circumstances they encounter. The opposite of these are "Orchard Children", children who are highly sensitive to their surroundings and when properly nurtured, blossom, often spectacularly, but when neglected often fail just as spectacularly. The article I read referred to a 2005 paper published in the journal *Development and Psychopathology* (1) that described these highly sensitive children as having both a great potential to excel or fail depending upon how nurturing or neglectful of an environment they lived in.

This idea of the Orchid Child who could flourish or wither was novel, and scientist began to ask if there could be a genetic component to this sensitivity. To begin looking for genes that might be involved, one team turned to a gene called CHRM2, which has already been implicated in alcohol dependency and codes a receptor that is involved in many brain functions including learning and memory.

For test subjects the researchers used a group of more than 400 boys and girls who had been involved in a larger child development study since around the age of 4 and were now in their late teens (2). The scientist combined genetic analysis with parental and child surveys and found an interesting result. Children with certain variations of the CHRM2 gene seemed to respond to parental negligence in a way that produced the ***least*** desirable teenage behavior, while children with this same variation responded to nurturing homes with the ***best*** teenage behavior. Put another way, these Orchid children were more likely than their Dandelion counterparts to wither in a neglectful home and more likely than a Dandelion child to excel in a nurturing home. These results suggest that the answer to the question of 'Nature versus Nurture' might be both, neither or one or the other.

It may turn out that the CHRM2 gene has nothing to do with the so called Orchid Children, or it might just be the first piece to a complicated puzzle. Either way, I found myself looking at my kids a bit differently. Is my daughter really a Dandelion or is she an Orchid? The truth is it doesn't matter; to me my daughter will always be my Dandelion Girl.

References

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