



## When Trauma is Passed on through Generations

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Transgenerational trauma is the transmission of the effects of traumatic experiences through generations via genetic inheritance. In other words, a father's trauma can change his genetic profile which is inherited by his son and grandson. This phenomenon has been well-documented since World War II (WW2) where the Holocaust and the Dutch Hunger crises led to transgenerational trauma in millions of families. This article discusses the transgenerational trauma aftermath of WW2, and dives into the new neuroscientific results that uncover how these trauma-induced epigenetic changes affect the brain and behavior of human beings. The article finishes with a discussion of what types of experiences can trigger transgenerational trauma, and reflects how the COVID-19 pandemic may be the source of a new wave of transgenerational trauma. The article was first published in 'Subkit' on August 01, 2022 (<https://www.subkit.com/pernillebuelow/posts/when-trauma-is-passed-on-through-generations>).

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## Abstract

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## What is transgenerational trauma?

Before we dive into the research, let's first define what is meant by transgenerational trauma (it's a long word, isn't it?). You are most likely familiar with the second word "trauma". According to the [American Psychological Association](#) (also known as APA), "Trauma is an emotional response to a terrible event like an accident, rape, or natural disaster. Immediately after the event, shock and denial are typical. Longer term reactions include unpredictable emotions, flashbacks, strained relationships, and even physical symptoms like headaches or nausea. While these feelings are normal, some people have difficulty moving on with their lives." I would like to add to this definition that trauma is not just an emotional response, but really a physiological response. Trauma changes our bodies, and these changes can sometimes be so debilitating that they halt our lives and require intensive treatment of all sorts. In future newsletters we will be diving more into what happens in the brain during acute and chronic trauma responses.

Now, transgenerational is defined as "acting across multiple generations". In other words, the effects of one person's experiences (in this case, traumatic effects) are transmitted to their offspring (i.e. children), and potentially their subsequent offspring as well.

Did one of your parents or maybe grandparents live through trauma? If so, you may be biologically affected by those traumas as well even though you did not live through those events. Personally, my paternal grandmother lived through World War II (WW2), with bombs dropping in her backyards and losing loved ones from warfare with serious consequences for her mental and physical health. Interestingly, most of her children (my father and his siblings) and her grandchildren (me and my cousins) all experience various mental health challenges and claustrophobia. Maybe you have a similar story?



## The first modern insights into transgenerational trauma

Century old fictional and non-fictional books are full of accounts of events that describe transgenerational trauma, but at the time there was no scientific backup. However, at the end of the second World War data was emerging from Dutch citizens that had lived through a year of severe hunger crises from 1944-1945, also known as the hunger winter. Women that were in the first half of a pregnancy during the hunger winter gave birth to children that had greater risk of metabolic diseases and mental health challenges (Kaati et al., 2007). Intriguingly, these consequences were not observed if the women were already past their first half of the pregnancy before the hunger winter started.

This tells us that there is something special about the first half of the pregnancy that predisposes fetuses to develop metabolic and mental health disease. Now, this phenomenon is “just” an example of what happens when a fetus does not receive the proper nutrients during pregnancy. The most interesting part was what happened to these children’s children. As you can tell, it is now starting to get confusing with which children I am referring to, so I am going to use the scientific lingo to clarify my definitions. The women pregnant during the Dutch hunger winter are referred to as the F0 generation, and their children are referred to as the F1 generation. Note that the F1 generation had an otherwise normal childhood, it was only during the pregnancy that the F1 fetuses did not receive the sufficient nutrients. Yet, the children birthed by the F1 generation, i.e. the F2 generation, also showed an increased risk of metabolic disease and mental health challenges. However, this was only the case when the F1 mother had become pregnant with a man that was also at risk for metabolic and mental health disease, e.g. a man that had also been conceived during the Dutch hunger winter.

What does all of this imply? It suggests that there is some genetic code in the germ cells that are 1) affected by nutrient status and psychological stress during the first half of the F0 pregnancy and 2) passed on to future generations although they have not been exposed to the lack of nutrients or stress.

Studies on the children of parents that lived through the Holocaust have also pointed to a transgenerational transmission of mental health challenges: as adults they were more likely to suffer from post-traumatic stress disorder (PTSD) (Levav et al., 1998; Solomon et al., 1987, 1988; Yehuda et al., 1998). Other studies have



reported higher rates of depression and behavioral problems in adolescents born by holocaust survivors (Major 1996).

This transgenerational transmission of trauma became a hot topic that many researchers debated. An important question was whether this transmission of trauma was rooted in the biology (i.e. the germ cells) of the children or rather a consequence of being raised by parents that had lived through the holocaust. Maybe holocaust survivors raised their kids in a way that made them more likely to become depressed and anxious?

### A timeline overview of transgenerational trauma based on data from the Dutch Hunger Winter and the Holocaust



Note that this figure represents heterosexual couples. This is not meant to mean that only cis-people are affected by these traumas. It merely reflects the way these studies were designed. Of course, eggs and sperm cells are necessary for pregnancies (for now at least!), but regardless of gender orientation these biological effects have implications. Future studies will have to address whether growing up in cis or non-cis parental households modify the expression of transgenerational trauma.

**Figure 1:** The documentation of transgenerational trauma at the psychological level across three generations of humans.

Several studies did go on to demonstrate that it is the environment in which the children grow up that determines how likely F1 and F2 generations are to develop anxiety, depression, PTSD, and other mental health challenges (Sorscher and Cohen, 1997; Schwartz et al., 1994). However, Holocaust survivors differ in how they tackle the long-term consequences of surviving the concentration camps. Some become depressed and anxious, some develop PTSD, others are primarily preoccupied with the events – perhaps leading to prejudices – while another



subpopulation may simply not talk about it and live the rest of their lives as if the holocaust never happened. As for the latter group, it is important to note that these are not holocaust-deniers, but rather don't want, or feel the need, to process and/or recall their horrific experiences. Why am I mentioning these varied responses? Because the way people process their experiences will affect their parenting style. We will talk much more about this in later newsletters, but the take-away for now is that parenting style, regardless of genetic transmission, can influence how children develop, and even how those children parent their own offspring in the future. This type of "trauma transmission" is referred to as "intergenerational trauma". It's incredibly challenging to disentangle the effects of biology and parenting style. The gold-standard is to evaluate how children that are born by holocaust survivors develop in adoption homes. I investigated that data, but the number of studies is pretty scarce, and clearly is very environment dependent. Anyhow, let's turn our focus back to transgenerational trauma and dive into what the neuroscience research has to say about that. Could there be a genetic component to the transmission of trauma observed in the F1 and F2 generations from the Holocaust and Dutch hunger winter?

## **The neuroscience of transgenerational trauma**

In 2014 a new study came out from Emory University, the university I received my PhD from, which demonstrated how a traumatic memory in mice could be genetically transmitted not only from a parent (F0) to an offspring (F1), but also to the subsequent generation (F2) (Dias & Kessler, 2014). In short, they replicated what had previously been described in humans from the Dutch hunger crisis. What was remarkable about this study was threefold:

1. In this study, it was only the male mice that were traumatized (i.e. trauma from just one parent could influence the offspring). They received an electric shock every time a specific scent was presented to them. Ultimately the male mice began associating the scent with an electric shock, which, unsurprisingly, led them to be rather scared.
2. Only after this traumatic memory had been established, did the male mice mate (F0) with a non-traumatized female mouse, and regardless of whether the mouse babies were reared by their non-traumatized mother or another foster mouse mom, these mouse babies (F1) were already scared of the scent their father (F0) was traumatized by, despite not receiving any electric





shock when smelling it! This was true even for their later babies (F2) too!

3. The last exciting part of this study was that the researchers observed changes in a particular brain region that is already known to detect smells. Specifically, the F1 and F2 generations both had larger neuronal structures known to detect the scent their father or grandfather (F0) were traumatized by. Moreover, they could trace the genetic transmission through the generations to an epigenetic change in the germ cells (just like the researchers from the Dutch Hunger crisis studies theorized!). Epigenetics is when a gene is modified by an experience that ultimately affects the genetic expression, specifically whether the gene is turned on or off, and it can impact how your brain (and body) develops and functions with consequences for behavior and mental health. There are different types of epigenetic changes one of which is called "CpG methylation", which, when in effect, creates "CpG islands" around the parts of the gene that are necessary for initiating the transcription of the gene. The more CpG methylation, the less transcription, and ultimately less protein expression of the particular gene. In this study, there was a reduction in CpG methylation of a gene called *Olf151* which encodes for a neuronal receptor called M71 (if you are not familiar with neuronal receptors, take a look at the 'Intro to the Brain' document I sent you when you first signed up), which the researchers already knew was activated by the traumatic scent. In the F0 generation, meaning the initial male mouse that received electric shocks, the sperm cells had a hypomethylation (a fancy, but slightly simpler, way to say reduced methylation) of the *Olf151* gene, and this was also true of the germ cells in the F1 generation. Peculiarly this hypomethylation was not found in the neuronal cells that had structural changes in the F1 and F2 generations (see the first part of this paragraph). Why is that? We don't know yet, but it likely tells us that methylation changes in germ cells can directly affect brain development and function without changing the gene expression in the brain. Confused? Hopefully not, but if so, I promise you we will get more into epigenetics in future newsletters.

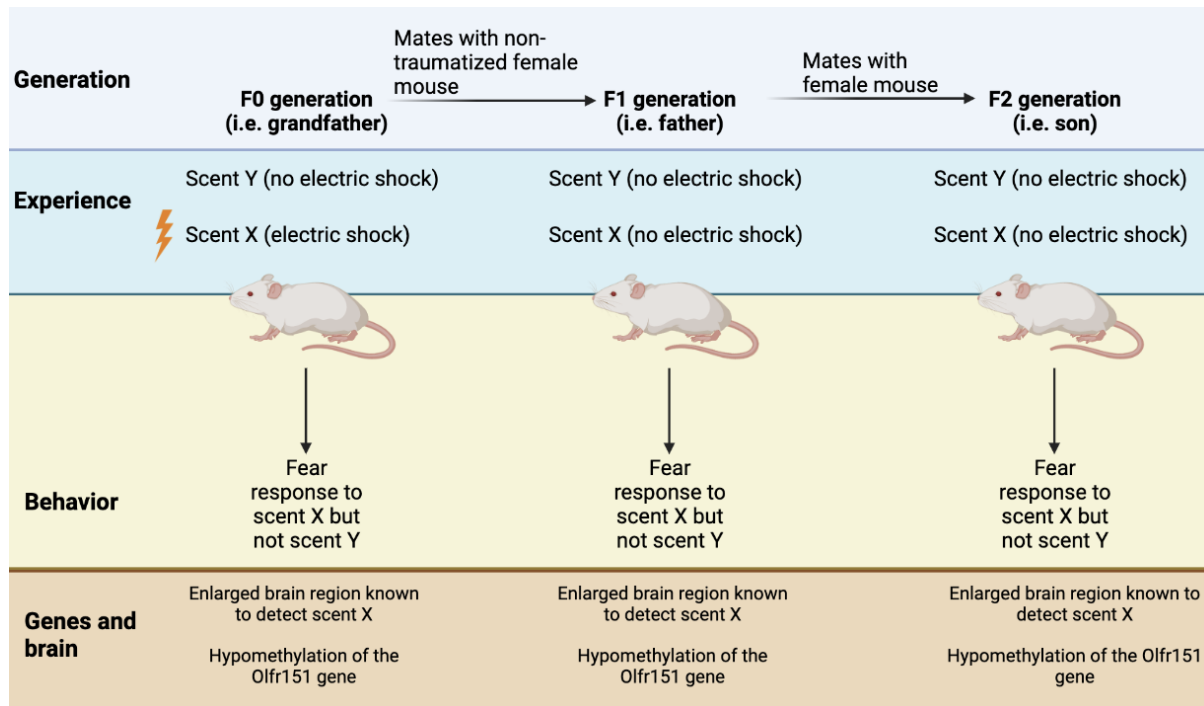


Figure 2: Experience dependent changes to the brain and epigenome of the F0 generation are transmitted to the F1 and F2 generations through the germ cells that carry the epigenetic modifications.

I just blasted you with information from one study. Have these results been replicated? Are they found in other species too? Yes, and yes. But do not fret, I will not go into as much detail. The biggest take away from this newsletter, and particularly the paragraph above, is that **experiences can change gene expression in your germ cells, which is then passed on to future generations**, including both your own children and your grandchildren. Most importantly, these epigenetic changes can ‘imprint’ a traumatic memory you had, in your children and grandchildren. This work is not just biologically interesting, but also has implications for how we think about the consequences of trauma. For example, should children from holocaust survivors be sent to war if we know that they are more likely to develop PTSD?

A recent study just demonstrated that exposure to chemicals in plastic products resulted in epigenetic changes in marine fish, which was passed on to both their offspring (F1) and the subsequent generation of marine fish (F2) (Cohen-Rengifo et al., 2022). Interestingly, this epigenetic change led to greater viral resistance to the chemicals (along with changes to their metabolism and scent detection). This





appears to be good news for the fish, and certainly reflects how humans are impacting other species through waste and climate change. Is the human epigenome changing in response to climate change? Are younger generations becoming more resistant to the detrimental effects of pollution? Science will soon tell us.

Do we know more about how these epigenetic changes may be represented in the biology of an infant? Yes. In fact, a study from 2014 found that infants from holocaust-surviving mothers diagnosed with PTSD have heightened sensitivity to glucocorticoids (Lehrner et al. 2014). Glucocorticoids are our stress hormones, the most well-known being cortisol, and when those hormones are released, it activates different parts of our body and brain. For example, it may lead to a suppression of inflammation and trigger an increase in growth hormone signaling. Typically, cortisol release is also associated with an activation of our sympathetic nervous system which releases adrenaline, leading to pupil dilation and heart rate increase. This means that infants born from mothers with PTSD are going to be more impacted by stressful experiences, and this may actually change their immune function as well as their body growth. Indeed, studies have found that females that grow up in stressful environments start menstruating and develop breasts earlier than same-age females that grew up in non-stressful environments (Ellis et al, 2011; Cesario and Hughes, 2007). The increased glucocorticoid sensitivity is most likely due to the hormones the infants were exposed to during pregnancy resulting in epigenetic changes. Whether these effects are passed on to the infants' future offspring was not covered in this study, however the study underscores how traumatic events, such as the holocaust, can affect not just one but multiple generations in a multitude of ways. Could this also be true for other types of traumas?



## **How bad does the trauma have to be & how far does the trauma extend through generations?**

The answer to both those questions is easy: we don't really know. In the next newsletter we will be talking about the effects of cumulative trauma, that is when you have many 'smaller' traumatic experiences that can lead to, sometimes sudden, full blown PTSD responses. Maybe this type of cumulative trauma also leads to epigenetic changes and transgenerational trauma?

As for the second question, we know that F2 mice (which could be comparable to holocaust survivors' grandchildren) 'inherit' traumatic memories. However, in humans, research has not (yet) uncovered whether great-grandchildren of holocaust survivors also have higher likelihood of developing mental health challenges. Does the transgenerational trauma transmission stop at one point? Could it be that depending on what type of environment you grow up in, you are more likely to be impacted by your biologically imprinted transgenerational trauma. Our current scientific knowledge suggests that this is likely the case.

It is important to note that the severity and likelihood of developing mental health challenges, with or without transgenerational transmission, is highly modified by the environment someone grows up. The communication style, socioeconomic status and geographical location can be greater determinants than genetics. I addressed some of that literature in the most recent Mental Health Newsletter. If you are interested in getting access to it, make sure to sign up for the Continued Education Plan (see link at the end of the article) and you can get a sneak-peak at the most recent article on the power of community as a mental health treatment approach [here](#).

### **I have so much more to say on this...**

... but clearly I am pushing the limits on this already lengthy newsletter.

So here are some quick thoughts:

- Other fantastic writers have emphasized that we should not pathologize entire generations simply because they descend from parents (or grandparents) that underwent trauma (Auerhahn and Laub, 1998), such as the holocaust but also slavery, colonial oppression, torture, severe poverty. What about racism? Sexism? Isolation? A pandemic? While we need to



consider how we can help these groups of people, we should not pathologize and assume them to be incapable of handling stressors.

- Am I writing this newsletter simply because I am a left-winged extremist who descends from a socialist Scandinavian country? No but.. it is correct that we currently live in times where transgenerational trauma is discussed more openly in political and public circles. However, this research originated 70 years ago and while it can appear to be an 'excuse' for reparations or policies that are leftist, it should be (and is by many politicians) seen as an explanation for why oppression, racism, and sexism, have much more far-fetched implications into future generations than we previously recognized. And that is something we need to consider and address accordingly. That, is **called research-informed policy strategies.**
- Transgenerational transmission may seem more negative than positive. Why did evolution lead subsequent generations to suffer the traumatic consequences of their parents and grandparents? There is a lot to say to this, but I will keep it to one thought: sometimes, just like the example with the marine fish mentioned earlier, transgenerational transmission can be biologically advantageous (i.e. more resistant to pollutants in the water). There may also be ways in which the children of holocaust survivors biologically benefit from transgenerational transmission.

If you are subscribed to the Continued Education Plan you will soon receive the next Mental Health research newsletter. This month's focus is on SSRI treatment. You think it sounds boring? I would challenge that idea by sharing [this recent news article](#) with you that summarizes how big disruptions have (finally) arrived on how clinicians and researchers (although this has been well-known among many neuroscience researchers for years) on what really causes mental health challenges such as depression, and what SSRIs can and cannot do in the treatment of these.

Have lovely day!



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