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No way out of the smartphone epidemic without taking into account the findings of brain research

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SUMMARY

The widespread use of smartphones since the beginning of our century has had a profound impact on the psychological and social development of children and adolescents. The research paper by Gertraud Teuchert-Noodt and Peter Hensinger analyzes, from a neuroscience perspective, how the digital media use influences brain development and why a change in approach is necessary. A central concept in the paper is the role of Systemic Neuroplasticity, particularly controlled by Hebb's learning synapse. For brain maturation up to young adulthood, neuroplasticity typically enables neuronal networks to adapt and function by maturing transmitters, hormones and even receptive fields. This process helps form stable neural networks and subsystems not only during early development but up to young adulthood. Screen media consumption leads to sensory-motor deprivation and reduces spatial-temporal experiences, particularly in high-associative brain systems responsible for psycho-cognitive functions. As a result, this can lead to long-term behavioral deficits, such as anxiety disorders, depression, decreased academic performance, and social isolation. The authors argue that the digitalization of educational institutions, driven by industrial interests, occurs without consideration of neurobiological findings of a half past century. International developments, such as the shift in Denmark and Sweden, demonstrate that avoiding digital media during childhood and adolescence are necessary to ensure healthy brain development. On the background of results the article advocates for a stronger focus on playful learning, holistic action-oriented approaches in education and analog social interactions to safeguard the long-term cognitive health of future generations.

Keywords: Children ; Adolescents; Digital media; Neuroplasticity

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INTRODUCTION

The smartphone came onto the market in 2007. A turning point that still has a serious impact on families, their children, daycare centers and schools today. In his book „The Anxious Generation", social psychologist Jonathan Haidt [1] defines this turning point as "the complete shift from the playful childhood we have had for millions of years to a phone-based childhood". He describes the serious impact on the psycho-social condition of children and young people: "Around 2012, young people's mental health fell off a cliff". This article moves from the phenomenological description of the negative symptoms of digitalization to the deeper causes. Neuroscience and human biology explain why digitalization is imperceptibly leading us to a dead end. Digitalization is a cyber-attack on the brain [2].

Turning point of times: Telephone-based socialization

In 2007, a digital euphoria began, if you wanted to prepare your children for the future, you had to make them media literate. Mastery of smartphones and tablet PCs was stylized as a key qualification. A network of IT lobby firms formed [3]. They spread the narrative "Leave the chalk age". In 2017, the German government adopted the Digital Pact for schools. Wi-Fi in schools became a hallmark of progress. For the first time in the history of education, industry dictated how nurseries and schools should educate children. Third-party funding flowed to educational scientists who legitimized "digital education" with courtesy studies [4]. Digital-savvy media educators still dominate the federal government's advisory bodies today.

Scientists formed the Alliance for Humane Education back in 2016 to combat this dehumanization [5]. In their publications, they warned of the pathological consequences of early screen use. They were labeled as old-fashioned alarmists. In 2012, the Baden-Württemberg State Media Center tried to refute Prof. Manfred Spitzer, co-initiator of the alliance and predicted: "What Spitzer is proposing won't be taken seriously anyway and is guaranteed not to happen - so the all-clear" [6]. Spitzer [7] notes in retrospect that the predictions in his book "Digital dementia" (2012) about how "excessive screen media consumption has a negative impact on learning, memory, attention and concentration, the ability to regulate emotions and social behavior" are fully confirmed by current studies, to the chagrin of a generation of children.

Medical associations and health insurance companies are sounding alarm: In response to the smartphone

epidemic, 11 German medical associations adopted the "Guideline on dysfunctional screen use for children and adolescents" (2023) and warned of the consequences Obesity, sleep disorders, eye disorders, developmental disorders, attachment disorders, behavioral disorders, internet addiction, bullying and sexual harassment, gambling, radiation exposure and postnatal effects due to use during pregnancy [8]. Prof. Christian Möller, head physician at the Hanover Department of Child and Adolescent Psychiatry, advocates the zero smartphone rule in his handbook "Internet and computer addiction":" Media literacy begins with media abstinence. Young children in particular need comprehensive basic sensory experiences and not a reduction to swiping and visual and auditory impressions." Movement and climbing trees not only promote cognitive skills, but also prevent many lifestyle diseases such as obesity, diabetes, cardiovascular diseases and short-sightedness" [9]. According to Möller, digital media in young children has a negative impact on language acquisition, writing, reading, creativity, and intelligence development. This is already an omnipresent reality. Health insurance companies are sounding the alarm in the face of exploding numbers of addicted children and the rise in language deficits and disorders [10].

Smartphone-designer drug of the tech companies: Children and young people are tied to their smartphones. Digital media, games, and apps are programmed for addiction, for the elimination of impulse control [11]. The smartphone is a drug. The child's brain cannot develop any defense mechanisms for it [12]. The number of children and young people addicted to the internet is increasing enormously [13]. The devices programmed for addiction by tech companies are cannibalizing the lives of our children and young people. Creative periods of silence, boredom, and contemplation are disappearing. Supper / Teuchert-Noodt have demonstrated the negative consequences of this sensory overload for brain development in a study of third graders: In particular, the space-time calculation in the frontal lobe remains underdeveloped [14]. School educator Prof. Klaus Zierer [15] concludes his meta-study by writing: "The longer children and young people spend their free time on their smartphones and the more time they spend on social media, the lower their learning performance at school". In 2023 forty experts from the fields of education and medicine from Germany and Switzerland called for an immediate stop to digitalization up to the primary school level in an appeal [16].

However, German education policy continues to follow the path of digitalization of education dictated by industry lobbyists. Given the study results, this is deliberate bodily harm. Even more and even earlier digitalization is being funded, right down to nursery schools, even though countries that were ahead of Germany in terms of digitalization are pulling the ripcord. Denmark is currently reversing digital education up to and including elementary school. Education Minister Mattias Tesfaye apologized, saying that children had been massively harmed and turned into "guinea pigs in a digital experiment" [17].

A report by Karolinska University in 2023 also led to the reversal of digitalization up to the elementary school level in Sweden [18]. Finland, the Netherlands, Spain, France, New Zealand, Russia, and China have drawn similar consequences [19]. The trend: children should only be given smartphones or tablets between the ages of 14 and 16. In the USA, the U.S. Surgeon General [20], the supreme health authority, intervened with an expert opinion on the threat to the mental health of children and young people posed by digital media. The UNESCO Education Report 2023 warns against early use [21].

The book by Jonathan Haidt should lead to a paradigm shift: Published in 2024, Haidt J's [1] book "The anxious generation. How the Great Rewiring of Childhood Is Causing an Epidemic of Mental Illness", was also a bestseller in Germany. According to Haidt, the smartphone is a product with "addictive content" that "pushes physical play and socialization through personal contact into the background", "Rewires childhood and changes human development to an almost unimaginable extent". Jonathan Haidt defines this turning point as "The complete shift from the play-based childhood we've had for millions of years to a phone-based childhood". Children are "Missing out on almost everything, while they pile up their online hours". They are here, but at the same time "forever elsewhere", in the TikTok worlds created by corporations. A "historic and unprecedented transformation of human childhood", with serious consequences: "Around 2012, the mental health of young people fell off a cliff". 700,000 children and young people in Germany are already considered internet addicts, 2.2 million as problematic users. Fewer and fewer children are mastering basic skills such as listening, arithmetic, reading and writing. The charts **(Fig. 1.)** from Haidt's book show that, as a result, pathological developments have increased massively since 2010: Depression, suicides, anxiety, feelings of loneliness and stress have up to tripled,

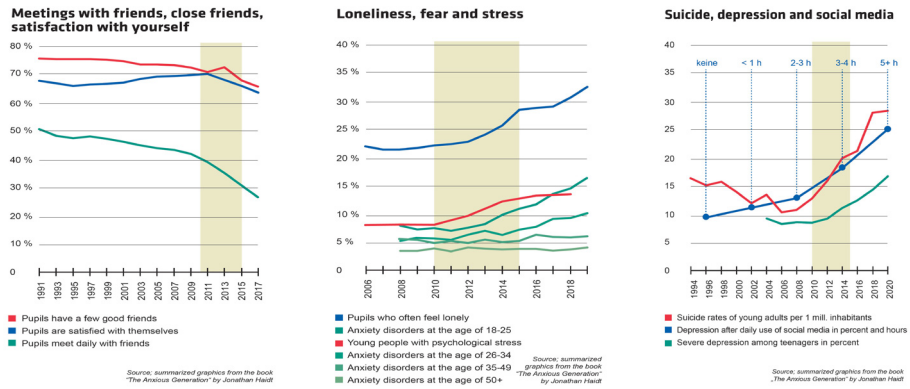

Fig. 1. Summarized graphics from the book 'The anxious generation' by Jonathan Haidt (2024).

friendships and social contacts are rapidly declining.

"Human beings are only human where they play" (Friedrich Schiller): Haidt's central thesis that the cause of this global mental health crisis is the complete switch from a play-based to a telephone-based childhood would have been confirmed by Friedrich Schiller. "Human beings only play where they are human in the full sense of the word, and they are only fully human where they play" wrote Schiller, who was brought up in Duke Karl-Eugen's training school at Solitude in Stuttgart. Haidt makes us aware of the great importance of children's communal play: "Free play is the work of childhood, and all young mammals have the same task: to wire their brains by playing wildly and as often as possible. Hundreds of studies with young rats, apes, and humans show that young infants want to play, need to play, and suffer social, cognitive, and emotional damage when they cannot play". In virtual game, however, the interactions are "disembodied; apart from swiping and typing, there are no muscles involved". The brain cannot wire itself. Turning away from play in the community, the "loss of affective coordination" in PC gaming prevents empathy from arising or atrophies it, making it incapable of life: "To thrive, children need a lot of free play. This is an imperative that can be proven across all mammalian species. The small challenges and setbacks that occur during play are like an inoculation that prepares children to face much bigger challenges later".

If creative but also risky play, roaming the neighborhood, adventures while hiking and climbing, walking to school together are missing because anxious helicopter parents tie their children to the digital umbilical cord, the result is an anxious generation. Jonathan Haidt sums it up: "It's as if we give our toddlers tablets with movies about walking, but these movies are so engrossing that kids never take the time or make the effort to actually learn to walk". The tablet-swiping, overstimulated, lonely and obese child, trapped in the net, becomes a modern-day Kaspar Hauser.

RESULTS (REV.)

Most previous publications, including Haidt's, impressively document correlations and symptoms but do not get to the mechanisms of action. The fixation on the leading question: "How do we use digital media?" steers us in the wrong direction in a targeted and sales-promoting way. It's about: How does a child learn? How does the brain mature? What do children need to grow up in a healthy way, develop their senses, their ability to reflect and their self-confidence? So, let's move on from the phenomenological description of the negative symptoms of digitalization to the deeper causes. The digital acceleration of space, time and information deprives children of the opportunity to "wire their brains". Brain research has shown just how profound the effects of digitalization can be, because they prevent maturation processes and imperceptibly lead to a dead end.

The causal mechanisms of brain functions have been well known to us for almost half a century now; they can be found in the textbooks for undergraduate students: On functional neuroanatomy [22], neuropsychology [23] and neuropathology [24]. AI-computer scientists have long consulted knowledgeable neuroscientists to elicit the last secrets of brain functions and program them into their addictive algorithms. This is precisely how they have managed to push the younger generation "over the spiritual/intellectual cliff" and earn themselves golden noses. Didn't our decision-makers have a duty to inform themselves professionally long before they initiated reforms that destructively affected school education?

Now to the point the brain is an ecosystem: The Chilean neurobiologists H.R. Maturana and F.J. Varela [25] put this message out into the world in the second half of the last century and triggered an intellectual tsunami with their book "The Tree of Knowledge". Autopoiesis/self-organization was the new buzzword that fell at the feet of dusty interdisciplinary scientists. Now it was possible to take a completely new look at our species Homo sapiens, it's onto-/phylogenesis and cultural history. The latter is obviously not just based on a definable gene pool, but is the result of creative, talented and expertly trained brains that have passed on their knowledge from generation to generation and opened their eyes to new horizons. But will our children still be able to continue a humane cultural history in the age of growing electronics? Asked more directly: Will we be able to bring Generation Z back from the other side of the cliff and save the younger generation from the same fate? These are the questions we want to address here. The brains of our children and young people and their mental constitutions are in grave danger.

The most complex of all ecosystems on the earth planet, our brain, grows and thrives in natural conditions, either mentally healthy or mentally slightly or severely damaged, depending on the environmental conditions it is exposed to. This is why the intelligence development of every child can be read from the given conditions. An epidemiological pilot study carried out a few years ago with a colleague showed us that prenatal experiences (stressful or stress-free pregnancy) already lay the foundation for the question of whether the schoolchild will perform well or poorly at school [26]. A metaphor, discovered during a hike on the Baltic coast and captured in the film "Aufwach(s)en im Umgang mit digitalen Medien" ("Waking up to/Growing up with/the use of digital media"), may illustrate this: Depending on the location, a beechnut can grow into either a tall beech or a crooked dwarf beech.

Like all ecosystems, the brain does not function in closed but in open control loops that are sensitively exposed to the environment and adapt flexibly. Neural adaptation means coupling brain structures to functions, coupling neuro-chemical processes to behavior and, in turn, adapting behavior to the neuronal ecosystem. This also takes effect prenatally, and that is why our children are different from what we once were. In the digital age, a cardinal upheaval of traditional space/time culture is underway, and the question arises as to what we must retain and what we can give up for technological progress? When it is said that we "must take our children with us into the new technological age", this is also self-evident from the point of view of neuroscience. But we cannot do this by digitizing them in childhood and adolescence.

Children and young persons must first be allowed to let space and time on our planet mature in their brains first using n e u r o p l a s t i c i t y in order to develop

their own intelligence and self-determination. Otherwise, they will become digital psychopaths, trapped in anxiety, depression, suicidal tendencies and more, as scientifically documented in J. Haidt's book "The anxious generation".

What is neuroplasticity?

At the time, two theories or working concepts were used to understand the neuroplasticity that dominates all brain functions. In fact, in the pioneering years of neuroscience, it was initially hypotheses that posed many questions and showed us researchers the way forward for half a century. Today, however, they can be regarded as largely proven theories of knowledge. We should be familiar with them in order to be able to deduce how smartphones and other electronics affect the maturing brain in childhood and adolescence.

The two theories are Hebb's [27] learning synapse and Wolff's [28] compensation theory. A synopsis of both is intended to show how comprehensively neuroplasticity from embryonic age onward, holistically controls the brain and behavior, from the molecular to the systemic level, and how susceptible it is to electronic technology. Neuroplasticity explains why human societies have been able to create advanced civilizations and now are rapidly becoming entangled in electronic networks. If we keep in mind the latest findings of J. Haidt mentioned above, then from a brain physiological perspective, a global decline of Homo sapiens cultures is not only foreseeable, but recognizable as being imminent. We still have to take countermeasures for our children.

Hebb provides the first understanding: Hebb's learning synapse (=NMDA receptor system; see Kandels textbook) [29] is at the center of all neuroplastic events that have to do with maturation and learning at the cellular and molecular level. It is particularly present in those places that deliver new information to the cerebral cortex, awaken alertness, curiosity, concentration and activate memory storage in order to organize the necessary everyday planning of life. This complex receptor system is always equipped with the same molecular attributes. It is remarkable that the subcellular processes in ionic and neurochemical back and forth pathways are basically the same as in macroscopic circuits: An initial "sensitization" enhances the neuro-chemical action profile of the synapse, the released transmitter (glutamate) locally initiates a process cascade that ultimately leads to sustained increased release and electrical excitation (=Long-Term Potentiation, LTP), which acts like an echo effect on ongoing excitatory conduction. We subsequently encounter this self-referential control and increase in arousal again at a systemic level under the keyword "reward system". The learning synapse virtually rewards itself and its immediate environment. It can retain an increased level of activity for a certain period of time, extend it to neighboring nerve networks and adapt them plastically.

An entire generation of molecular and electrophysiological neuroscientists has researched this fantastic learning synapse over the last century and, with increasing findings, dominated the annual neurobiology conferences from the 1960s to the end of the 1980s. A stress-free environment and repeated stimuli consolidate learning success epigenetically at the synaptic and molecular level and ultimately at the behavioral level. These processes are already activated and rehearsed before birth. How important it would therefore be to educate expectant mothers and guarantee them a sustained stress-free time. Moreover, these briefly summarized and globally known findings of the last century could be enough to make it clear that learning requires the student's full attention and that it should be ruled out from the outset to have a cell phone stimulating neuronal "sensitization" on the learning desk or in one's pocket. So why is Germany only now banning cell phones in schools?

It is not enough to refer neuroplasticity only to Hebb's learning synapse: Wolff's compensation theory has shifted the focus to the systemic level. Buzzwords such as "neuronal self-organization" and "activity-driven adaptation" of entire circuits came into play. In other words, genetically imperfect equipment of an embryonic brain can lead to a higher level of talent under favorable environmental conditions in childhood/adolescence than genetically perfect equipment can under unfavorable environmental conditions (see the beech metaphor). Unfortunately, unfavorable environments almost inevitably impose themselves on the child's brain in this technologically highly equipped age. Does this perhaps also explain why modern societies are classified as becoming increasingly dumber? [10], and doesn't the smartphone epidemic of Generation Z that began in 2010 have a long history? It is important to get to the bottom of this question in order to develop or revive effective concepts for a new and healthy upbringing for children, because sometimes the human genders are and have been quite well positioned. For the first time in recent scientific history, we also have real knowledge about the causes of digital dangers for children and young people. Those in positions of responsibility should use this opportunity to inform themselves professionally and act accordingly [30].

Wolff's concept of compensation did not fall from the sky. It picks up on the reactive neuroplasticity discovered shortly before the middle of the last century, which causes in patients with brain damage, for example after blindness, other healthy functions to reactivate the damaged area of the brain, in this case the visual cortex. In this process, morphogenic signals are emitted by the damaged neurons in the visual cortex or their released receptors in order to chemically attract environment-related activities. This brain's own repair mechanism was documented in an exciting book "If you could see what I hear – A blind man defeats his fate" [31]. This was also confirmed by certain thalidomide accidents. Children born without upper limbs were able to use their intact lower limbs to draw, write and work, if they were trained in time, in order to develop a healthy intelligence. It is the ubiquitous Hebbian learning synapse that allows fibers to grow and guide them to vacant neurons to (re-) functionalize them. The critical time window for this must be used quickly in the first weeks/months after an accident for sensory-related activities. This realization has been established in accident clinics and good therapy facilities since about the beginning of year 2000.

Is it conceivable that the mistakes made by children through the overuse of digital technology could perhaps also be made good, let's say reactively triggered, promising an environment related recovery for partial functions of the brain? Let's get to the bottom of this

question, because there is an urgent need for action in view of the increasing number of digitized children with language, reading, math and writing problems. For the developmental neurobiologist J. Wolff, the next flash of inspiration was obvious regarding his compensation theory, but the thunderbolt that was actually needed has yet to come: the keyword "reactive neuroplasticity" could also reflect a natural process in brain development in order to network the developing life with its environment systemically, right from the start. Even before birth, maturing neurons with free receptors and maturing neurotransmitters prepare the fertile ground to put existing nerve networks in a constant state of restlessness i.e. readiness for growth. This means causing them to flexibly expand, disassemble and reassemble their synaptic connections, and to do this through endogenously induced partial degradation and reorganization of contacts. The environment would automatically intervene in physiologically critical phases and induce a structure-function coupling. Individually, such phases would of course vary in time, i.e. they could not be precisely determined, but this should not interfere

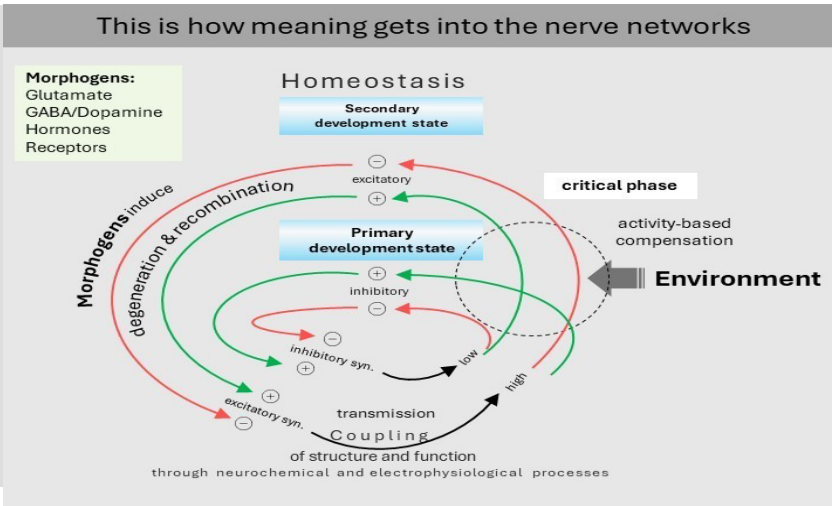

Fig. 2. Wolff's compensation theory (illustration from Wolff, Wagner (1983) 28, slightly modified): Self-organization of circuits in neuronal networks via neurochemical-electrical processes against the background of excitatory and inhibitory receptive fields. Transient states are always structurally and functionally related. Morphogens are the regulating forces that induce degradation and recombination of primary, secondary and tertiary circuit levels until an approximate stable final state is reached in the mature brain. Critical phases, in which environmental references from one switching level to the next through activity-controlled compensation.

with the process. Wolff has developed a clear model of this self-controlling organization of brain functions and the coupling with the environment (**Fig. 2.**).

Anyone who has understood Wolff's principle of functional reorganization by systemic neuroplasticity should be shivering right now. Students over 50 kept saying to me after this lecture, "My God, if I had known this earlier for the upbringing of my children". Any human embryo with a normal genetic predisposition could become a (highly-) gifted adult. In the mid-1980s, the discovery of receptors with a morphogenic signaling effect was awarded a Nobel Prize (Nobel Prize winner Rita Levi-Montalcini). At almost the same time, Wolff himself discovered that the classic neuromodulator GABA, which is omnipresent in the brain, also has a morphogenic effect; other neurotransmitters and hormones were soon added to this effect profile, including dopamine.

The conclusion is that during pre-and postnatal maturation, young neurons, maturing neurotransmitters and hormones have growth-promoting effect, like rain after a dry period, which allows the seed to germinate and the buds to sprout. Below we take this up for the maturation of the frontal brain, which is determined by such unsettled neurotrophic weather conditions until the $18^{th}/20^{th}$ year of life, only then being able to take the lead for all brain functions. If this guidance is prematurely entrusted to the smartphone, even to a limited extent, then this nevertheless causes a structural-functional habituation and permanently reduced memory storage is pre-programmed.

Defined time windows open the gates to the brain: The conclusion of Wolff's compensation theory is that in the maturing brain, physiologically unstable states open windows as if by themselves, in which the environment automatically intervenes *via* any activity and co-determines behavior. This happens in natural brain maturation, just as described above for the repair process after blindness. This is how relation enters the nerve networks. Learning and development are two sides of the same coin. Konrad Lorenz's filial imprinting of his graylag geese was and remains a vivid example of stable learning during critical phases in early childhood. There is no biology lesson in which this example was and is not played out with enthusiastic schoolchildren. The reverse is also true the Kaspar Hauser effect, which has become a cancer in today's digitalized childhood. This starts when the mother, while feeding her child, virtually refuses the eye contact instinctively sought by the baby by surfing on her cell phone. These little ones soon become frustrated "eye contact deniers" themselves with consequential damage at school age, such as ADHD syndrome, learning disabilities and drug risk [31].

The lasting damage caused by tablets in children's bedrooms goes far beyond the mental damage caused by TV in the living room, which has been known since the 1980s: Today, parents are putting a digital straitjacket on their child. They don't realize that the basic circuits between sensory-motor and emotional functions are formed in early childhood through sensory-related activities and lay the foundations for the complex functions that build on them. The conclusion must be to focus particularly on nurseries and elementary schools and to keep them digital-free. Instead, general play and craft activities, singing, reading aloud and drawing

must dominate the nursery and the (pre-)school day. The opposite view, that children should perhaps become strong through digitalization at an early age, is pure nonsense in terms of brain physiology and suggests profit intentions.

Critical phases are of course not limited to pre- and postnatal brain maturation but occur throughout childhood and again particularly clearly during puberty, when hormones with a morphogenic effect also demand their say in the highest cortex fields responsible for cognition. However, this also means that a global "Rewiring", which the book "The Anxious Generation" speaks of, does not really take place, but is based on individual previous experiences, from which, in any case, preconceptions are always taken along. There is much to suggest that Generation Z was already damaged or made vulnerable by cell phones, television and other technical stressors. It is likely that a large proportion of future young people will be even more digitally damaged. It is time to completely reorganize school education for young people, who are generally under a heavy burden today, for example, through practical training projects, a dual school system, etc. I base this proposal on the findings of brain research, which is why i would like to explain this in more detail here.

Space-time organized sensory-motor cortical fields are the prerequisite for a constant maturing of mental abilities, and this can also bring back digitized children

As in every ecosystem, successions, i.e. sequences of developmental stages, determine the slow path to the maturation of the highest brain functions. In the beginning, it is basic sensory-motor functions that lay the foundation for the all-determining spatial reference in the cerebrum and cerebellum and begin to strengthen it. Physical activities are necessary in order to really develop the foundation of the three spatial coordinates in a functional way. The main feeders are the sense of balance in the inner ear and the muscle and tendon spindles of the entire motor system. This is why the toddler is insatiably hungry for movement, in order to upgrade sensory and perceptual fields with activities from the horizontal, vertical and sagittal planes. These fields are located in the posterior and middle cranial calvaria. The tirelessly exploring crawling child demonstrates one-to-one what is going on in its little brain. And toddlers balancing on tree trunks, adolescents climbing trees and skate-boarders performing daring capers demonstrate the high demand for spatial sensory experience that persists beyond the early years of childhood and is now demanded by the maturing associative parietal cortex. We call it play. All play, arts and crafts, singing and sports give immediate expression to inner needs for the maturation of a cognitive foundation. In the early years of childhood, the enormous neuroplasticity of the cerebrum can be used at any time to smooth out and even repair previous damage.

Back to activity-based teaching: If sensory perception and processing precede the ability to act, this is not just an early childhood process. Rather, the maturation gradient that progresses forward from the posterior pole of the brain remains decisive for the further development of adolescent behavior. It is also advantageous for teenagers to prepare the cerebellum and the motor association cortex, which is intended for action concepts, for understanding vector calculations by building and constructing right-angled triangles and octahedrons in a spatially playful way. The pedagogical concept of the 1980s in this regard was called "action-oriented teaching". It is a whole-body approach and activates the spatial modules in associative fields to stimulate abstract thinking. While many generations of parents and experienced teachers have endeavored to help young people with such methods, this wealth of experience is quickly turned into a rope by Chat GPT. "Why learn French vocabulary when I can call it up on my smartphone at any time?" That's what the language teacher takes from his students nowadays. Hoping that this digital octopus can be integrated into the adolescent thinking apparatus through familiarization and practice is a huge mistake. This is because the human forebrain stands in the way, which is at the very back of the time scale of maturing brain fields and requires a great deal of personal effort. Its natural youthful weakness causes it to resort to convenience and all kinds of escape maneuvers in order to postpone strenuous thinking and memory formation. This is exactly what the already brain-infected narcissistic computer scientists and money-grabbing IT companies have grasped.

When the frontal lobe in a stressed child suffers an emergency maturation and adults are stressed by work overload

Through playful learning in childhood and action-oriented learning in early adolescence, the natural maturation gradient is brought forward from the parietal cortex to the frontal brain. In this way, the ecosystem in question moves towards a certain homeostasis, which defines the status of adulthood. When the age of 18/20 is formally announced as such, this happens against the background of the then somewhat matured frontal brain (prefrontal cortex) as the highest authority of control over fears and conflicts, control over social behavior and memory working, the executive. The prefrontal sub-functions mature in this order for the purpose of general impulse control: in the basal frontal brain, the anxiety control functions mature between the 4th and 6th year of life, conflict management between the 11th and 14th year of life and executive control between the 14th and 20th year of life [32]. Against this background, it is understandable why the term "The Anxious Generation" is already meaningful for the fact that psychotic anxiety behavior of today's smartphone youth has long been implanted in the child's forebrain. Corresponding maturation disorders are already creeping in among preteens when they are using their cell phones a lot. This was shown to us by an epidemiological pilot study conducted before the coronavirus. In this study, we used two specific test procedures for forebrain-related behavior, an age-appropriate "Time delay test" and a "Spatial" writing test **(Fig. 3.)**. Both have been clinically proven for decades to diagnose the mental state of patients.

If young people today are finding it increasingly difficult to be integrated into a work relationship, a "generation of weak motivation" is emerging. They are simply in a condition of inner failure when they wish to activate their own will *via* the frontal brain to initiate

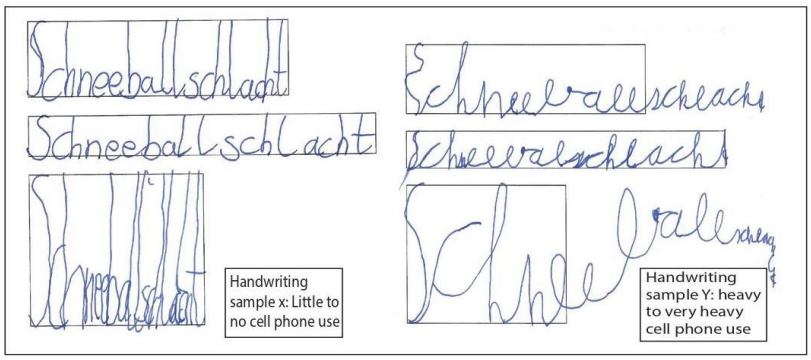

Fig. 3. The study by Supper/ Teuchert-Noodt (2021, note 14) showed that children who use their cell phones a lot have underdeveloped space-time mapping.

anticipatory thinking (procrastination). This phenomenon is far from inexplicable if we consider the fact that, according to neurophysiology, this is also a matter of the sub-functioning of parts of the forebrain, which have been replaced by the use of the smartphone as a life partner. Brain research emphasizes that also 16/18-year-olds in particular should still be protected from the devices. Our own studies have shown us that the prefrontal growth of fibers into distant association fields only picks up speed in this phase of life, and that stressors significantly hinder this [33,34]. So are children's cell phones already capable of sending little ones on the path to anxiety psychosis? Parents need to be educated.

An "emergency maturation" of nerve networks in the forebrain is the result of a long path through childhood, naturally through the child's brain itself. The cause of this has to do with an undersupply of the frontal brain due to inadequate intervention of the meso-prefrontal dopamine pathway. Under considerable stress, this pathway originating in the midbrain, from where the hippocampus is also supplied with dopamine by the meso-limbic pathway, can only intervene insufficiently in the basal frontal brain **(Fig. 4.) [**35-37]. Instead, the stress-loaded hippocampus consumes the noble growth hormone in excess to such an extent that the reserves in the mesencephalic dopamine nucleus are depleted. The result is an undersupply of dopamine to the maturing frontal brain stem. This also reduces the important flow of information from the brainstem. Think of a three-lane highway, one lane is closed, then two: traffic chaos is inevitable. Entire neuron fields and several neurotransmitters are involved in the local consequential damage in the forebrain itself, which ultimately have no other goal than to compensate for the lack of maturing products through local network amplifiers. But this decompensates partial functions of the forebrain and in the most extreme case – after early childhood traumatization – can lead to schizophrenia [33,37,38]. This is discussed in more detail in recent articles [12,14].

An increasingly digital workplace will also progressively deny employees access to their prefrontal cortex. Let's take a closer look at what mental work means: The healthy frontal brain works as a kind of collecting lens for content prepared in advance in sensory-limbic brain fields and forwards the data to various cortical fields *via* mature long pathways. These can develop thoughts and create memory traces. How many events are accepted by the various fields is determined by an endogenous clock *via* a 40 Hz frequency and the temporal oscillator set by the forebrain itself. In contrast to the rapid timing of information in the hippocampus, prefrontal stimulus sequences are broken down into events lasting several seconds [39]. This gives time to compare them with current circumstances and evaluate them mentally. The temporal profile can be used to make a conscious decision and initiate a memory trace. Each re-evaluation draws on stored content and creates a state of awareness that is retained for long moments and transformed into reflection, decision-making and action. Concentrated reflection means consciously shaping this process, and this requires real time. Convincing examples of fleeting and erroneous *vs.* a slow and error-free thinking can be seen in the illustrative case studies in Kahneman's book [40].

The enormously high and ever-increasing digital work intensification affects demanding mental activities like a cloud of haze that spreads paralyzingly over the employees. Aspects of the information remain undigested in the undergrowth of nerve networks like swallowed morsels of food, leading to wrong decisions paralyzing the quality of work and life and leading to burnout, which is based on physiological frontal brain failure.

Fossil history also reflects current findings from brain research: At this point, a phenomenon from fossil primate finds should be mentioned, which illustrates why mankind is currently putting its highest genetic material at risk with the prefrontal cortex. Spouts from fossil skull calvaria also contain the impregnations of the blood vessels that enter the brains cerebral convolutions *via* the surface. This made it possible for paleontologists to decipher phylogenetic lineages from fossil spouts, as the level of blood flow achieved in each case provides information about the hierarchical status in the primate family tree [41] (**Fig. 4.**).

In Neanderthals, the maturation of the cerebral blood vessels reached approximately the same stage as in Homo sapiens in early adolescence; it had only just arrived at the premotor cortical fields, and progressive parts of the vascularization reached the forebrain even less quickly, in order to create an executive floor in them as well. The receding forebrain and receding chin of a Neanderthal facial skull also provide further evidence that our cousin, with an only slightly developed forebrain, was not yet able to think to the same extent as Homo sapiens sapiens – in historical categories – and was not yet able to speak in a truly articulate manner with a larynx that had not yet fully descended. If our children growing up digitally are underdeveloped in basic skills such as reading and writing, they run the risk of epigenetically slowing down the blood supply and maturation of their frontal brain. We have long been feeling the effects of this on their intelligence development and social behavior. To put an

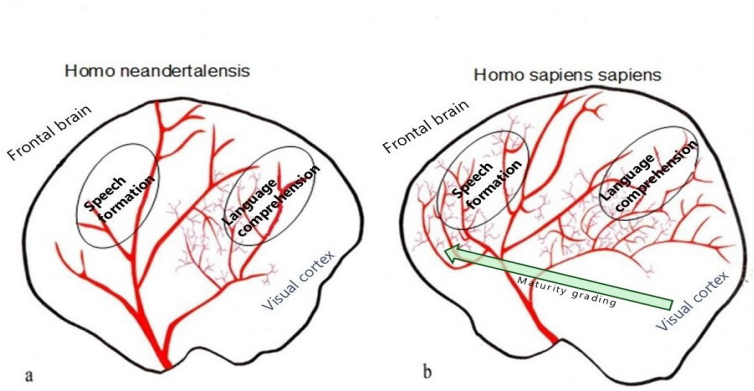

Fig. 4. Reproduction of the inner skull wall of Neanderthals and Homo sapiens sapiens: The blood supply to the brain in the Neanderthal skull corresponds approximately to that of a small child; fine vascular ramifications are found in the occipital lobe of speech comprehension, but they are absent in the parietal lobe of motor speech formation.

end to this development that is corroding our society, we need to systematically reverse the use of electronic devices in schools and families. Bans on cell phones and tablets would become a lifeline for the survival of our society. This anchor is also hidden in the brain and can be accessed *via* special properties of the limbic hippocampus.

The limbic hippocampus – secretary for the forebrain

What executive floor does not have a secretary? This function is the responsibility of the hippocampus, which is positioned in the center of the brain and has its doors open to all the senses that constantly feed it from sensory cortical fields and the brain stem. It does what every secretary does: it checks the content of all inputs at the rhinal entry gate and stores them in neuronal grids that create a spatial memory, as was recently researched and honored with a Nobel Prize for its great importance. This is why we can find our way around spatially from memory at any time, let our practiced hands glide blindly over the computer keyboard anchored in the grids and race along the motorway at the same top speed. And the secretary manages all this in a 30-40 millisecond cycle [40]. An oscillator contributes constant theta activity (4-8 Hz). Initially stored in the clearly organized hippocampal cortex, the information is then passed on to the frontal brain and cortical fields for long-term storage.

We can deduce from this alone what permanent damage the spatial organization of the secretary suffers when the toddler wipes over the tablet instead of playing with building blocks. In the hippocampus are concealed other sub-functions that regulate our state of being in the unconscious. It cooperates with thalamic reflexes and operates a kind of Skinner-box-learning, i.e. classic conditioning. The accelerated thumb wiping across the screen turns the hippocampal circuit into a turbulator. As a result, there are no limits to the omnipresent work intensification in professional life either, and desk workers are becoming subcortical work machines. With all this, who can seriously hope that children can learn to use a tablet sensibly while their healthy counterpart, the frontal brain, is still in diapers? Even adults find it extremely difficult to switch on the frontal brain when they can do without it with the help of electronic housekeepers. A digital addiction is pre-programmed in cell phone and tablet schoolchildren. Because this also means the ubiquitously necessary spatial calculations cannot mature sufficiently, this has the most serious consequences for the entire development of children and young people [42].

The danger of digital addiction: But that's not all: two helpers support this hippocampal turbator as neuronal bypasses (**Fig. 5.**), and TikTok thus captures even the youngest of consumers. One of the helpers connects the hippocampus with the amygdala and thalamus (yellow)

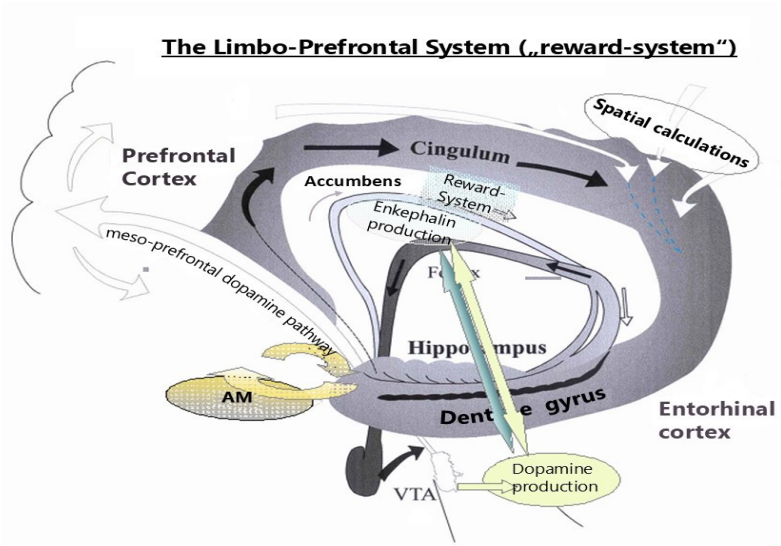

Fig. 5. The limbo-prefrontal system with its incoming and outgoing connections (marked by arrows) between hippocampus and forebrain is at the center of cognitive brain functions: The amygdaloid-hippocampal bypass (from AM: yellow) and the mesencephalic-accumbal bypass (from VTA: green) support the hippocampal circuitry in its versatile functions (e.g. as a reward system) and form the basis for an addictive disorder.

and allows emotions and likes to flow. The second, as a "reward system", connects the hippocampus with a back and forth switch between mesencephalic dopamine and accumbal enkephalin (green). Its self-amplification was documented in the 1980s *via* the pathological densification of opioid receptors after drug consumption. In our laboratory in Bielefeld, we were able to document that stressors in childhood also lead to pathologically increased dopaminergic innervation density in diverse limbic areas. This means that this neuronal bypass is extremely susceptible to both substance and non-substance drugs and anchors the excessive demands of addictive behavior in the circuits of the afore mentioned turbulator.

If the casual term "reward system" was also used for compensation-system at the time, this has to do with the self-rewarding that primarily describes a behavior that is evolutionarily important for survival. It matures from birth in order to strengthen the parent-child bond. And what person is not subject to this life-giving self-reward in their play behavior throughout childhood? Bouncing the ball eternally on the pavement, constantly driving the spinning top with the whip and hurling oneself through the air on the roundabout, this challenges all the senses and the two bypasses. An addiction? Yes, of course, and it leads the child from one level of difficulty to the next. At some point it gets boring and that is the moment when the forebrain switches on because it wants to conquer new horizons, matured by the tireless play activities. But the playing on a cell phone is not really playing for the child. This is because the real spatio-temporal demands anchored in the limbic system are missing. All of the aspects of sensory-motor development described above cannot take effect because the child's natural hyper-activity remains trapped in the two bypasses and cannot reach the frontal brain to activate it for further maturation.

"A fountain of youth in the brain" ensures systemic neuroplasticity: With this cover title, SPIEGEL 2000 brought the message to the public that in a certain hippocampal region, the dentate gyrus, young nerve cells are formed from an embryonic germ store throughout life. This was supposed to help people suffering from Parkinson's disease, dementia and mental illness. However, this promise was not fulfilled because technically implanted embryonic neurons are systemically integrated and then, of course, did not play along as expected. Nowadays, the Neuralink-Implanter would do well to reflect on former surgical failures in patients in order to spare its test subjects unspeakable suffering. The dentate gyrus is a caretaker of lifelong neuroplasticity for all the sub-functions of the hippocampal secretary described above. This is the last chunk that patient readers will have to endure. And it even promises salvation from digital media addiction. However, it requires a great deal of effort and a rejection of those seducers.

Hidden in the cortex of the dentate gyrus is an embryonic germ store (**Fig. 6.**), from which young neurons mature throughout life and infiltrate the local nerve networks to ensure local reorganization [43]. How clever: This is where Wolff's compensation theory comes into play for our entire life. Like the spider in the web, this manager of neuroplasticity has reserved the center of all events for itself in order to impart systemic neuroplasticity to the mature cortex from here with radiating hippocampal force [44]. It was and remains the center that strives to adapt all behavior to the environment in a meaningful way. A guarantor of our lifelong curiosity, alertness and ability to learn. Even 80-year-old deceased people have been shown to have retained neurogenesis.

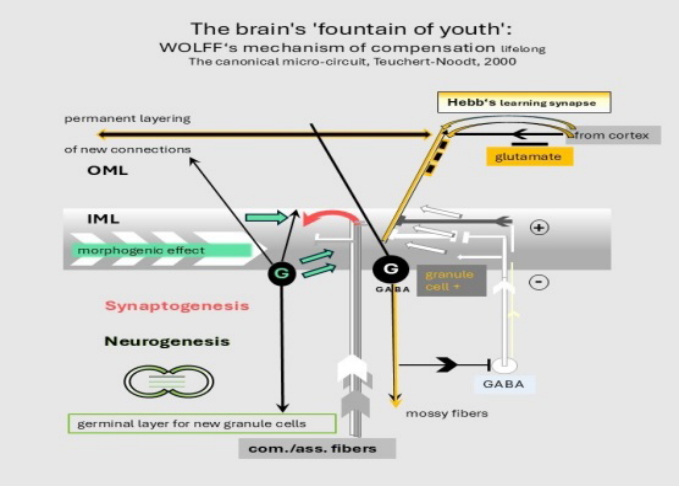

Fig. 6. Neurogenesis and synaptogenesis in the dentate gyrus, illustrated by a canonical circuit. According to Wolff's compensation theory, maturing granule cells are integrated into the existing circuitry with the morphogenic effect of their receptors (green arrows); synaptic degradation and recombination (red arrow) is restricted to the Inner Molecular layer (IML), while new connections are constantly added in the outer molecular layer (OML). Hebb's learning synapse determines the external excitation potential, which has a direct effect on the dynamics of neuro-and synaptogenesis.

Ways out of addiction and hope for harm reduction of digital addicts: One conclusion of the explanations on lifelong neuroplasticity in the hippocampal system is that we should regularly feed the "fountain of youth" with natural activities to make optimum use of its plastic potential. Only these provide what the seismograph (the NMDA- receptor system) needs, namely rhythmic activities and natural spatio-temporal experiences. Therefore, there is a therapy program suitable for all age groups: walking, scootering and cycling. The tasks associated with learning and practicing cycling (movement, balance, attention, and coordination tasks) are crucial for the ability to organize and train all three dimensions of our planet in space and time in the brain. Sports pedagogue Christian Burmeister, who is currently offering extensive courses in this area not only in Hamburg's schools, could

tell us much more about this. This is a teacher initiative that needs imitators.

"Human beings are only human where they play". This quote by Friedrich Schiller remains relevant to this day. Increasingly, rehabilitation facilities are finding that neurodegenerative patients are helped a great deal if they play, dance, make music and sing a lot. In this way, they can delay, reduce and make the illness more bearable. It also helps enormously in drug withdrawal if patients are introduced to sports, handicrafts, gardening and other outdoor activities. In special education, it is part of everyday instruction to support disabilities specifically through the use of such practical educational measures. Of course, all of these experiences also apply to digital drug withdrawal in order to help children and young people who are already addicted. It is always necessary to avoid digital devices altogether, at least in private, in order to train nerve networks as well as movement muscles. The purpose of this article on cellular, reactive and systemic neuroplasticity in the human brain was primarily to highlight the current dangers of electronic technology that threaten us as individuals and as a society and to which the young „Anxious Generation" in particular is currently exposed. At the same time, the aim was to raise awareness of how digital brain damage can be avoided but also repaired again [45].

What can we learn from brain research for everyday life?

From the principles of brain functions presented in this article on the activity-controlled adaptation of nerve networks and functional systems during the maturation of the child's brain, consequences for education in childhood can be derived. It became clear from our presentation that all these steps towards healthy brain maturation are blocked by digital media. The digital acceleration of space, time and information, the reduction of the urge to move to playing games and swiping, deprive children of the opportunity to "wire their brains" (Haidt). Against the background of current findings from brain research, these rules become generally binding.

(1). It is important to protect the developing life and the infant from stressors of any kind, because endogenous rhythms and primary reflexes mature *via* the brain stem before birth, which together prepare the ground for constructive functions such as sleep-wake activities and the replacement of reflexes by more complex movement patterns.

(2). It is important to practice socialization in the parent-child interaction field, as the first aspects of a basic motivational and social disposition mature in early childhood *via* the aminergic transmitter pathways (especially the dopamine pathway) that ascend from the brain stem into the frontal brain.

(3). It is important to allow and encourage children's urge to move, but under no circumstances should it be suppressed by televisions, computers and smartphones. This is because early childhood patterns of movement coordination gain access to spatial processing through the maturation of highly selective cortical circuits.

(4). It is important to promote emotionality and general curiosity, as limbic circuits undergo a high level of dynamic maturation in early childhood and the formation of lifelong circuits that later on, determine the basic disposition for the general mood.

(5). It is important to nurture one's imagination individually, because cortical circuits are initiated in early childhood that give rise to more complex circuits that trigger thinking and memory.

(6). It is important to protect the child from overstimulation and excessive demands, as the various aspects of movement, emotion and cognition mature in temporally and spatially assigned sequences. The child signals this in the context of selective attention.

(7). Conflict management, tolerance and basic ethical principles must be practiced, as these skills are not innate, but must be learned. Against the background of the progressive maturation of nerve cells and functional modules in the cortex, any environmental stimuli have an impact on their design and coupling to the functions during the development of an individual person.

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