Chapter 2

The highly sensitive dog

I'll spare you a description of the sausage-making process that got us to this point. Suffice it to say that we now have a validated tool for identifying highly sensitive dogs: the HSD questionnaire.[1]

It was developed from Dr Aron's Highly Sensitive Person[2] and Highly Sensitive Child[3] questionnaires, each adapted for domestic dogs by veterinary behavior specialist Dr Maya Bräm and her colleagues at the University of Berne in Switzerland. (Dr Bräm is now at the University of Zürich in Switzerland.)

'Validation' in this context basically means that the newly designed questionnaire was put to the test under real-world conditions, in a large and diverse group of dogs, and then evaluated for its consistency and utility in domestic dogs.

The process involved a detailed survey of 3,647 companion, sporting, and working dogs (*i.e.,* dogs belonging to people, not institutions or corporations) and their people.

The study included dogs of all types, ages, and sensitivities, in several countries in Europe and North America, mainly Switzerland, Germany, Austria, UK, USA, and Canada.

The represented dog breeds, listed by Fédération Cynologique International (FCI, the international federation of kennel clubs) breed group,[4] are shown in Table 1 on the next page.

Most were mixed-breed dogs. The second and third most prominent categories were the herding dogs and the retrievers. These three categories reflect the most popular dogs in the surveyed countries.

In the developmental portion of the study, the 26 dogs (16 highly sensitive) ranged in age from 6 months to 13 years. We are not told the age range for the main study group, but the average age was 6 years and most dogs were between 2 and 9 years of age.

Table 1. Breed categories for the 3,647 dogs whose people participated in validating the HSD questionnaire.[1]

FCI breed group	Percentage of dogs
Mixed	31%
Sheepdogs and cattle dogs	16.8%
Retrievers – flushing dogs – water dogs	15%
Terriers	8%
Companion and toy dogs	7.8%
Pinschers and schnauzers – molossoids – Swiss mountain and cattle dogs	6%
Pointers and setters	5.5%
Scenthounds and related breeds	3%
Spitz and primitive breeds	2.7%
Sighthounds	1.5%
Pure breed not FCI recognized	1.4%
Daschunds	1%

HSD, highly sensitive dog

FCI, Fédération Cynologique International

The HSD questionnaire

Now to the HSD questionnaire itself, which is shown on pages XX and XX. It uses a 7-point Likert scale or scoring system to rate each of 32 statements about the dog, which span these three overlapping yet distinct categories:

1. Easily excited
2. Easily overwhelmed
3. Emotionally sensitive

For each statement, assign a score between 1 (strongly disagree; does not apply at all) and 7 (strongly agree; applies completely).

> Four of the statements (items 3, 4, 9, and 30) are worded in such a way that highly sensitive dogs will score lower than average on these ones. For all other statements, 1 = very low sensitivity, and 7 = very high sensitivity. Don't sweat these four anomalous ones. Just give every statement a score that best describes your dog, otherwise it may affect the accuracy of the final HSD score.

Add up the scores for all 32 statements — the total will be somewhere between 32 and 224 — and then divide that number by 32 to get the average, which is your dog's HSD score. It will be somewhere between 1 and 7.

In the validation study, HSD scores ranged from 1.4 to 6.7, with an average ('mean') score of 4.0 for the whole group.[1] For us science nerds, the standard deviation of the mean was 0.9, so around two-thirds of the dogs had a score between 3.1 and 4.9.

In other words, we can consider a HSD score between 3 and 5 to be average for domestic dogs. More on that later.

while you're at it…

While you're at it, fill out a Highly Sensitive Person (HSP) questionnaire for yourself. The original consists of 27 questions or statements, each likewise scored on a 7-point scale from 1 (not at all) to 7 (extremely).[2] The revised HSP questionnaire consists of 18 questions and is shown at the end of Chapter 1.

Add the scores for all 18 (or 27) questions and then divide the total by the number of questions to get the average, which is your HSP score. For example, mine is 6.3 on both versions.

In the HSD validation study, the people were also asked to filled out the original HSP questionnaire. Individual scores ranged from 1.4 to 7. The average for the group was 4.2 ± 1.1.

Unlike the HSD scores for the dogs, which were 'normally distributed', the HSP scores for the people 'skewed' or leaned slightly toward higher sensitivity. That's not completely surprising, given that a highly sensitive person would be more likely to participate in a survey about highly sensitive dogs. More on the people in Chapter 3.

HSD questionnaire

Give each statement a score between 1 and 7.

1	2	3	4	5	6	7
strongly disagree; does not apply at all	disagree	somewhat disagree	neither agree nor disagree	somewhat agree	agree	strongly agree; applies completely

A. Easily excited	Score
1. My dog is easily stressed, is easily overwhelmed by situations.	
2. My dog gets nervous quickly or is often nervous.	
3. My dog is generally relaxed, can cope well with stress.	
4. My dog is emotionally stable; *i.e.,* s/he is mostly even-tempered and not easily unnerved.	
5. My dog tends to be uncertain and/or careful.	
6. My dog startles easily.	
7. My dog has problems adapting to changes in everyday life (*e.g.,* changes in routine, visitors) and/or bigger changes in life (*e.g.,* change of partner, rearranging furniture, going on holidays, moving home).	
8. My dog tends to be mistrustful.	
9. My dog easily adapts to new environments and can relax there.	
10. My dog has trouble when people touch her or when things touch him (*e.g.,* harness, coat, wet leaves, *etc.*).	
11. My dog needs a sense of security.	
12. It takes a long time for my dog to calm down after an arousing event.	
13. My dog has problems when left alone outside and I move out of sight.	

continued on the next page

B. Easily overwhelmed	Score
14. My dog is always on the alert, always has her/his "antennae up."	
15. My dog observes everything that is happening around her/him.	
16. My dog seems to absorb everything that is happening around her/him.	
17. My dog is easily excitable, be it through positive or negative stimuli.	
18. My dog is reactive; *i.e.,* quickly perceives small stimuli and reacts quickly and/or strongly to them.	
19. My dog reacts strongly to visual stimuli.	
20. My dog has a subtle perception; *i.e.,* notices a lot or almost everything.	
21. My dog tends to be restless.	
22. My dog is demanding.	
C. Emotionally sensitive	
23. My dog is sensitive.	
24. My dog reacts to small changes in voice; *i.e.,* changes in intonation and volume.	
25. My dog reacts strongly to punishment.	
26. My dog is emotional; *i.e.,* reacts strongly to positive and/or negative events.	
27. My dog reacts when we (people) argue at home.	
28. My dog is attentive.	
29. My dog notices small changes.	
30. My dog is biddable (obedient, docile, amicable).	
31. My dog seems thoughtful.	
32. My dog is intelligent.	
Total	
divide (÷) by 32	
HSD score	

interpreting your dog's HSD score

As I mentioned, the average HSD score in the validation study was 4, and most dogs scored somewhere between 3 and 5. Highly sensitive dogs had scores between 5 and 7.

What if your dog has a score of exactly 5? Interpretation of that number is up to you. How many of the 32 statements did you agree with in some way?

The more of those you have, particularly if the 5+ scores are spread across at least two categories (and don't include those four anomalous questions), the more likely it is that your dog is generally sensitive, rather than simply being strongly reactive to one or two things, based on his/her unique life history.

what if s/he is not my dog?

You can still use the HSD questionnaire if the dog does not belong to you, as long as you know the dog well. In the validation study, the correlation between HSD scores determined by the dog's person and separately by another person familiar with the dog (*e.g.,* close friend or family member) was good ($P < 0.001$; $r = 0.65$).[1] The two scores differed by an average of only 0.04 point — that's a fraction-of-a-fraction of a point.

what about puppies?

Dr Bräm has reported elsewhere that the HSD score in puppies 9–12 weeks of age was significantly correlated with the HSD score in those same dogs at 16 months of age, so the HSD questionnaire also has predictive value in young dogs.[5]

The DOES scale

In recent years, the DOES scale has been developed and tested as another way of examining sensory-processing sensitivity in people.[6] It expands on the HSP questionnaire by separating the specific characteristics of the highly sensitive person into four core categories, summarized by the acronym DOES:

Depth of processing

Overstimulation

Emotional reactivity and empathy

Sensing the subtle

The DOES scale involves a 20-item questionnaire, five items *per* category, as shown in Table 2 on the next page. It is designed to cover the positive, negative, and neutral aspects of sensory-processing sensitivity, with minimal overlap.

Through a series of studies, the authors concluded that the DOES scale best captures the full spectrum of characteristics and experiences of people self-identifying as highly sensitive.[6]

> ❝ Unlike the HSPS [Highly Sensitive Person Scale], which primarily focuses on Overstimulation, the DOES Scale provides a more nuanced and neutral understanding of how individuals perceive and interact with their surroundings. ❞

How all of this relates to highly sensitive dogs remains to be fully explored. However, the main finding of the DOES research is that these categories represent four related yet distinctly different traits — the authors call them 'trait constellations' — that make up the highly sensitive individual.

'Constellation', 'cluster': these terms remind us that sensory-processing sensitivity is not one single or uniformly experienced thing. They also make the point that personality is composed of many different elements, the arrangement of which is unique to each person — and dog and horse and hamster.

The authors propose we examine these four trait constellations separately rather than looking at a single, composite score from the HSP questionnaire.[6]

> ❝ [T]he results of this study argue in favor of a novel interpretation of SPS [sensory-processing sensitivity] in that the four subscales of the DOES Scale should be understood as manifestations of the four trait constellations and not as a mere aggregation of the components into a unidimensional [or overarching] SPS factor. ❞

Table 2. The 20 items that comprise the DOES scale in people.[6]

Depth of processing	Emotional reactivity and empathy
It is difficult for me to mentally switch off.	The moods of other people are highly contagious to me.
I have intense thoughts about situations that I will experience in the future.	I am intensely moved by deep conversations.
After experiencing something positive or negative, I think about what happened for a long time.	When others quarrel, it greatly affects me.
I spend a lot of time thinking about everyday experiences.	Emotional film scenes touch me deeply.
It often happens to me that I lose myself for hours in new ideas.	When I listen to beautiful music, I can become completely absorbed in it.
Overstimulation	**Sensing the subtle**
Events where I am exposed to multiple impressions overwhelm me.	During a walk, I notice sounds around me clearly.
I often feel exhausted after being out with a lot of people.	I clearly perceive the kind of textiles I wear on my skin.
When there is a lot going on around me, I am easily overwhelmed.	I am aware when the light in a room is glaring or bright.
I am very disturbed by sounds that occur at the same time.	I notice slight differences in temperature quickly.
I often find odors like perfume or strong food smells unbearable.	I can perceive odors very clearly.

The person completing the questionnaire gives each statement a score as follows: 1 (strongly disagree), 2 (disagree), 3 (agree), and 4 (strongly agree). There is no neutral option; you must either agree or disagree with the statement, the only variation being in how strongly you feel about it. The average for each category is 2.5.

the DOES scale and dogs

We don't yet have any data on how the DOES scale might apply to dogs, but Dr Bräm published her thoughts on the matter in a special issue of *Veterinary Clinics of North America* on canine and feline behavior.[5] I'm paraphrasing them here and expanding on them a little, as the original was written for veterinarians and intended to be used in a clinic or hospital setting.

D — depth of processing

Highly sensitive dogs process sensory information more deeply, so they need to both receive the necessary information in order to feel safe, and be given time to process it.

O — overstimulation/arousal

Highly sensitive dogs are more easily overstimulated, or over-aroused in scientific parlance, and so they are more easily overwhelmed.

This is especially true if there is a lack of sensory information (*e.g.*, the dog is unable to see what is making a disturbing noise), the dog has a quick and intense physical and emotional response, and there is no time to process it all.

E — emotional reactivity and empathy

Highly sensitive dogs don't just experience their own emotions more intensely, they also pick up on the emotions and moods of those around them, people and animals.

So, when we are nervous or anxious, or otherwise feeling some strong emotion (anger, sadness, *etc.*), the dog immediately picks up on it. That may increase the dog's stress in situations in which he or she is already feeling unsure or overwhelmed.

S — sensing the subtle

Not only are highly sensitive dogs more aware of, and reactive toward, sensory stimuli around them, they are probably more 'interoceptive' as well.

Interoception is the awareness of the physical processes going on inside our own bodies, such as our breathing, heart beat, digestion, and muscle tension.

Assuming that dogs consciously experience interoception too, it is likely that highly sensitive dogs are more aware of subtle changes within their bodies, and they may respond with physical or behavioral reactions that may seem exaggerated for the circumstances.

For example, a full bladder may be more alarming to a highly sensitive dog than to a less sensitive dog with the same house training. Similarly, motion sickness, nausea, loss of balance, pain, and even mild hunger or thirst may be more arousing or alarming to a highly sensitive dog.

This aspect of high sensory-processing sensitivity may also manifest as greater sensitivity to the effects of medications, such as sedatives and pain relievers, and greater potential for side effects. Dosages may need to be adjusted accordingly, or a different medication altogether may be needed for these dogs.

By the same token, highly sensitive dogs may respond better to gentle body work and other subtle therapeutic approaches than do less sensitive dogs.

'sensing the subtle' put to good use

I'm beginning to see how the DOES approach may be useful in dogs. Consider, for example, what 'sensing the subtle' means for dogs who do scent work, search-and-rescue more generally, and even assistance dogs such as "seeing eye" dogs and seizure-alert dogs.

It's not a stretch to imagine that dogs who score high in this category yet not so high on 'overstimulation' would be ideally suited for these purposes.

Here's an example, a Finnish study on scent detection in dogs.[7] The researchers set out to find the threshold of detection in dogs trained to detect various dilutions of *Eucalyptus* hydrosol (eucalyptus oil in water).

The starting dilution was 1 in 10,000 (100 parts *per* million), which is a common dilution used in the sport of 'nose work'. The dilutions serially increased from there until the point at which the dog no longer alerted to the scent.

The study tested 15 dogs of various breeds, all trained to detect various scents but having a range of nose-sport experience from none to seasoned competitor.

Types of scents the dogs were trained to detect prior to the study included household contaminants (bedbugs, rats, mold, floor carpet glue residue), essential oils (eucalyptus, lavender, *etc.*), chanterelle mushrooms, canine and human scents (*i.e.,* tracker dogs), blood, and cancer.

The limit of detection in 11 dogs (73%) ranged from 100 parts *per* million to 100 parts *per* trillion. That's impressive.

But then there was an enormous gap between this majority and the other 4 dogs (27%), whose limits of detection ranged from 10 parts *per* quintillion (which is 1 followed by 18 zeros) to 10 parts *per* septillion (which is 1 followed by 24 zeros)!

This gap represents an almost incomprehensible difference in detection limit between the more and less sensitive dogs.

As for the genetics of scent detection, Japanese researchers conducted a genome-wide association study to examine the genetics of successful drug-detection training in dogs, specifically 121 German Shepherd Dogs and 205 Labrador Retrievers trained for use by Tokyo Customs.[8] The dogs were trained to detect various prohibited substances, including marijuana, hashish, cocaine, heroine, and methamphetamine.

Based on breeding kennel of origin, qualification success after 4 months of scent training had a strong genetic component in German Shepherd Dogs, with a heritability of 84%. However, its heritability in Labrador Retrievers was only 17%.

Various behavioral traits considered important in drug-detection work were examined, including activity (how active or energetic the dog is), boldness, concentration, friendliness toward humans, independence, interest in the target, and tolerance of other dogs.

The two behavioral traits identified as having significant genetic components were boldness in German Shepherd Dogs (82% heritability) and tolerance of other dogs in Labrador Retrievers (53% heritability).

In regard to specific genetic variants (polymorphisms; see page XX) that reached or trended toward statistical significance in the German Shepherd Dogs, interest in the target was associated with polymorphisms in five regions on canine chromosome 24, and qualification success with ten regions on chromosome 10.

Qualification success in the Labrador Retrievers was more complex, involving multiple regions on chromosomes 12 and 23. In addition, friendliness toward humans was associated with polymorphisms in three specific regions on chromosome 15.

In other studies, polymorphisms in olfactory receptor genes, serotonin transporter genes, and oxytocin receptor genes have been associated with performance in odor-detection tasks and training success in dogs.[8]

Olfactory receptors are those involved in the sense of smell ('olfaction'), so that's a no-brainer. Involvement of the oxytocin receptor and serotonin transporter genes is far more interesting, as they're integral to social bonding and emotional well-being.

Clearly, being a successful scent-detection dog involves multiple behavioral traits and some fairly complex genetics. While the HSD questionnaire was not developed for this purpose, some features of high sensory-processing sensitivity in dogs are undoubtedly associated with the ability to detect odors at very low concentrations.

What might we find in other areas of canine sport and work if we were to begin examining the three categories of the HSD questionnaire separately?

Might we be able to develop a short-form, DOES-style HSD questionnaire and perhaps some task-specific questionnaires that are as robust and discriminating as the DOES scale in people?

Probably so. For now, let's continue with the HSD questionnaire as it is currently, because it already tells us a lot about how our

highly sensitive dogs perceive the world, how they respond and react to various stimuli, and how we might better manage them for greater comfort and function.

What proportion of dogs are highly sensitive?

As I mentioned in Chapter 1, earlier studies on high sensory-processing sensitivity in people indicated that 15–20% of the population is highly sensitive, regardless of gender, race, and culture. More generally, traits associated with greater sensitivity, such as "difficult temperament," behavioral inhibition, and sensitivity gene variants, are reported in 10–35% of individuals in the populations studied.[9]

The same appears to be true in domestic animals as well. For example, a small study of retired Thoroughbred racehorses showed that 3 of the 12 horses tested — that's 1 in 4, or 25% — were more reactive than the rest when subjected to a startle test (details in Chapter 3).[10]

And while all 12 horses became less reactive after a few months of regular training in a less stressful sport, the difference in startle response between the highly reactive few and the rest of the group remained.

In general, Thoroughbreds are more sensitive or reactive than most other horse breeds. This study showed that, within this one breed, some individuals are more sensitive or reactive than others.

That is consistent with high sensory-processing sensitivity: a small but significant proportion of the population is highly sensitive in relation to all the rest.

In the validation study for the HSD questionnaire,[1] the authors don't tell us how many dogs were designated as highly sensitive — nor, in fact, what the threshold is for high sensory-processing sensitivity in dogs. So, I've approached this question from two different angles: one statistical, using the classic bell curve for normally distributed data, and the other descriptive, using the popular dandelion-tulip-orchid metaphor.

'bell curve' approach

In the validation study for the HSD questionnaire, the average or 'mean' HSD score for all 3,647 dogs was 4.0, with a standard deviation of 0.9. Let's round that up to 1, because we're primarily looking for patterns or generalities here.

The individual scores for the group were 'normally distributed', meaning that the data formed some semblance of a classic bell curve (Figure 1).

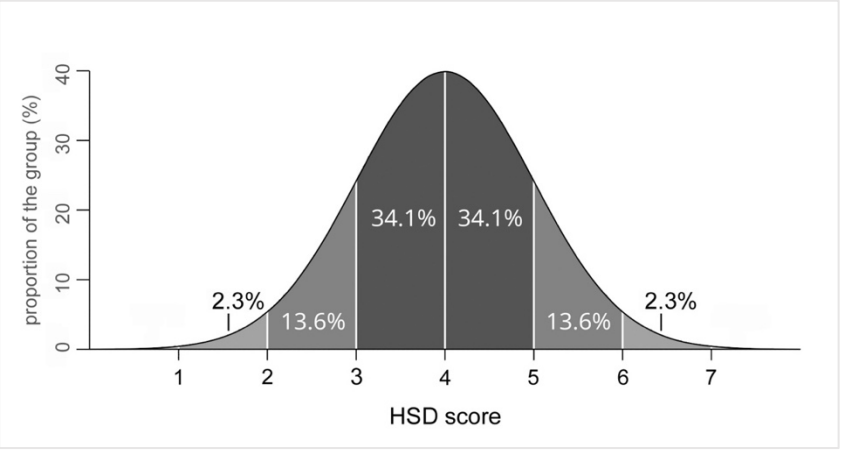

Figure 1. The 'bell curve' formed by normally distributed data, applied to Highly Sensitive Dog (HSD) score.

With normally distributed data, one standard deviation from the mean in each direction (above and below) accounts for around 68% of all individual values. That's the dark-gray area in the middle of the bell curve in Figure 1.

So, in any randomly selected group of dogs, we can expect that about two-thirds of the dogs will have a HSD score between 3 and 5. The actual range of values is 3.1 to 4.9 (*i.e.,* 4.0 ± 0.9), but '3 to 5' is close enough for our purposes.

As for the numbers on the Y (vertical) axis, around 40% of dogs will have a HSD score of 4 or close to it. The other 60% will deviate to some extent, in one direction or the other (more or less sensitive), from this average or mean value.

The further away from the mean we go, in either direction, the fewer individuals there are in that category. That's how normal distribution — the 'bell curve' — works.

As for the rest of the group — the dogs with HSD scores beyond 1 standard deviation from the mean — around 16% of dogs would be above (HSD score 5–7) and another 16% below (HSD score 1–3) the majority.

So, 1 in every 6 or 7 dogs would be considered highly sensitive, and the same proportion would score as having low sensitivity.

At the extreme ends of the sensitivity scale, where the bell curve really begins to flatten out, a little over 2% of dogs, or 1 in every 43 or 44 dogs, would score 6–7 (very high sensitivity) and the same proportion would score 1–2 (very low sensitivity).

These dogs are included in the 16% who lie above and below the majority. I simply mention them because these highly, highly sensitive or insensitive dogs are very uncommon, but they do exist, and they are a normal part of the sensitivity spectrum.

I should note again that these are all just estimates, based on the normal distribution of HSD scores in the validation study.[1] These figures do, however, give us a rough guide as to what to expect in the general population of domestic dogs.

dandelions, tulips, and orchids

In a study of 1,131 psychology students at universities in the US and UK, Drs Aron and colleagues reported that the sensitivity spectrum could be described as forming three distinct yet overlapping groups:[9]

- 'dandelions' — people with low sensitivity, comprising 30.5%
- 'tulips' — people with medium sensitivity, comprising 40.3%
- 'orchids' — people with high sensitivity, comprising 29.2%

The premise is that dandelions are resilient and can grow almost anywhere. Orchids, in contrast, do exceptionally well in ideal conditions but exceptionally badly in poor ones. And tulips lie

somewhere in between. They thrive in many different areas, but while they are less sensitive than orchids to environmental conditions, they are more sensitive than dandelions.

Although the three sensitivity groups had distinct mean HSP scores, there was considerable overlap between the 'tulips' and the two groups either side (Figure 2).

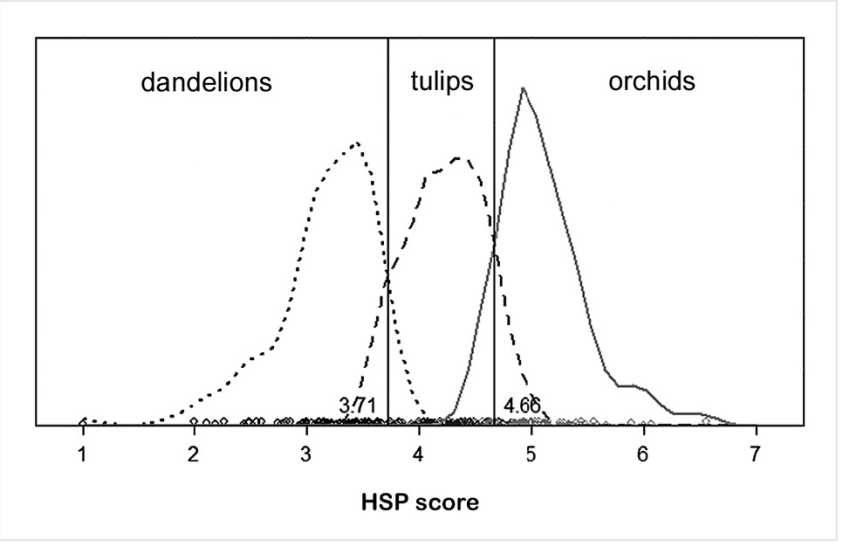

Figure 2. Highly Sensitive Person (HSP) scores for 901 psychology students, divided into three sensitivity groups: low ('dandelions'), medium ('tulips'), and high ('orchids').[9]

Not surprisingly, these psychology students skewed toward the more sensitive (Figure 3).

By the way, Figures 2 and 3 show examples of what normal distribution (the bell curve) can look like with real-world data. It seldom forms a perfectly symmetrical bell shape.

If we were to apply this same distribution to the HSD scores of the dogs in the validation study,[1] we would get these groups:

- 'dandelions' — dogs with low sensitivity; HSD score 1.4 to 3.2
- 'tulips' — dogs with medium sensitivity; HSD score 3.3 to 4.7
- 'orchids' — dogs with high sensitivity; HSD score 4.8 to 6.7

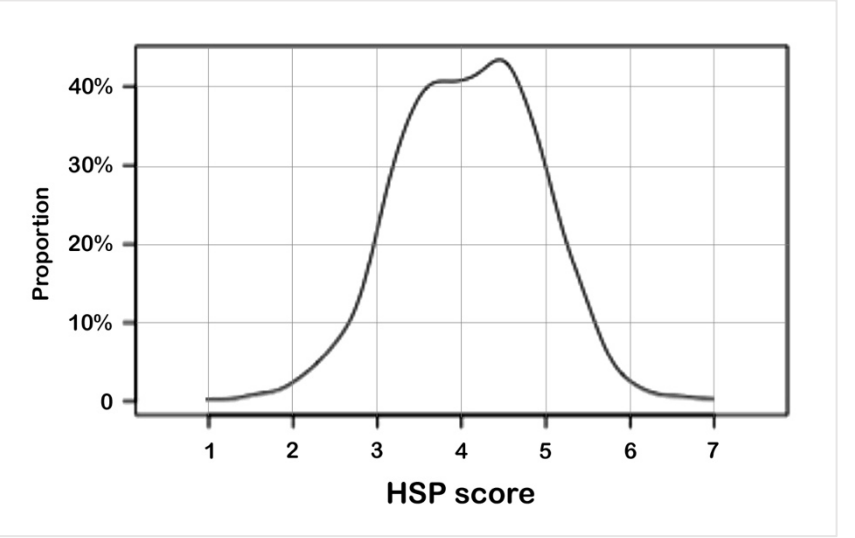

Figure 3. Overall distribution of Highly Sensitive Person (HSP) scores for 901 psychology students.[9]

I love this botanical metaphor as a relatable way of explaining the sensitivity spectrum. But in the absence of canine-specific data, this study hasn't really helped me decide on a practical threshold or cut-off for HSD score that differentiates highly sensitive dogs from those with medium or average sensitivity.

The way the HSP scores were divided into three sensitivity groups in this study overstates the proportion of highly sensitive individuals, as it folds in some who could just as well be described as having medium sensitivity.

Is it a problem if we do the same with HSD scores in dogs?

It depends on how highly sensitive dogs are viewed: favorably or unfavorably. If we view this trait favorably, then we would simply be erring on the side of treating some dogs with medium sensitivity a bit more gently. And that's not a bad thing.

But if we view this trait unfavorably, then some dogs with medium sensitivity might be branded as "highly sensitive" and thus potentially problematic. On this basis alone, they might be excluded from sport, work, or family life for which they could be very well suited and may thoroughly enjoy.

Until we have canine-specific data that settles this question, it seems fair to say that most dogs are 'tulips' and will have HSD scores somewhere between 3 and 5. The 'orchids', the highly sensitive dogs, will have HSD scores between 5 and 7. And the 'dandelions', the dogs with relatively low sensitivity, will have HSD scores between 1 and 3.

what about the noise sensitivity study?

In the first edition, I discussed a Finnish study which examined the genetic basis for two specific canine behaviors: (1) fear of loud noises (noise sensitivity or reactivity), and (2) fearfulness toward strangers and novel situations.[11]

Let's start with noise sensitivity/reactivity. In this study, 30% of the dogs were identified by owner questionnaire as being reactive to loud noises such as thunder, fireworks, and/or gunshots. I'll explain what 'reactive' meant to these researchers in a bit.

The study involved 330 privately-owned German Shepherd Dogs, all from either working or show lines. Of the total, 301 dogs were included in the noise-reactivity portion of the genomic study. Of these, 91 dogs (30%) were described as being reactive to loud noises, and the other 210 dogs were not.

I should note here that the noise-reactivity questionnaire used in this study is very different from the HSD questionnaire. Its purpose is different, and it is designed and scored differently.

For each of the three main categories (thunderstorm, fireworks, gunshot), the person was asked two questions: "1. Does your dog react to [the loud noise]?" and "2. How often does your dog react as indicated [below]?"

If the person answered 'Yes' to the first question, they were asked to indicate which of the following behaviors their dog exhibits: salivates, defecates, urinates, destroys, escapes, pants, hides, trembles, vocalizes, paces, freezes, tail low/between legs, excited (the dog gets excited when hearing [the loud noise], the tail is up, may bark). One point is given for each behavior that applies.

For the second question, the person must choose between four options: always (100% of the time, 4 points); almost always (60–100% of the time, 3 points); often (40–60% of the time, 2 points); and rarely (0–40% of the time, 1 point).

An essential difference between noise-reactivity score and HSD score is that this questionnaire is null and void (score of 0) if the person answers 'No' to all three categories (thunderstorm, fireworks, gunshot).

This particular survey seeked only to quantify the intensity and frequency of reactive behaviors in dogs described by their people as being reactive to loud noises.

A dog's noise-reactivity score would fall somewhere between 1 (slightly reactive) and 60 (extremely reactive). All of the 210 dogs not classified as noise-reactive had a score of zero. Of the 91 dogs who were noise-reactive to some degree, the median score was 12 (Figure 3).

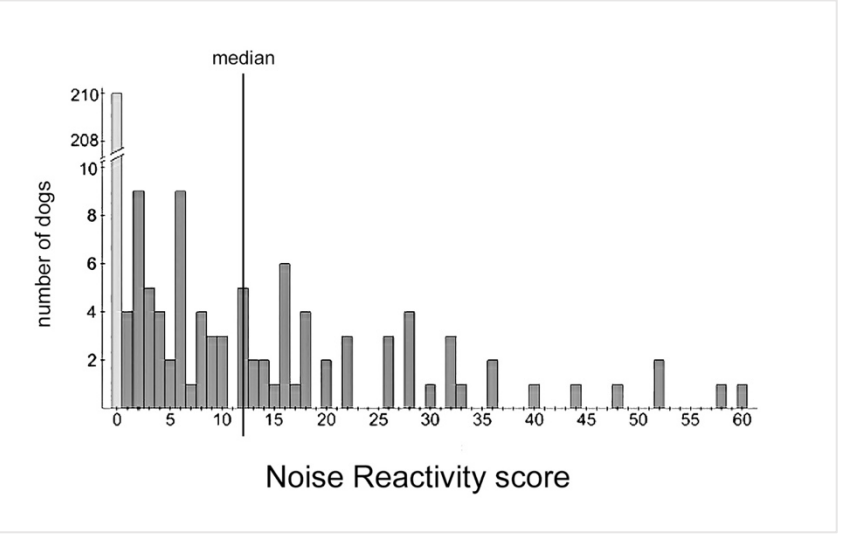

Figure 3. Noise-reactivity scores for 301 German Shepherd Dogs. All 210 dogs in the 'control' (not noise-reactive) group scored 0 (light gray bar). Of the 91 dogs described as being reactive to loud noises (dark gray bars), the median value was 12 on a scale from 1 (slightly reactive) to 60 (extremely reactive).[11]

The 'median' is a statistical figure which describes the value that divides a group into equal halves. So, 50% of the dogs had a noise-reactivity score between 1 and 12 and the other 50% had a score between 12 and 60.

But a dog would score 5 points simply by always getting excited about fireworks, by barking or trying to chase them! The dog would not need to have any other indicators of noise reactivity; just that one quirky response to fireworks, and he or she was considered noise-reactive in this study.

That median (12, out of a possible 60 points) is important, because the graph showing the distribution of noise-reactivity scores among all 91 noise-reactive dogs makes it look like there were a lot of very noise-reactive dogs.

The reality is that, of all 301 dogs in this portion of the study, only 46 dogs (50% of the 91 noise-reactive dogs) were moderately or very reactive to loud noises. That's only 15% of the dogs studied. And that fits with the expected distribution of genuinely highly sensitive dogs based on the 'bell curve' approach (see page XX).

genetics of noise sensitivity in dogs

Noise sensitivity/reactivity in this Finnish study was found to be associated with canine chromosome 20, most likely involving the oxytocin receptor gene. There's that gene again. (I mentioned it several pages back, in relation to scent detection in dogs.) I'll discuss oxytocin in more depth in Chapter 6. For now, I'll simply say that these associations are a fascinating coincidence.

In a Scottish study of 1,975 purebred Labrador Retrievers, 'noise fear' was associated with a single nucleotide polymorphism (discrete genetic variation) on canine chromosome 20.[12] In an earlier genomic study by a different research group, 'noise phobia' in dogs was also traced to canine chromosome 20.[13]

So, that makes at least three separate studies which have documented polymorphisms on canine chromosome 20 in relation to noise sensitivity or reactivity in dogs. That clearly marks noise sensitivity as having a genetic component in dogs.

Now let's take a look at the heritability of noise sensitivity in dogs, or the component of its expression that is genetically determined.

In the Scottish study, assessment of 'noise fear' as a specific component of 'nonsocial fear' was based on responses to two questions in the Canine Behavioral Assessment and Research Questionnaire (C-BARQ):

38. In response to sudden or loud noises (*e.g.,* vacuum cleaner, car backfire, road drills, objects being dropped, *etc.*) …

44. During thunderstorms, firework displays, or similar events …

In the C-BARQ, the person gives the dog's response a score between 0 (no visible signs of fear) and 4 (extreme fear; cowers, retreats, hides, *etc.*). Scores for the group ranged from 0 to 4, or 1 to 5 in the modified scoring system used in this study.

We're not told how many dogs were very noise-sensitive (score above 3 out of 5), just that the group encompassed the entire spectrum of noise sensitivity, from none to extreme.

The questions used to determine 'noise fear' were very similar to those used in the noise-reactivity portion of the Finnish study of German Shepherd Dogs, so let's call it noise reactivity or noise sensitivity.

In these Labs, noise sensitivity/reactivity had a heritability of 30%, meaning that genetics accounted for 30% of the variation in noise-reactivity scores seen in this group of dogs, and environmental influences explained the remaining 70%.

Most of the Labs in this study were gun dogs (42.5%) or pets (41%); the rest were show dogs (7%) or their primary activity was unspecified (9%). So, hunting and companion were the two predominant activities or roles, accounting for more than 80% of the group and being fairly evenly distributed between the two.

I was surprised that noise reactivity had such low heritability in a breed noted for being used and bred as gun dogs …

A very interesting Swedish study found that the heritability of 'gun-shyness' was 56% in Labrador Retrievers but only 22% in German Shepherd Dogs.[14]

Most of these dogs were purpose-bred at the Swedish Armed Forces Dog Training Centre, to be trained for various military and civilian tasks, including drug detection, police and protection work, and guide dogs for visually impaired people.

After about 8 weeks of age, the dogs were placed in foster homes until testing at 18 months to 2 years of age. The behavior test was used to select dogs for breeding and training. Gun-shyness was the only trait not considered in breeding decisions.

In the German Shepherd Dogs, gun-shyness was correlated with 'nerve stability', or the appropriateness of the dog's reaction to a certain situation. In the authors' words, it included the dog's ability to adapt to various types of situations, and to concentrate when highly aroused or in a situation of conflict, as well as the dog's ability to relax and to overcome a frightening situation.

Simply put, the gun-shy or noise-sensitive dogs were considered more 'nervy' or less emotionally stable and adaptable in highly arousing situations, and they took longer to calm down once overwhelmed.

In the Labrador Retrievers, gun-shyness was correlated with 'courage' and 'hardness' as well as nerve stability. 'Courage' was defined as the ability to overcome fear, and it could be determined only in situations in which the dog became frightened.

'Hardness' was defined as the lack of lasting effect of a pleasant or frightening experience. A dog with low hardness is very easily affected by corrections and/or frightening experiences, whereas a dog with high hardness is difficult to affect.

So, in Labrador Retrievers, gun-shy or noise-sensitive dogs were not only considered less emotionally stable and adaptable, they were also evaluated as being more easily frightened. And most interestingly in light of the positive and negative aspects of high sensory-processing sensitivity, these dogs were more easily affected by intense experiences, whether positive or negative.

It's not a stretch to consider gun-shyness as a proxy for high sensory-processing sensitivity in studies such as this. But why is its heritability so variable among breeds and studies?

As with pretty much all genetic traits, it's complicated. Even within the same breed — even when the breed was historically developed for gun sports — other personality or behavioral traits have a say in its expression, as do environmental influences.

For example, why the difference in the heritability between the two studies (Scottish, Swedish) of the same dog breed (Labrador Retriever)? Most likely because the Scottish study involved a more diverse group of dogs — genetically and in role or purpose — whereas the dogs in the Swedish study were bred and trained at the same facility, and for specific working purposes.

what about fearfulness?

In the Finnish study of German Shepherd Dogs, 273 dogs were included in the fearfulness portion of the genomic study.[11] Of these, 80 dogs (29%) were described as being fearful toward strangers or novel situations. But as with noise reactivity, only about 15% of the dogs in this study were scored as being moderately or very fearful toward strangers or novel situations.

But there's something interesting about fearfulness ...

In the validation study which is the focus of this chapter, fearfulness was positively correlated with HSD score, meaning that the two traits moved in the same direction (greater fearfulness in dogs with higher HSD scores). However, the relationship, while statistically significant ($P < 0.001$), was not very strong ($r = 0.38$).[1]

This 'r' value indicates that fearfulness scores, which were derived from other research questionnaires, explained only 38% of the variation see in HSD scores among the group.

In other words, fearfulness, on its own, is not a particularly good indicator of HSD score. And HSD score, on its own, does not reliably predict or explain fearfulness in dogs.

In short, not all highly sensitive dogs are fearful, and not all fearful dogs are highly sensitive.

In the Finnish study, fearfulness toward strangers or novel situations was genetically far more complex (several different chromosomes) than noise reactivity (single chromosome).[11]

This complexity is seen in other genomic studies of behavior as well. For example, in the Scottish study of Labrador Retrievers I discussed in the previous section, stranger-directed fear had a heritability of only 14%, although stranger-directed aggression was more heritable (26%), similar to that of nonsocial fear (25% heritability). Dog-directed fear had very low heritability (7%), although dog-directed aggression was higher (17% heritability).[12]

In a separate study of 1,041 German Shepherd Dogs, 426 pet dogs in the UK and 615 purpose-bred dogs at the Swedish Armed Forces Dog Training Center, stranger- and dog-directed fear and aggression were not significantly heritable (0–4%). And the heritability of nonsocial fear, while statistically significant, was low (12–16%).[15]

In other words, the dog's environment — which includes the trainers and handlers — had far greater influence on the expression of all types of fearfulness than did genetics.

Using whole-genomic mapping, several significant or suggestive polymorphisms were identified in association with specific behavioral traits in that study (Figure 4, page XX).

The specifics aren't important to us here, especially as these personality traits were not particularly heritable in this study. But what these sorts of studies show is that we must consider the impact of life experience on an individual dog's fearfulness. Fear is innate, but it can also be learned through painful or otherwise stressful experiences.

Noise sensitivity/reactivity is a more clearly heritable trait — and even its heritability may be low in some groups of dogs.

Here's one last example regarding fearfulness in dogs. In a study examining the heritability of everyday fearfulness in Swedish Rough Collies — a breed known for its problematic everyday

fearfulness — genetics accounted for between 11% (dog-directed fear) and 36% (nonsocial fear) of the variation among the 1,738 dogs tested.[16] Stranger-directed fear lay in between, at 25%.

That's an average heritability of only 24% across all three fear categories. Environmental influences explained the rest.

In other words, *epi*genetics plays an enormous role in the expression of fearfulness and evidently various other behavioral traits associated with high sensory-processing sensitivity in dogs.

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In the next chapter, we'll look at the factors known to affect the *expression* of sensitivity — potentially increasing or decreasing reactivity — in highly sensitive dogs.

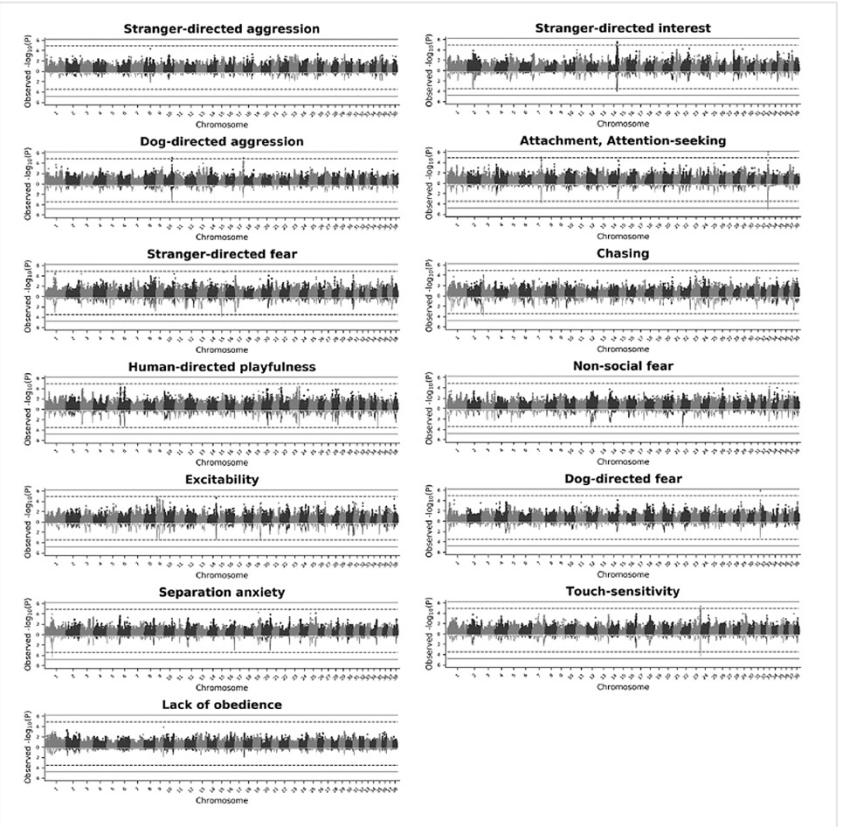

Figure 4. Genome-wide association plots for 13 behavioral traits examined in 1,041 German Shepherd Dogs in the UK and Sweden. The horizontal lines above and below each plot indicate the thresholds for significant (outer) and suggestive (inner) associations with specific chromosomes.[15]

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