Explainer: What is heritability?

December 23 2013, by Kate Lynch

Heritability: how much do your genes impact your traits? Credit: Jenn Durfey

Schizophrenia, depression, bipolar disorder and autism have all had recent attention for being "genetically caused".

In scientific research being genetically caused usually corresponds to having a high estimated heritability.

But what exactly is heritability? What does it mean when researchers and journalists label traits like these as genetic?

The nature-nurture debate

The nature-nurture debate historically referred to the disagreement between whether traits are caused by ones biology (nature) or the environment (nurture).

These days, disagreements centre on how much nature or nurture contributes. Nature – now usually referring to genes – may be more of a cause of schizophrenia, even though both genes and environment contribute.

Geneticists quantify the proportion that genes contribute using a heritability estimate, represented as h^2. When traits are claimed to be genetic, this usually means that they have a high heritability estimate.

Making sense of heritability

Heritability estimates have a value between 0 and 1. These values are sometimes represented as percentages, for instance "depression is 70% heritable" would correspond to an h^2 of 0.7.

However this does not mean that 70% of an individual's depression is genetic, with the environment making up the other 30%. It also does not mean that 70% of depressed individuals are so because of their genes.

To make sense of this, imagine that we found that height was 80% heritable. It seems obvious that this could not mean that only 80% of people have their height genetically influenced. It also strange to think that my particular height of 165cm can be broken down in to 132cm of genetically caused growth and 33cm of environmentally caused growth.

The interplay of genes and environment for individual traits is recognised by geneticists, and cannot be broken down in to percentage values.

The colour of Labrador fur is highly heritable. Credit: AlyssssylA

For my Labrador Bob to have brown fur, he needs to have particular genes to code for the brown pigment expressed in his coat. He also needs an environment in which to develop, in order to be able to grow fur at all.

In an individual case, it does not make sense to say how much is genetically or environmentally caused. It does not make sense to talk about "how genetic" my blond hair, your short stature, or Bobs brown fur is.

This is why heritability estimates can only be applied to populations.

Causes of trait variation

So what do these numbers refer to?

Heritability concerns how much variation in traits is caused by variation in genes.

If we looked a population of people and measured their height we are likely find variation between them – some short, some tall, and some in-between. Heritability tells us if this variation occurs because people have different genes or because they live in different environments.

In the Labrador case – it seems that dogs with particular genes are golden, while others with different genes are black or brown. Thus there is variation in genes between the three coloured groups.

If we looked at the environments in which they were raised, you would find that no matter what environment these dogs are raised in, their coat colour is not affected.

So, Labrador coat colour variation is caused by variation in the genes, and is highly heritable. As changes in the environment have no effect at all, the heritability would be 100%, or $h^2 = 1$.

Human skin colour however, has a lower heritability estimate.

Skin colour is influenced by genes as well as the environment, like being out in the sun. Credit: mikebaird

Although we know that some variation in colour can be explained by differences in genes, we also know that variation in the environment – such as sun exposure, can affect the colour of peoples' skin.

So variation in skin colour is caused partially by variation in genes and partially by variation in environment.

Some strange consequences of heritability

As heritability is a measure of the causes of variation in traits, things which we ordinarily think of as having a genetic basis can turn out to have low heritability.

For instance "walking on two legs" is a human trait which does not vary much. When it does vary, this is usually due to environmental variations, such as accidents where people lose the function of one or both legs.

As a consequence, "walking on two legs" has an h^2 close to 0. This does not mean that genes are not necessary for humans to walk on two legs. What it means is that variation in this trait is caused by primarily non-genetic factors.

Another strange consequence of heritability is that the estimate depends upon which population you examine.

For example the heritability of hair colour in a Chinese population would be quite low, yet in Australia would be quite high. This is because in China there is little "natural" variation in hair colour – variation that is genetically caused. As such, any large variations are usually due to environmental factors, such as artificial dyes.

So while heritability does measure the causal impact of genes, it does so in a very specific and limited way.

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