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Break out the trumpets and fanfare, the CNS is starting a new decade! While ringing in the new year, we’ve been busy putting together an exciting new issue to get you in the groove of 2020: The Neuroscience of Music. Almost everyone loves a catchy melody but there are many reasons to crank up the beats: learn about how music can promote cognitive flexibility (p. 11), productivity (p. 18), and perhaps mathematical ability (p. 26). What’s more, there’s great evidence to suggest that it can be used as a tool to treat mental disorders and dementia (p. 24), though sometimes, musicians can find themselves in some neurological difficulties of their own (p. 21). But what about if you’re tone deaf (p. 16), or your roommate’s death metal playlist is causing... concern (p. 14)? Don’t worry, we’ve got all the answers right here.

While jamming away to your “Finally-Doing-Those-PCRs” playlist, also be sure to check out our continuing “Dr. Brown” series on skills gained during your PhD (p. 32), an interview with the founder of International Women in Science (p. 28), and see what amazing conferences and talks have been happening in Berlin (p. 32). And if you should throw down your headphones and say “Enough of this! I’m going to be a DJ!”, we have an interview with a neuroscientist doing exactly that (p. 7).

For this issue, we’re also proud to welcome some new members to the editorial team: Shereen, Juliana, Zoya, Tejaswini, Sarah, Lolo, Genevieve, and Felicitas. Without their commitment and eye for detail, this issue would have never been possible!

On a final note, on behalf of the CNS Newsletter team, we hope that you, your friends and (lab) families had relaxing and wholesome holidays. We’re looking forward to a whole new decade with you, and wish you all the best in 2020!!

Bettina Schmerl
Alex Masurovsky
Ioana Weber
Constance Holman
Co-editors in chief

Like what you see?
Interested in contributing? We are always looking for new authors and submission on anything related to the topic of neuroscience and beyond. Send us an article, some beautiful shots from your microscope, poems, short stories, critiques, reviews, anything! The best contribution will be rewarded with the book The Future of the Brain edited by Gary Marcus. Come on and write like there’s no tomorrow! Send your contribution to cns-newsletter@charite.de to win.

This issue’s winner is Steve Garofano, who wrote an entertaining and enjoyable article on rhythm perception (page 4). Congratulations, and thanks to everybody for their contributions!
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Music Was My First Love And Will Be My Last
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Music for and by people with disabilities...22
While it seems rather banal, humans’ ability to detect the beat in music is, in fact, a rare feat of computation. Although recent evidence suggests that some animal species may be capable of synchronizing their motor activity to a repeating auditory stimulus (see Alex the parrot and Ronan the sea lion [1]), humans have the unique ability to infer periodicity in auditory stimuli which may not explicitly contain that periodicity.

What does that mean, exactly? Give a listen to James Brown’s 1968 hit “I Got the Feelin’”[2]. The song is rhythmically complex, with accents falling in unexpected places, and yet, moving to the beat is gratifyingly easy. However, in order for you to continue feeling the pulse while Brown and his band weave in and around the beat, significant cognitive and perceptual computations are required. Neural oscillations provide the means for those computations, and thus, subsequent hip shakin’. But, before delving deeper, let’s define some terminology at the intersection of music and brain science.

Musical Time and Rhythm
Time in music is hierarchical, with divisions broader and finer than the fundamental pulse at which you might tap your foot. In Western music, that fundamental pulse is called tempo. Tempo describes the rate of evenly spaced musical beats and is quantified in beats per minute (BPM). However, as scientists, we may prefer to describe tempo in Hertz (oscillations per second) as a measure of frequency. If you venture into a Berlin club, the techno music you hear will likely have a tempo near 120 BPM. Described as a beat frequency, this tempo would be 2 Hz (120 BPM/60 sec = 2 beats per second) [3].

The hierarchical level above the beat is called meter, which describes the grouping of beats into a unit called a bar or measure. In popular Western music, a bar typically has 4 beats, creating a quadruple meter. A waltz is an example of a musical style in which 3 beats define a bar, creating a triple meter [4].

Tempo and meter provide a temporal framework against which we can perceive rhythm, which we’ll define as an expressive pattern of musical note onsets, durations and accents. The music of James Brown is full of excellent examples of rhythmic syncopation, where the musical content does not always fall on the beat [5]. While the familiar ‘4 on the floor’ of techno music clearly indicates each beat, in the case of “I Got the Feelin’”, some notes in the rhythm fall in-between beats, while other beats are left silent. Syncopation builds a sensation of rhythmic tension and, when wielded properly by Brown, et al., it creates a powerful urge to dance.

Entrainment to the Beat
If we were to look at “I Got the Feelin’” as a time-series of sonic amplitude events, we would see that musical sound does not occur on every beat, yet we feel the beat continuing unbroken as the band syncopates. We perceive a periodic pulse despite the fact that the music does not explicitly sound that pulse [9]. In order for a listener to feel the beat as a regular framework continuing steadily despite rhythmic variations in the song, recent music neuroscience research indicates that neural oscillations in the auditory pathway entrain to the beat. Entrainment describes the ability of ensembles of sensory neurons to adjust the phase or period of their oscillations in order to synchronize to a regularly repeating external stimulus [6]. In the case of our James Brown song, neurons in your auditory pathway adapt their cycles so that their oscillations align with the foot-tapping pulse.

Several lines of cognitive neuroscientific theory converge on the idea that by synchronizing the rhythmic activity of neurons in perceptual networks to the rhythmic activity of repeating external stimuli, organisms are able to improve their perceptual accuracy and predict the future activity of that stimulus [7, 8]. If oscillatory activity in a listener’s auditory network is synchronized to a repeating musical beat, that listener is able to predict when the next beat will happen. Dancers, musicians and even passive listeners are not reacting to every beat with surprise. Rather, they can predict that the beat is coming, given the internal metronome provided by entrained neural oscillations.

Ongoing entrained oscillations allow the human brain to track a musical rhythmic stream and also provide a temporal framework against which syncopation and other complex rhythms can be judged.
When James Brown’s band plays an unexpected phrase, the listener understands this rhythmic surprise as a variation against the internalized, ongoing temporal framework. Interestingly, this phenomenon is proposed to exist in the visual domain as well. When we look at a bistable percept like Rubin’s famous vase/face, where one might see a white vase against a black background or two black faces in profile against a white background, neural oscillations in the visual pathway code for figure vs. ground. Similarly, neural oscillations underlie the perception of a musical background (the pulse of the tempo) against which we perceive a musical figure (a syncopated rhythm or an expressive solo) [5, 6].

**Neural Oscillations Track the Beat and Meter**

In examining EEG data recorded from the brains of subjects exposed to rhythmic music, oscillations can be identified whose frequency corresponds to the tempo of the music they hear. If we examine the EEG time-series of a person listening passively (EEG is no good when you’re dancing) to that techno track at 120 BPM, we would see ongoing oscillations, stable in phase and period (called steady-state evoked potentials or SS-EPs), occurring at 2 Hz. Additionally, because musical meter is often marked by accentuation on the first note of the bar, we would observe a sub-harmonic of the beat frequency oscillation corresponding to the meter frequency; in the case of our quadruple meter techno song, 0.5 Hz [6].

Given the steady beat of techno, it’s easy to imagine cells in your auditory pathway firing every time the bass drum hits. However, in the case of Brown’s “I Got the Feelin’”, where not every beat is sounded and some notes happen in unexpected places, it becomes clear that entrained oscillations are the key to tracking the beat despite complexities and variations in rhythm. The repetition in Brown’s music reinforces a listener’s perception of the beat, but even in the case of improvised, non-repetitious jazz music, listeners’ entrained neural oscillations provide a guide through which the rhythmic acrobatics of the band can be understood.

By allowing a listener to infer the beat, entrained neural oscillations give James Brown the opportunity to create rich rhythmic complexity safe in the knowledge that his fans will not trip over themselves. And, for those who feel inherently un-rhythmic, there is hope. Musical training has been shown to increase the strength of neural entrainment to musical rhythm and to improve musical beat tracking [3]. Few people are born with the rhythmic aptitude of the Godfather of Soul, but practice can improve anyone’s beat keeping. In addition, the hierarchical nature of musical time and the non-linear dynamics of the neural oscillations involved in perceiving that time mean that it’s possible for different listeners to feel the beat at different harmonics of the fundamental pulse. So, leave any shyness behind you and take your brain for a workout on the dance floor. Let your oscillating neurons guide you and you’ll never lose the beat.

**Steve Garofano**

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Neural entrainment is the process by which ensembles of neurons in sensory networks synchronize their oscillation in phase and period to that of rhythmic, repeating external stimuli. In music perception, evidence suggests that neural oscillations entrain to the frequencies of musical beat and meter. Polyrhythms are complex rhythmic structures in which two non-factorial rhythms co-occur over a common tempo. For example, if you walk down the street, your feet create a duple rhythm (based in two): left-right, left-right. If, while walking, you repeatedly count to three (a triple rhythm) in time with your footsteps (left-right-left; right-left-right), you will be the embodiment of a three-over-two (3:2) polyrhythm.

To investigate the effect of musical experience on entrainment strength to musical polyrhythm and to determine if stronger entrainment correlates with improved musical performance, Prof. Dr. Gabriel Curio and Dr. Gunnar Waterstraat of the Charité Neurophysics Group, Carola Bothe of the Freie Universität Department of Computer Science, and myself conducted an EEG study with a musical behavior performance task. While EEG was recorded, subjects listened to a 3:2 polyrhythm and were asked to complete either the duple or triple rhythm by striking an electronic drum pad when cued for that rhythm. We collected information on subjects’ musical background and compared this with their accuracy on the musical task and with EEG measures of neural entrainment to the polyrhythm stimulus.

We found strong relationships between musical experience and performance on the musical task. Increased musical experience correlated negatively with performance error and positively with performance consistency. Additionally, musical experience correlated positively with entrained oscillatory power at rhythm-related frequencies. A strong positive correlation was found between musical experience and entrainment at the first common harmonic of the duple and triple rhythm frequencies. This suggests that, with musical training, the brain can increasingly track the separate components of a polyrhythm in an integrated manner, via oscillations entrained at frequencies that encompass both rhythms.

A significant relationship between entrainment strength and accuracy on the musical task was also present in the data. By employing spatial filtering algorithms adapted to the purpose by Dr. Waterstraat, a strong negative correlation was found between the power of oscillations entrained at the duple rhythm frequency and error on duple rhythm trials of the musical behavioral task.

The results of the study strongly suggest that by entraining oscillations in the auditory pathway to the components of musical rhythm, the brain gains accuracy in musical rhythm performance, and that musical training can increase the strength of this entrainment. Additionally, the work showed the value of interdisciplinary scientific collaboration, given the team’s skill sets which ranged from neurology and electrophysiology to advanced algorithmic coding to experience as a professional musician. Dr. Curio’s interest in leading a team with a diversity of perspectives and training created a very productive and collaborative environment for research, which I’m grateful to have been a part of.
Perhaps when you imagine a mathematics PhD student, the picture in your mind is different from when you imagine a DJ. Alma Lindborg is both. Known to many as DJ Almaty [1], she is currently finishing her PhD in the department of Applied Mathematics at the Technical University of Denmark in Copenhagen. Though a native of Sweden, part of her heart may have always belonged to Berlin. This summer, she worked as a visiting scholar with AG Senkowski at the Charité, applying her specialized knowledge of mathematics to design, run and analyze an EEG study on neural oscillatory activity during speech comprehension. She was interested in how the brain integrates visual and auditory information when someone hears and sees another person speaking. Daniel Senkowski, a researcher and cognitive behavioral therapist, has a long record of investigating (and publishing on) neural oscillatory activity during multisensory integration. It was a good fit.

Also a good fit was Berlin, a major electronic music hub of the world. See what Alma has to say about math, music and chasing the flow state.

**Which came first? The love of DJ’ing or the love of science? How did you get started with DJ’ing?**

I’ve loved both music and science since I was a little kid, but in their current expressions these interests formed sometime in my early 20’s when I did my BSc in mathematics and also went out dancing a lot. Studying maths and dancing for me both share a pursuit of the flow state, of letting go of everything, losing track of time, but in two different ways of course. I would sit and study really intensely and listen to techno on weekdays, and on weekends I would go out. Friends told me I should start playing, but I didn’t dare until I joined a women-only crew that wanted to change the very male-dominated local scene. In that environment, taking up DJ’ing was easy because it felt like a politically important thing to do, and we were a group of enthusiastic people teaching and supporting one another.

**How would you describe your style of music?**

I like to mix a lot of different styles when I DJ and I’d say that my sets are pretty busy and eclectic, so quite different from some DJs who work with slower transitions of mood and intensity. The styles I play most frequently would probably be acid, rave, breakbeat and electro, although I also play more and more trance and progressive house. A lot of the music I play is from the early 90’s so my sets usually have a bit of an oldschool feel, but I like to mix it up with newer sounds. The oldschool feel is true for my own productions too, although I try to steer clear of the most nostalgic clichés.

**When we talked you seemed to really enjoy living in Berlin, and the music scene seemed to be a big part of it. Can you tell me what particularly draws you to this city?**

Berlin has a spirit of freedom and exploration, it attracts a lot of interesting people and there’s always something going on. So for me it’s a great place to live and work in. There are lots of places with an interesting music scene (London would maybe fit my taste in music better, actually) but the overall quality of living is a lot higher in Berlin. I think.

**What’s a great memory (or two) you have from a show that you have played?**

The best moments are when I feel intensely connected to the dancefloor and I can tell that people share that feeling with me. It’s happened many times when I played at local underground parties with lots of friends on the floor, of course, but also in unexpected places. Recently when I played at a pretty posh club abroad this older woman came up to me several times to say how much she enjoyed the music. I could tell she probably didn’t get to go out and dance to music she enjoyed that often anymore (she was probably a big raver back in the days though). That was a sweet encounter.

**Are making music and the study of neural oscillations related (other than the fact that they both involve you)?**

I’m keeping them separate for now. Of course there are a lot of interesting psychoacoustic aspects to making music (many of them probably related to neural oscillations), but at this point I’m not confident that connecting these two areas of my life would make my music (or research) better. I like my music to be about flow and spontaneity, whereas I have to be analytical and skeptical when I do my research. I’m really happy to have the opportunity to do both.

Alma will be returning to Berlin in 2020 for a post-doc position at Uni Potsdam, examining the neural correlates of an artificial neural network model for language comprehension based in predictive coding.

**The Scholar/DJ**

**DJ Almaty Is Getting A Dual PhD In Her Spare Time**

Alex Masurovsky

MA Student, Berlin School of Mind and Brain

1. https://soundcloud.com/almaty-international
What Is White Noise?

The Noisy Sound Of Silence

You probably know this sound of “nothing” when you try to find a radio station, when you listen to the sea in a shell or when, at the time of analog television, you accidentally spent your evening in front of a cryptic TV channel. But perhaps you did not know that it has a precise definition - not only for sounds, it has applications in physics, mathematics or even statistics - and that, on this basis, it is used in healthcare and scientific research!

...And there was white light... as well as white sound!

In analogy with white light, which is a mixture of all visible wavelengths of light, the audible white noise is a signal having equal intensity (in decibel, dB) along the band of audible frequencies (between 20 Hz and 20 kHz) giving it a flat power spectrum. Actually, if we listen to a flat spectrum noise with nothing beyond, nothing that could awake our musical ear, can’t we say that we listen to the sound of silence? Our ears are more sensitive to middle-high frequencies than the lower ones, which makes the hiss produced by white noise brighter than expected for an audio signal with a flat spectrum [1]. To remedy this, you can listen at pink or brown noises that emphasize the lower frequencies. To have a try you can visit the page “White noise & Co” on the website “mynoise.net” [2] or, for the most courageous of us, you can listen to one of the many “10 hours of white noise” videos that the platform YouTube hosts. However, it could be relevant to know that persistent exposure to loud white noise is seen as a modern form of torture through its sensory deprivation channel. But perhaps you did not know that it has a precise definition - not only for sounds, it has applications in physics, mathematics or even statistics - and that, on this basis, it is used in healthcare and scientific research!

White noise for sleep....

Back in the nineties, researchers made babies hear a continuous white sound and noticed that they were falling asleep earlier and easier and that this was associated with a decrease in pulse rate. This idea came from the fact that babies seemed to be calmer when listening to intra-uterine sounds - which were considered in this study as falling into the white noise category - and that white noise could cause the ambient sounds that could prevent babies from sleeping to be drowned out [4]. In the EEG (electroencephalogram) of adults listening to white noise an increase of the delta component was noted [3]. Delta brain waves have an oscillation frequency between 0.5 and 4 Hz and they usually occur exclusively during sleep in healthy individuals.

Why not use the air conditioner sound as white noise to improve sleep? In South Arabia, many people reported that they slept less well in winter than in summer because they no longer used their air conditioner, so researchers wanted to check this by comparing healthy adults that were exposed to air conditioner sound or not when sleeping [6]. Well, it turned out not to be significant... So, this winter, you can turn off your air conditioner!

...For cognition...

Many workers in open space listen to white noise to stay focused and not be bothered by the ambient sounds of their office. And great for them to do so as it seems that listening to white noise while performing a cognitive task, like learning new words for example, positively affects the success rate [7]. This little help given by the white noise is called "stochastic resonance". The white noise may have effects on cognitive function not only by improving the concentration in reducing the signal-to-noise ratio of ambient sound – as it seems to be the case when falling asleep [8] – but also by modifying dopaminergic pathways. In memory processing, the dopaminergic neurons of the substantia nigra play an important part in conversing with the hippocampus. The white noise boosts the activity of these dopaminergic neurons which may enhance the transmission of information to the hippocampus and may therefore improve the encoding of long-term memory [9].

...And for tinnitus

Perhaps you have already noticed that after listening to too loud music for too long you hear an annoying humming or whistling afterwards. No matter how many times you plug your ears, that sound is still there. Because this sound is “in your head”. Some people hear that all the time with more or less intensity, they suffer from tinnitus. The causes of tinnitus are not well known but in general, it coincides with a certain degree of hearing loss. For those whose tinnitus substantially reduces the quality of life, there is Sound Therapy, a non-pharmacologic method that relies on plasticity or rewiring of the brain in order to achieve down-regulation by listening to a continuous low-level white noise. It is also possible to mask the tinnitus (with Masking Devices) by increasing the white noise so that the patient cannot detect the annoying sound anymore [10]. However, the latter has recently been criticized because the continuous white noise exposure could worsen the maladaptive plasticity that may be the actual source of tinnitus. Therefore, in the long-term, one could end-up with the opposite effect. This could also lead to a hyperactivity of the central auditory pathway and generate adverse events like auditory perceptual problems [11].

Are neurons dancing on white sounds?

For a cortical circuit not to be totally anarchic, you need the population of neurons to work together. Each neuron has to decode the information sent by their buddies (input) to then send out itself information to the neighborhood (output). However, to have a coherent and functioning cortical circuit, the output of these single neurons, their action potential, has to be precisely correlated in time to the output of other neurons which are part of the same circuit. The capability of a neuron to fire an action potential at the right moment depends on its capacity to encode high frequency inputs hidden in asynchronous background noise and is called...
“dynamic gain”. Guess what, you can use white noise to test this capacity of neurons! The white noise is injected in the form of current with a current-clamp to the neurons and the frequency of firing or the action potential onset rapidness is then recorded and analyzed. This technique has, for example, an application in the “spreading depolarization” research field.

Injection of white noise to neurons after a brain tsunami

The spreading depolarization is poetically named “brain tsunami” and corresponds to a massive transmembrane movement of ions in cortical neurons, leading to a sustained depolarization, a corresponding depression of the spontaneous activity and cytotoxic edema. This wave can spread in the gray matter across a whole brain hemisphere at about 3 mm/min and originates, for example, from a brain injury that can be either an ischemic event, a hemorrhage or a brain trauma. In the case of ischemic stroke spreading depolarization starts in the core region where the neurons stay depolarized and will eventually die. However, spreading depolarization also invades the surrounding area where blood supply is less depleted. In this so-called penumbra region the neurons only undergo a transient and reversible depolarization and may survive. But even if they recover, are these neurons fully functional and back to normal after several hours? Until recently, this was not clear because the neurons do not look particularly impacted at the first glance. By studying the dynamic gain of neurons which had undergone a spreading depolarization and recovered from it, it was now shown that their capacity to encode high frequency inputs was significantly reduced [12]. In other words, they had lost their efficiency to function in a multi-neuronal circuit.

Who could have thought that the sound of silence has so much to say?... Ok, it is probably time for me to listen again at Simon & Garfunkel’s song...

Coline Lemale
PhD Student, AG Dreier

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Music is cross-culturally pervasive in human life, yet its exact functions and origins constitute an enduring enigma. Aristotle considered the power of music to be an unsolved riddle of human existence [1], and in the late 19th century, Charles Darwin ranked it “amongst the most mysterious [abilities] with which [humanity] is endowed” [2]. Since then, the academic study of human musicality has gathered momentum, producing several competing explanatory frameworks.

Is music like cheesecake?
The origins of evolutionary musicology can be traced back to Darwin, who considered it likely that music arose as a protolanguage [2]. On a basic level, the field addresses the fiercely debated question of whether music represents an evolutionary adaptation or an exaptation, that is, a by-product of evolution [3]. There is mounting evidence supporting a biological predisposition for music, yet many musical abilities may not be adaptations for music, instead reflective of more general-purpose mechanisms [3]. The cognitive scientist Steven Pinker took this idea a step further by dubbing music ‘auditory cheesecake’ [4]. While a preference for fat and sugar was evolutionarily adaptive, cheesecake did not play a role in the selection process. Similarly, Pinker propounds that music emerged from our liking of other adaptive phenomena, and has persisted because it offers pleasant mental stimulation.

How palatable are alternative accounts?
In contrast, other hypotheses highlight adaptation. For instance, the biologists Hagen and Bryant postulate that music has its roots in animal territorial signals, eventually developing into a method of signaling social cohesion between individuals and groups [5]. Perhaps music began as an adaptive extension of human communication, facilitating social cooperative and coordinated behaviors, and was finally enjoyed for its own sake [6,7]. Alternatively, human musicality may be attributable to the shift to bipedalism [8]. According to this view, proposed by Larsson (2013), synchronization of movements reduced the extent to which human locomotion and ventilation masked critical sounds in the environment. Thus, bipedal gait and the corresponding sounds of locomotion stimulated the development of synchronization of behavior and human rhythmic abilities, possibly resulting in adaptive selection for ‘musical’ aptitude. Unfortunately, these and the myriad other explanatory attempts in the field of evolutionary musicology are highly difficult to test and therefore remain controversial.

But wait, what is music?
After millennia of pondering and probing, theories about the origins of music remain speculative at best. In fact, biomusicologists concede that even the very definition of ‘music’ is a contentious matter. It is not a holistic entity, but modular in nature [9]. Consequently, the perception and production of musical characteristics may involve different cognitive functions with distinct evolutionary origins. Clearly, evolutionary musicology itself will need to evolve both conceptually and methodologically if it truly strives to illuminate the history of music, an evasive, yet ubiquitous feature of human existence.

Sarah M. Gawronska
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You are having a bad day and it has snow-balled into a persistent headache. Coffee, food, chocolates - you’ve tried it all. Nothing seems to work. Then your eyes fall on your instrument lying against the wall. On a whim you pick it up, tune it and start playing whatever comes to mind. In no time at all, you realise that your headache has vanished! You feel fresh and ready to take on all the challenges of the world! Are the benefits of music just subjective, or does it leave a more indelible mark on your brain?

Effect of music on the brain
Music perception is a complex task that involves comprehending the tune, rhythm and meaning of the composition being played. Multiple areas of the brain are implicated in this task and modulatory effects of music have been observed on functional connectivity. Musicians show higher connectivity in the resting state networks such as the ventral default mode network (DMN) and bilateral executive control network (ECN) [1] which are involved in creative idea generation [2]. Even within musicians, differences in connectivity were observed between those who perform genres that require a lot of improvisation and those who don’t. Improvisations require high levels of on-spot creativity and command over the musical notes in order to create a sequence that’s both structurally correct and aesthetically pleasing. Musicians who were involved in improvising during performances showed improved connectivity of the primary visual network to the DMN and ECN compared to musicians who performed pre-set compositions [1]. Professional training in music also leads to different listening strategies in musicians. Left hemisphere dominance of phase synchrony (in EEG frequency bands) was observed in musicians, while right hemisphere dominance was observed in non-musicians [3].

Sculpting your brain with music
A musician’s brain differs neuroanatomically from that of a non-musician. The corpus callosum is larger in musicians, especially in the anterior part [4], indicating increased inter-hemispheral connectivity in musicians. String players have enlarged cortical representation of the digits of the left hand (fingering hand) compared to controls. This increase in cortical representation was however not seen in the area corresponding to the digits of the right hand (the hand that did not have to do any fingering) [5]. The extent of cortical reorganisation also depends on the age at which the musician starts learning to play their instrument. Instrumentalists also have preferentially increased auditory cortical representations for tones from the specific instrument that they are trained in [6].

Are musicians smarter?
Musical training also has additional benefits and enhances performance in non-musical areas such as memory and IQ. It increases verbal intelligence and executive function [7]. Children who trained to play a musical instrument had better vocabulary and non-verbal reasoning skills compared to control children who didn’t play an instrument [8]. They also had better auditory discrimination and fine motor skills. In another study children were divided randomly into two groups- one received musical training (vocal or keyboard) and the other group went for drama classes. IQ was measured before and after the training, and the musical group showed a greater increase in IQ [9]. The benefits extend well into old age, as playing a musical instrument was seen to be associated with lower risk for dementia in the elderly [10].

Scoop out stress with singing
Some musicians learn to play an in-built instrument in their body-their vocal cords. Singing is associated with a plethora of benefits for both the performer and the audience. In a study conducted among choir participants (who were divided into three groups: cancer patients, carers, and bereaved carers) one hour of singing was shown to have a positive effect on the immune system by significantly increasing cytokines including GM-CSF, IL17, IL2, IL4 and sIL-2ra, and decreasing cortisol, beta-endorphin and oxytocin levels [11]. In professional performers, singing was observed to reduce stress by decreasing both cortisol and cortisone level [12]. Making music is not only enjoyable as a subjective experience, but also appears to confer a multitude of cognitive and health benefits. So take out your instruments and have fun!

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The linguistic network
Production and decoding of language involve complex neural architecture. Early research on language processing in humans dealt with patients with brain lesions and has helped identify the involved brain structures as Broca’s area (motor speech center), Wernicke’s area (sensory speech center) and articulate fasciculus fibres connecting both with each other. Individuals with damage to the Broca’s area (Brodmann’s areas 44 and/or 45) experienced expressive aphasia, whereby they know what to say but can’t find the words to convey the information. On the contrary, individuals with damage to the Wernicke’s area (Brodmann area 22) experienced fluent aphasia in which they can speak all they want, but experience difficulty in language comprehension [1]. The dual stream model provides a better understanding of language dominance within the hemispheres. For most people the left hemisphere is the dominant path of language procession. The model consists of a dorsal stream which is responsible for projection of auditory input to the motor speech delegation. The dorsal stream mediates phonological processing. It is also known as the “where pathway” [2]. The ventral stream of the model conveys the auditory input to semantic representation and mediates semantic processing. It is also known as the “what pathway” [2]. If one tells you the word “Ball” your brain will immediately identify the word, visualize the picture of a ball and recognize what they mean.

Let’s talk about lexicons!
Have you ever wondered about the biology of words, and which areas of the brain and neurotransmitters help us understand, learn, store, and retrieve them? Well, the majority of our lexical knowledge is confined to the temporal lobe. Recent PET and fMRI studies found activation of temporal lobe regions during tasks which involve words and meanings. Individuals with damage or lesions in the temporal lobe often experience lexical deficits and semantic dementia. However, different lexicon-related functions depend upon the various structures of the temporal lobe. For example, the medial posterior temporal lobe is thought to mediate phonetic processing [3]. In addition to this, the right cerebellum forms a canonical basis for lexical knowledge, since the structure is proximal to the left rather than right hemisphere of cerebrum and seems to underlie lexical knowledge. On the contrary the active recall and selection of this knowledge depends on the basal ganglia along with certain parts of the inferior frontal gyrus (Broca’s area). Example, individuals with lesions in the inferior frontal gyrus and Parkinson’s disease have difficulty in finding words but less difficulty in recognition of words (due to frontal and basal ganglia degeneration). [3]

What’s the difference between “deer” and “hammer”? As you read the words “Deer” and “Hammer” specific, yet different, areas of your brain activate. This is primarily because both words belong to two different categories. Research has shown that our understanding of words of different conceptual categories is mediated via different networks of brain structures. The words which have a strong visual input such as shape or color involve the temporo-occipital ventral area (located in front of the visual cortex), specifically words in which the visual form is important such as animals (“Deer”). In addition to this, words implicated via motion perception (“Hammer”) action or verbs involve the posterior lateral temporal area [3]. Likewise to the anatomical constitution, the neurotransmitter acetylcholine forms a canonical basis of hippocampal function and is involved in word memorization [3].

The Universal Language of Mankind: Music!
We all love music, and it is undoubtedly an essential part of our human experience. From ameliorating creativity, imagination and expression to developing better working memory, it forms an integral part of our lives. Recent Neuroimaging studies exhibit that sentence processing and musical perception depend upon similar anatomical substrates. The syntactic processing is mediated via Broca’s area and a similar activation is seen in response to chords in musical sequences. In language the activation of this area
is lateralized towards the left (dominant path of language processing). However, in music it is bilateral with slight lateralization towards the right hemisphere [3].

The more, the merrier?
At the Swedish armed forces, groups of individuals with no previous knowledge of languages such as Arabic, Russian and Dari were given classes. Before and after language learning with a three month intensive study fMRI, scans of all participants were taken. While the structure of the brain remained unchanged overall, specific areas of the brain seemed to have grown [4]. Students with greater growth in the hippocampus and areas of the cerebral cortex related to language learning (superior temporal gyrus) had better language skills than the other students. In students who had to put more effort into their learning, greater growth was seen in an area of the motor region of the cerebral cortex (middle frontal gyrus). The areas of the brain in which the changes take place are thus linked to how easy going one finds it to learn a language and development varies according to performance.

To sum up, the field of linguistics studies not just about the fundamentals and practicalities of forms and their meanings, but also how language is learned (both as a first and second language), how anatomical substrates form a canonical basis of language processing.

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Playing an instrument requires very specific skills. It takes a lot of practice (daily and life-long) to improve neuromuscular connections which allow accuracy. It takes time to develop a precise feeling for nuances in tune and rhythm. It takes training to remember dozens of pages of notes.

It also takes psychological strength to keep practicing beyond one’s current motivation and it requires stamina to be out on a stage. In addition, especially professional (and extremely passionate) musicians frequently overstrain particular parts of their bodies. Given how many people create and perform music for a living (and to our utmost enjoyment), it is truly surprising that only recently, medicine has begun to pay attention to this group of patients with very particular needs, with the implementation of institutes and centres focusing on musicians as main patients.

The Berlin Centre for Musicians’ Medicine (BCMM) at Charité offers the combined service and competencies of physicians, physio-, body-, and vocal therapists in joint efforts with musical experts from the University of Music and the University of Arts (UdK) to help the specific needs of musicians. Their aim is to treat and prevent disorders of the oral region and the voice, the skin, as well as musculoskeletal defects and neurological diseases like focal dystonia (see also page 21), in addition to providing counseling for performance anxiety.

Moreover, members of the BCMM also conduct research, e.g. on musician-specific pain syndromes, the therapeutic influence of music on certain diseases, and the neuropsychiatric changes underlying typical pathologies.

For more information, check out https://musikermedizin.charite.de/.
Music can elicit a variety of emotional and behavioral reactions within us. But what effects do lyrics have on us? If relaxing songs can cause relaxation, can violent songs trigger violent behavior?

Effects of violent music on behavior
Numerous studies have shown that aggressive words can prime aggressive thoughts, perceptions, and behavior [1]. Music with violent lyrics should therefore be able to elicit similar violent behaviors. What does science have to say about this assumption?

Research focusing solely on musical lyrics is surprisingly sparse compared to research focusing on other forms of media, such as video games and TV. Moreover, the studies that do exist on the topic show mixed results. One of the studies that does show a behavioral effect of violence in songs was conducted by the Iowa State University and the Texas Department of Human Services. In a series of five experiments involving over 500 college students, participants listened to different violent and non-violent songs. Results showed that songs with violent lyrics led to aggression-related thoughts and emotions [1].

A more recent study supports the finding of a link between aggressive music and aggressive behavior [2], while other studies do not show a significant behavioral effect [3,4]. To make sense of these mixed findings, they need to be viewed in respect of short-term versus long-term behavioral effects. As it turns out, the behavioral effects elicited by violent song lyrics seem to be mainly short-term and may be easily disrupted by the occurrence of some other non-violent event. Listening to music containing violent lyrics does not seem to have any relevant long-term effects on behavior.

No effect – case closed?
This sounds like good news to most. In fact, it does not seem surprising at all. We don’t expect people to actually shoot the sheriff. Just like they don’t run around bringing sexy back [5,6]. But there is an important point that needs to be made before we dismiss the issue. There are songs that go far beyond the violence found in Marilyn Manson songs. These are songs containing explicit depictions of rape, sexual and domestic violence, murder, suicide, misogyny, necrophilia and racism. Even if there is no proof of long-term behavioral effects of violent songs, there might be a more important question at hand: What does listening to and enjoying hateful music say about a person? If there is no causal link, can we still expect a correlation between such music and personality?

As it turns out, we can. Scientific research on the matter has proven a significant link between engagement with violent genres of music and emotional and behavioral problems, such as aggressive behaviors, drug and alcohol consumption [7,8]. Furthermore, a study conducted only a few months ago showed that fans of Death Metal music with extremely violent themes score lower in conscientiousness and agreeableness than non-fans [9]. Although, the effects of violent musical themes seem to be limited, research points to the fact that individuals with preexisting problems of aggression find pleasure or comfort in listening to violent music.

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1. Anderson, Carnagey & Eubanks, 2003
2. Lennings & Warburton, 2011
3. Wannamaker & Reznikoff, 1989
5. Song: Bob Marley - I Shot the Sheriff
6. Song: Justin Timberlake - SexyBack ft. Timbaland
7. Chen, Miller, Grube, & Waiters, 2006
9. Thompson, Geeves & Olsen, 2019
Many of the sounds that reach us during the day are words. Before our brain integrates them into something intelligible, these words are a little music that accompanies us wherever we go. As a child, we learn to distinguish the sounds of our mother tongue by social interaction [1] and store these sounds in our brain like books in a library. This sound library becomes an integral part of our identity. Through the way we pronounce words, it is not only possible for others to « identify » the country we come from, but often also the region.

When you live in a foreign country, this daily music becomes more diverse. To start with, there are words that remain in the world of noise, as we are unable to understand them. But we would like to understand them and we would like to talk in the other language. This is when the trouble starts because the way we hear and speak a new language is largely determined by the sound library that we have developed as children. Therefore, it is easier for people to learn a new language if they already grew up with two or three different languages [2]. When I started my PhD, I took German classes. We were about ten students of the same number of different nationalities. It was indeed interesting to see that we could almost always recognize each other’s home country, although we all spoke German. This is because we all had different sound libraries in our heads giving us different accents. These accents come from the way sounds are processed according to our mother tongue and are often inaudible to the speaker.

Many sounds exist in one language but not in another, although there are also universal sounds. There is even sounds commonly associated to the meaning of a word across different languages. For example, did you know that the word for the color “red” contains the sound “r” in at least two thirds of all languages spoken on the planet? But scientists still don’t understand which feature of the human brain makes it more likely to prefer the sound “r” for red or “n” for nose [3]... On the other hand, some approaches to pronunciation are rather unique. For example, in Chinese the pronunciation of each word is characterized by a tone. A European person will not necessarily be able to distinguish all these tones, but they are essential for understanding Chinese. In German the differences in pronunciation between an “ie” or an “i” or between an “e” or an “ä” is important. Otherwise there may be misunderstandings. A “belegtes Brot” (a toast) is not the same as a “belecktes Brot” (a licked bread), yet it is easy for a foreigner to pronounce “eck” instead of ”eg” (I made the mistake myself...). Being French, I still have trouble with the “h” in both German and English. In French, the “h” does not really have any sound and the risk for a French person talking English is either to forget it or to say a little “h” before each vowel. Certainly, it makes a difference if an English-speaking person hears me say “heat” without “h” and therefore understands “eat” or vice versa. In French, however, there is a large difference between the nasal sounds \p\ṽ and \p\ı. Foreigners often have difficulties with this. A “pont” \p\ṽ (a bridge) is not the same as a “paon” \p\ı (peacock) or “pain” \p\ı (bread).

So that’s the difficulty: as much as our ears are trained to recognize very specific sounds, our muscles are trained to produce very specific sounds [4]. It is both fun and pain for our brain to re-learn this!

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AG Dreier

1. Kuhl et al., PNAS, 2003
Total Eclipse Of The Ear*

The Neuroscience Of Awful Singing

We all know the drill. A contestant takes the stage in a reality TV show, visibly nervous, but excited to show the judges their stuff. The music swells, the singer takes a deep breath and then... disaster. They are indisputably terrible, and worse, oblivious to the fact. Less dramatic versions of this scenario are played out every day in choir practice, karaoke bars, or the shower. Some people just can’t sing. Period.

To a certain extent, singing is a matter of taste, but a certain slice of the population just does not have the ability to reproduce music with any accuracy or consistency. In scientific circles, the term for this state of affairs, “tone deafness”, is amusia. This phrase collectively refers to the inability to produce accurate pitch in absence of other explanatory factors (such as injury or congenital hearing difficulties). But why is this? Is it a question of exposure, a failure of perception, or something yet more intriguing? Though it is still a nascent field, the study of amusia is a fascinating collision of scientific disciplines.

More Than Meets The Ear

Despite what Julie Andrews-types might tell you in syrupy musicals**, singing is an incredibly complicated pursuit, and it’s truly a wonder that anyone can accomplish it without thinking. One needs to be able to accurately hear tones, keep them in memory, and produce a faithful replica on-demand. Those are good singers. Great singers also have the ability to adapt musical phrasing, and fill it with emotion.

In this way, singing has an awful lot in common with language. You need perception, retention, production and prosody. Have you ever tried to understand a foreign language, and not been able to pick out words from a garbled stream? That’s perception, akin to not being able to distinguish the difference between notes in a scale. What’s the word for residence permit in German, again, and how does the famous bit in Beethoven’s ninth symphony go? That’s retention. Can you say “Streichholzschächtlechen” or do the long vocal runs in “We Are The Champions”? And as for prosody, simply examine the subtle differences (sung or spoken) between “He loves his wife” and “He loves his wife”.

Vocal Acrobatics

This complicated nature of music makes it a fascinating research subject, particularly when certain aspects go wrong. For example, due to brain injuries, patients can lose the ability to speak, but not sing and vice versa [1]. Additionally, one can have selective amusia, where solely the ability to write, sing/hum/whistle music, or play an instrument are missing [2]. The nature-nurture debate is still also wide open. For example, speakers of tonal languages such as Mandarin or Thai are better at reproducing pitch patterns [3]. On the other hand, speakers of tonal languages who still have profound amusia often have problems with language processing in general [4].

Thus, if we understand the different components of singing, we come closer to untangling language, and brain processing of environmental stimuli, generally. But back to the ruthless mangling of beautiful melodies: why are some people just bad singers in the first place? This question is currently being studied by several research groups worldwide, and their findings provide some interesting food for thought.

Where Does It All Go Wrong?
The simplest explanation goes something like this: good singers are just naturally gifted with the lungs and vocal cords needed to produce sweeping melodies across and enormous tonal range. Freddie Mercury, for example, famously could sing over three full octaves [5]. While vocal ability and breath control can certainly be trained, are some of us simply born with insufficient equipment? Happily not! In a study by Pfordresher and Brown, poor singers were found to have identical vocal ranges to more talented musicians [3]. Thus, peripheral motor control of the voice apparatus does not seem to underlie poor pitch.

Are bad singers simply bad listeners? The experimenters in the same study asked a group of college students to reproduce a series of four notes sung in a recording. Participants were then classified on a spectrum of good to "pitch poor" singers, based on their accuracy at mirroring the tones [3]. This amounted to about 10% of total participants, although more recent studies claim that the percentage of bad singers in the general population could be higher [6]. And just how bad was the singing? When asked to mirror sung tones, participants were frequently off more than three semitones (i.e. more than a full note in the Western musical scale)... even when they were attempting to repeat a single tone [3].

Interestingly, despite these deficits, the singers could distinguish between notes in the recording just as well as the "normal" population. In fact, many

* With apologies to Bonnie Tyler and her power ballad hit, “Total Eclipse of the Heart”, which is one of the most popular karaoke hits of all time (https://bit.ly/358Fbs5)

** I refer here to The Sound of Music, a cultural touchstone in North America, virtually unknown in Europe. Loosely based on a true story, it follows Julie Andrews’ work as a nanny in an upright military family, teaching the children (and father) to loosen up and enjoy life through song. In one of the most famous sequences, she teaches the children to sing the Western musical scale through the song “Do-Re-Mi” (https://bit.ly/2XmKz8f)
good singers also scored badly on tone perception. So it seems that their listening skills were not directly the cause of poor tone production. Therefore, it seems that the “input” (tone perception) and “output” (tone production and range) of bad singers is fairly similar to the rest of the population. Something must be going on (or going awry) in the brain.

**Songs Getting Stuck in Your Head**

One theory about central processing of music has to do with auditory imagery, or the extent to which participants can visualize the “shape” of what they want to sing. For example, there is a greater “distance” between a high and a low note than two that are close together. Indeed, bad singing was correlated with poor self-reported musical imagery [7].

A related theory has to do with auditory modelling, or the ability to create an abstract model of tone production (i.e. “The singer sounds like this, so they are probably doing that with their vocal cords”). Another study from the Pfordrescher lab contrasted poor singers’ abilities in mimicking recordings of themselves (where they would have a concrete model based on their own experiences) and recordings of other singers. The poor pitch participants indeed were far better at singing along with recordings of themselves, suggesting a general deficit in this model-making [8].

**I Sing, The Neurons Electric**

Are there solid neurological correlates which can be tied to poor tone-matching? The study of the neurological basis of singing in humans is still relatively new. However, a structural neuroimaging study recently found that the arcuate fasciculus, a band of tissue connecting connecting frontal and temporal areas was smaller in individuals with amusia compared to the general population [9]. Interestingly, strokes in this area can cause conduction aphasia, whereby patients are able to understand sentences spoken to them, but not repeat them back [6].

A separate fMRI study also found that the striatum seems to be involved in pitch mimicry, much like analogous structures in songbirds [10]. Thus, it could be that planning of sequential action is somehow at fault in bad singers. As it stands, there remains much more research to be done...

**Coda**

However, there may be one final reason for poor singing which has nothing at all to do with cortical and subcortical processing of pitch information. And that, my friends, is sweet, sweet denial. To all those suffering in the audience, I can only remind you of the immense power of music to bring joy and understanding to the human condition. Who are we to judge, none the less point out that our friends and colleagues may have deficits in cortical information processing.

So live and let live. Perhaps with earplugs...

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3. Pfordrescher and Brown 2007, Music Perception
4. Liu et al. 2010, Brain
7. Pfordrescher and Halpern 2013, Psychon Bull Rev
8. Pfordrescher and Mantell, 2014 Cog Psychol
9. Loui et al., 2009 J Neurosci
Does Music Enhance Your Productivity?

It’s Monday morning, you had a crazy weekend and already hit the snooze button a couple of times, yet you know you’ve got to get dressed quickly and go to work. By the time you get there, you feel like you’ve accomplished enough for today, but the to-do list seems to be endless. You start to become more anxious, your motivation and energy levels begin to drop. Soon you start listening to music and you are now wide awake and kicking to seize the day. Before you’ve even realized it, that huge pile is finished....easy-peasy. But honestly, is music really the magic potion to get through your working day effectively?

Music and attention systems

If you feel like you can’t focus on one thing for too long, don’t worry; the brain is not supposed to pay attention on just one thing at a time. The explanation lies on our attention systems; which are proposed to be a conscious one, directing our attention towards where we want to focus, and an unconscious one, changing our focus towards what our senses consider important at that time [11]. The conscious system relies on higher-order reasoning (top-down cognitive selection of sensory information and responses) and is centered on the dorsal posterior parietal and frontal cortex [2].

On the other hand, the unconscious system is largely lateralized to the right hemisphere and is centered on the temporalparietal and ventral frontal cortex [2]. It is simpler, more fundamental, related to emotional processing and acts quicker. Should you hear something strange all of a sudden, it is immediately employed, allowing you to react fast [11]. In other words, your unconscious attention system is always on, searching for anything significant in your peripheral senses, while your conscious attention is concentrated on one thing. No wonder, if that’s not particularly interesting, then your unconscious attention system will seek out distraction, thereby directing your focus somewhere else rather than your task [11]. For this reason, music can act as a non-disturbing background noise, thereby keeping you more focused on your task rather than external distractors [11].

Music and reward system

Music is also believed to stimulate our reward and motivation centers, thereby increasing the need to do the task at hand, and thus being more productive! How? There is an emerging consensus that learning and goal-directed actions are mediated by dopaminergic neurons in the Ventral Tegmental Area and their projections to the nucleus accumbens (NAc) and prefrontal cortex (PFC). The very subjective feelings of reward are suggested to be mediated by these connections: mesocorticolimbic system. However, the function of NAc dopamine release during musical reward remains unclear. It is also important to note that dopamine in one region may affect attentional control, in another region learning, and in yet another motivation [1].

Music at work now & then

In the first half of the 20th century, after the industrial revolution, research was conducted to examine the effect of music on fatigue, boredom and productivity in industrial settings. Those studies suggested that indeed western work songs not only enabled rhythmic synchronization in physical activity tasks, but also rendered the jobs less monotonous [4]. More recent studies have also confirmed the positive effect of background music on productivity at work, especially in relation to quality control tasks [6].

Control your focus time

Listening to music you like stimulates the pleasure center in your brain. Thereby, a particular pathway through the limbic system up to the orbitofrontal cortex is activated, where your “thinking area” is located. As a result, your focus is expanded and takes in more options, hence an enhancement in problem solving and creative thinking is observed [9].

Note though, that these improvements are observed only if you actually do like the music. Should the music be imposed in your workspace, but you don’t really enjoy it, as music affects mood, it will consequently have an impact on focus and as a result on your work performance [4, 9, 11]. On the contrary, it was found that, when employees are able to choose their playlist at work and listen to music through headsets, they focus more easily and are more motivated [4]. Thus, it’s less possible that they think of finding a new job, too [6].

Interestingly, another reason for increased focus on their tasks, when they select the music and wear headsets is that they feel they set their boundaries, especially in shared office spaces [4]. Music acts as a “do not disturb message” towards their colleagues, by avoiding external sounds e.g. conversations [4]. Since, music is a matter of personal preference, exposing your workforce to a single type of music, results in unclear outcomes [11]. Choosing music based on one’s personal preferences generates more pleasure and positive feelings than e.g. algorithmic music, suggesting that different music structures may have a different effect. Still, stress alleviation is more or less the same in both cases [8].

Music properties

According to several studies, music type can also interfere with your reading comprehension and information processing. Songs with a more complex musical structure that are also fast and loud, can be more distracting to listeners...
when compared to songs with a simple structure [3,4]. For instance, chaotic and unpredictable music can induce very high levels of arousal, thereby interfering with attention and consequently task performance [4,11]. This is for example true for free jazz, which usually includes high levels of syncopation. In contrast, middle ground music (e.g. funk music) is just in the right place for the brain; between predictable and chaotic, where most modern pop is also found [11].

In another study, the effect of streamlined music was tested, mainly by participants who claimed that this type of music had a positive impact on them. The results showed that the effects of streamlined music significantly exceeded plain music in terms of perceived focus, task persistence, precognition, and creative thinking with borderline effects on mood [8]. On the contrary, it did not significantly affect visual attention, verbal memory, logical thinking, self-efficacy, perceived stress, or self-transcendence [8].

Others support that also video game soundtrack enhances your concentration. Not too surprising, given that’s exactly what it is about: to keep your attention and focus on the game task [11]. Apart from that, a new trend implemented by a lot of companies to increase performance at work is pink noise, a less invasive form of white noise. However, the results are controversial [11].

**Task-dependent music choice**

There have also been studies suggesting what’s the best type of music to listen to based on your task. So, when your task has to do with mathematical problems or attention to detail, you’d better listen to classical music [6,10]. Ambient music, is also proper if you are solving equations [10]. Pop music has been found to interfere with information processing and reading comprehension. However, it’s suitable if your work is related to data entries or, similar to dance music, working to deadlines [6,10]. Interestingly, dance music, scored the greatest overall accuracy and quickest performance among a variety of tasks such as spell-checking, solving equations and dealing with mathematical word problems, proof-reading speed and abstract reasoning [10].

Another factor which influences the extent to which music can affect your productivity, is your expertise in the work. If you are already an expert, music is beneficial in relation to your mood, but not your performance, which is anyway high [5]. On the contrary, if you have a moderate level of expertise, your productivity is greater when you listen to music [5,9]. However, this doesn’t apply if you are new to the job and in the process of learning the skill. Nonetheless, music will have a positive impact on your mood [5,9].

**Listening habits**

Music’s correlation to work performance also varies based on preference for external stimulation. In a study, developers who were used to listen to music while working, experienced a more positive effect on their emotions and focus, than those who did not often listen to music.
During work [5]. Interestingly though, the ‘low music listening’ group exhibited an increase in positive affect only after the third week of music listening [5]. So, do the ‘low music listening’ people need more time to realize what impact music has on them and their mood and how they can actually take advantage of it?

Lyrics in a well-known language for example can be distracting, since your brain is going to pay more attention to them, rather than on the task [4,11]. Especially when the song is familiar, it could be even more distracting by awaking feelings and/or memories [3,4]. Obviously, particularly if it’s sad music, it could hinder your motivation to do the task [11]. Another study found that familiarity or past experiences with a particular music can have an overriding impact on positive behaviour change than the actual type of music [5].

**Personality-dependent music choice**

Are you an introvert or an extrovert? Well, this shall influence your choice on whether you like to work with music or not. According to a study, introverts’ performance on complex cognitive tasks is generally more affected by distracters, be it music or background television, than that of extroverts [3]. These tasks include reading comprehension, a prose recall and doing mental arithmetics [3]. A significant interaction was observed only on the reading comprehension task. However, a similar pattern was obvious on the other two tasks. In another study, performance was also lower in a memory and observation task [3]. Regarding extroverts on the other side, music has a positive impact on stress relief. Extroverts with either high or low trait anxiety, experienced anxiety reduction while listening to music. In contrast, introverts with high trait anxiety exhibited no decrease [5].

Another trait affecting music choice is neuroticism, where participants scoring high on this trait tended to listen to music because of emotional reasons (e.g. due to nostalgia or mood regulation). On the contrary, participants characterized with high openness used music more in terms of cognition (e.g. finding pleasure in music composition analysis and performance techniques) [5].

**Should I or shouldn’t I listen to music while working?**

Is distraction caused by music bad after all? No, given that music acting as a distractor, it also acts as a stimulator of pleasure and induces dopamine production. Moreover, it lowers stress levels by decreasing the hypothalamus–pituitary–adrenal axis activity, thus reducing cortisol production and as a result overall stress [7]. To sum up, music has a similar effect as giving a toy to a child; you are doing your work while the kid is busy playing with it; thus increasing focus and performance [11]. And that’s how it enhances productivity; by offering a non-disturbing background noise, while inducing positive feelings, thereby inhibiting the unconscious attention system’s ability to distract us [11].

It has even been suggested that music at work, except for productivity could also promote a more ethical working environment [6]. How? Because music makes the people come together! Music increases communication and a sense of community among colleagues. Apart from that, by reducing anxiety, aggressiveness or tiredness, it induces a more positive attitude not only in general (you become more motivated) and enthusiastic, but also towards others, such as being helpful and compassionate [5, 6].

So, what’s the take home message? Well, as with pretty much everything, decide what works best for you according to the occasion. Should somebody see you listening to music and nodding your head while you work, don’t worry; maybe you are being more efficient than him [10]!

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3. Furnham and Strbac, Ergonomics, 2002  
5. Lesiuk, Psychol. Music, 2005  
7. Raglio, et. al., J. Public Health (Oxf.), 2005  
A Musician’s Dystopia: Focal Dystonia

Although it may surprise you, musicians have exceedingly dangerous jobs. In fact, health insurance companies regard professional musicians as a high-risk group for physiological impairments. Indeed, their bodies and the precise and enduring control of their capabilities (be it voice and/or fine motor skills) is what they make a living from, and often renders them desperate when lost. Unfortunately, about 1-2% of professional musicians (more likely men than women [1]) in their 30-40s start to experience a mostly painless and subtle incremental loss of their precision and muscle tone control, essential for their job. The most affected instrumentalists are violinists, brass players, pianists, and also professional guitar players [2]. Robert Schumann is thought to have suffered from it, Glenn Gould as well: Focal Dystonia.

The very cause of focal dystonia is not quite understood. Neurologists hypothesize that malfunctions involving the basal ganglia cause disinhibition of very finely coordinated muscle movements. Another theory involves overlapping and/or over-representation of certain muscles/limbs/joints in the motor cortex, causing involuntary triggering of closely associated muscles. Therefore, over-practicing may lead to accelerated progression of focal dystonia and, additionally, could lead to the symptoms being misdiagnosed as over-use injury [3].

Dystonia may be task-specific, meaning that other, unusual movements of nonetheless equal precision might be entirely unaffected [4]. There are also secondary dystonias, which are associated with trauma, or other diseases like Parkinson’s, Huntington’s or MS [4].

Currently there are few therapeutic approaches, involving e.g. botox, retraining and ergotherapy, but eventually the disease will end a third of all affected musicians’ careers [2]. Extreme cases might benefit from implantation of deep brain stimulating electrodes or surgery for selective denervation of specific muscle groups [3]. Unfortunately, only a fraction of patients will remain free of symptoms, whereas most experience persistent restraints and have to change their career, making dystonias the leading cause of occupational disability among musicians..

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Music can have a profound effect on our mind and body. Music is described as multidimensional and researchers have categorized it by its arousal properties (relaxing/calming vs. stimulating; reward, motivation and pleasure), emotional quality (happy, sad, peaceful), immunity, social affiliation and structural features (as, e.g., tempo, tonality, pitch range, timbre, rhythmic structure). Understanding of neural correlates of music-evoked emotions has been invaluable for the understanding of human emotions [1]. Choosing a type of music is a personal preference, and you’re most likely to relax while listening to familiar music that you enjoy. Current findings indicate that music around 60 beats per minute can cause the brain to synchronize with the beat causing alpha brainwaves (frequencies from 8-14 Hz or cycles per second). This alpha brainwave is what is present when we are relaxed and conscious.

Listening to music can powerfully alter mood, while making music (e.g. by playing an instrument) may directly alter neural functioning [2]. Learning a musical instrument is a multi-modal experience — students observe and imitate a teacher’s actions and listen to the sounds created [3], thereby engaging the visual, auditory, somatosensory and motor systems [4]. Several research groups are now investigating music making as an empirically based intervention for such neurological and neurodevelopmental disorders as Parkinson’s PD) and Alzheimer’s diseases (AD) and Autism Spectrum Disorders (ASD) [5].

**Effects of music in neurological diseases**

Functional MRI studies show [6] that individuals with ASD exhibit relatively intact perception and processing of music-evoked emotions despite their deficit in the ability to understand emotions in non-musical social communication [7]. Active music therapy can be used to develop communication skills since music involves communication capabilities [8]. Bose and colleagues [9] studied the potential benefits of music therapy on young adults with severe autism. Patients took part in a total of 52 weekly active music therapy sessions of 60 minutes. Each session consisted of a wide range of different musical activities including singing, piano playing, and drumming. At the end of the one year training period, significant improvements were found in musical skills.

Another lab conducted six tests involving different aspects of melody and language processing administered to five groups of participants, including younger and older adults, as well as older adults suffering from Alzheimer’s Disease (AD) classified into three levels of AD severity—mild, moderate and severe. The researchers found that musical semantic memory may indeed be spared through the mild and moderate stages of AD [10]. In Parkinson’s Disease (PD), the irregular timing of walking pace suggests a disturbance of coordinated rhythmic locomotion [11-13]. Music rehabilitation programs in this case make use of acoustic stimuli that enhance the connection between rhythmical auditory perception and motor behavior [14], and aim to elicit sustained functional changes to movement in patients, improving quality of life and reducing reliance on medication [15].

In patients with schizophrenia, a randomized controlled trial was conducted with 115 eligible patients, two-thirds of whom were randomly assigned to music therapy (plus the standard care being given) and attended at least four sessions over a period of 12 weeks were compared with the one receiving standard care alone. A trend was observed towards improved symptom scores among those receiving to music therapy [16].

**Limitations of music literature**

Unfortunately, there are several important limitations of the current literature on the neurochemistry of music: (i) the heterogeneity of methods employed across studies; (ii) the lack of standardized means of selecting musical stimuli; and (iii) the lack of adequate non-musical control conditions to tease apart the effects of attentional engagement, mood state modification, and arousal [17]. PET neuroimaging studies suggest that musical reward involves activation of the nucleus accumbens, ventral striatum as well as opioid-rich midbrain nuclei known to regulate morphine analgesia and descending inhibition of pain, and deactivation in the amygdala, hippocampus, parahippocampal gyrus, and the temporal poles in response to pleasant music [18]. The activation of the amygdala and the hippocampal formation by musical chills as demonstrated in PET scans [19] may give direct support to the phenomenological efforts in music-therapeutic approaches for the treatment of disorders such as depression and anxiety because these disorders are partly ascribed to dysfunctions of the amygdala and presumably of the hippocampus [20].
What happens when we are not “normal enough”, at least in the traditional sense, and disenfranchised or unable to control our body to deliver the musical play that you always wanted to give?

The rapid advancement in electronic technology is a boon to the disabled musicians. “With traditional instruments, note selection is intricately connected to the way the instrument is devised. With electronics you can divorce those,” says musician Dan Daily. For instance, the skoog\(^1\) or using an instrument like a wooden resonance board lets young people experiment with sound and feel the physical vibrations even if they can’t hear or a modified clarion\(^2\) that can be played independently with any part of the body, even the eyes. Running on iPad and Windows, it allows the musician to control everything from the sound it makes to the number of notes it can play – and the way in which they’re played.

Transcending speech impediments by producing music

For people with speech language deficits such as those with characteristic stuttering or in verbal autism, engaging in music seems more fluid than the spoken dialogues and the child who might normally be reluctant to speak would now feel more comfortable experimenting with verbal sounds in context of music making. This is probably because the kind of rules of etiquette and the kind of social demands are actually much looser in a music making environment [21].

Music from Williams syndrome patients

Patients suffering from Williams syndrome (WS) are an ideal population to study musical learning because of the syndrome’s characteristic auditory sensitivities and visual–spatial/visual–motor weaknesses that map onto neuronal processes engaged in learning to play a musical instrument [22]. Lense et al. [23] identified a wide range of musical abilities in children and adults with WS when judged during a musical performance of their choice and when learning a novel musical instrument. Strikingly, their self-reported use of an auditory learning style significantly predicted achievement on the new instrument above and beyond musical ability and visual–motor skills: so their musical abilities (sense of absolute pitch, suggesting different tempos, and alternative endings) are far more outstanding than their general cognitive abilities!

Creating music by a brain–computer music interface system

A group at Royal Hospital for Neuro-disability [24] in London built a brain-computer music interfacing system (BCMI) for a female patient with Locked-in Syndrome, which is characterized by a patient being fully awake, but left with no or little control over the body. The BCMI system uses the Steady State Visual Evoked Potential (SSVEP) method, whereby targets are presented to a user on a computer monitor representing actions available to perform with the system. Each target is encoded by a flashing visual pattern reversing at a unique frequency. In order to make a selection, the patient had to direct her gaze at the target corresponding to the action she would like to perform. By varying the intensity of her gaze, meaning changing the amplitude of her EEG signals, the patient was thus able to vary the consequent musical parameters.

So don’t get complacent as there are no barriers for anyone wanting to make music!

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1. https://skoogmusic.com/specialeducation/

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3. Haslinger et al., J Cog Neurosci., 2005
4. Schlaug et al., J Music Perception, 2010
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15. Rochester et al., J Movement Disorders, 2010
22. Meyer-Lindenberg et al., J Neuron, 2004
23. Lense and Dykens, J Intellectual Disability Research, 2013
24. Miranda et al., J Music and Medicine, 2011
Imagine a person with Alzheimer’s disease. Someone unable to tell you which day it is, to recognize relatives, to report what happened an hour ago. Would you be surprised if that person sat down at the piano and played a piece of Mozart?

Any nursing home can probably tell a story like this about patients suffering from dementia. Additionally, several case studies describe individuals with Alzheimer’s who are still able to play an instrument or sing songs, even though other cognitive skills are severely impaired. One such study by Beatty et al. (1988) featured an 81-year-old female pianist who very likely suffered from Alzheimer’s disease, yet had retained the ability to play different pieces on the piano, including four Christmas songs. However, she could not name the Christmas songs. Furthermore, she could play a simple song on the xylophone, although she had not played this instrument for over a decade.

Musical memory might be independent from other memory systems
Not only Alzheimer’s patients, but also people with amnesia can show intact musical memory, even when they are not able to form new memories or remember things from their past.

In general, it is suggested that musical memory is stored independently from other memory systems, which would explain the above described cases. But what is musical memory? In a theoretical definition of long-term memory, one can generally distinguish between explicit and implicit memory. Explicit memory, also known as declarative memory, makes you remember facts and events. In terms of music, you need it to memorize song texts, titles, and artists but also to put music in a personal context by remembering specific situations or emotions connected to a certain piece of music. Implicit memory, on the other hand, includes procedural memory, allowing you to do things subconsciously, like driving a car or playing an instrument.

In the case of the 81-year-old pianist, the procedural musical memory seemed to be quite intact, as she could play different songs on the piano and on the xylophone. Her explicit memory, in contrast, seemed rather impaired, as she could not recognize Christmas songs while playing them. Is this the typical pattern that arises in patients with Alzheimer’s disease?

* From the song “Music”, by John Miles
Music from your youth will stick
If we want a simple answer: Yes. In a review from 2009, Baird and Samson summarize results from eight different case studies, showing intact procedural musical memory and impaired explicit musical memory in most of the cases. Astonishingly, even patients with severe stages of Alzheimer’s disease could still play instruments. Recognition of familiar melodies, on the contrary, was impaired [1].

Let’s examine the evidence more closely: In some cases, also described in the review, the explicit long-term musical memory seems relatively preserved. Also, the recognition of familiar melodies was not impaired per se, it was rather the differentiation between long-known familiar music and only recently known music. The tested persons could indeed recognize all the songs which were familiar to them, they could just not say for how long [1]. In general, it is observed that music from the childhood and youth is better preserved than music from later times in life. The older the memory, the longer it stays [5].

That being said, at this juncture there are various points to consider such as the type of musical intervention, length of exposure, or the available evidence still being insufficient due to the smaller number of randomized scientific studies that evaluate memory in patients undergoing music treatment.

The Place Where Music Goes
A study from 2015 attempted to address the neural substrate for encoding long-known music. In their approach, they first tested young and healthy individuals, which were imaged with fMRI while listening to different melodies. One third of the melodies was long-known, one third only recently known and one third not known at all. The researchers found that the brain areas involved in storing long-known music are the caudal anterior cingulate and the ventral pre-supplementary motor area. These areas are involved in complex motor movements [4]. The so far existing theory that temporal lobes are involved in musical memory was thereby rejected [6].

In a next step, three characteristic traits for Alzheimer’s were investigated in the previously identified brain areas for musical memory. The result: There was no significant difference between Alzheimer’s patients and healthy individuals regarding degeneration of grey matter and expression of specific biomarkers (such as β-amyloid deposits) for Alzheimer’s. The authors of the study concluded that this probably explains the well-preserved musical memory in many Alzheimer’s patients. If those regions are addressed by the degeneration at all, this would happen at a relatively late stage of the disease [4]. Even though different aspects of musical memory may have remained intact, overall brain anatomy and cognitive functions were found to be impaired.

Music as a mood lifter
If musical memory is spared by neurodegeneration for a long time, how might this help people with dementia? If you know the person’s favorite songs and artists: a lot. Simply listening to music can help to treat depression, which often occurs in the early stages of neurodegenerative diseases, while the patient can still reflect on his or her situation [7]. But also later on, the right music can stimulate patients’ brains and help them recall old memories [8].

Actively playing music is even better, says Stefan Kölsch of the University of Bergen. It creates a sense of identity, makes the person happier and trains the brain [7]. This is what makes musical therapy so successful for people with neurodegenerative diseases. It also helps to treat effects like agitation, which occurs very often in people with dementia [9]. Surprisingly, Alzheimer’s patients are able to improve their musical performance when playing regularly and can even learn new instruments [5].

Music as a cure for Alzheimer’s?
Stefan Kölsch envisions music as a medical prescription. He is conducting a long-term study on musical influence on Alzheimer’s disease – with expected results in about two years. He hopes that in the future, music will not only attenuate the effects of dementia, but also make it possible to stimulate the generation of new brain cells [7]. Another study reports that neural areas of musical memory could function as a compensatory region. The authors found that in those areas, new connections are made during the disease while elsewhere in the brain destruction is advancing [10].

Carsten Finke from the Charité thinks in a similar direction: He believes that an intact musical memory in demented patients could be used to restore memories from other brain areas [9]. On the neuronal level, it was already shown that music can improve memory in Alzheimer’s patients [11]. So, there is great hope that in the future, music will be able to do more than “only” helping Alzheimer’s patients to be happier and calmer. Perhaps music could actually be the key to curing or slowing down the disease. This could, in the ideal case, help affected people not only to remember their love for music, but also other aspects of their lives.

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Good At Music, Good At Math?

Music can be more than a pleasurable experience. It can also benefit your cognitive abilities. But can it make you a better mathematician? Would mathematicians also make great musicians? Since the 90’s, this hypothesis has been investigated by researchers across different fields. Most literature related to music and mathematics linkages emerges from cognitive research and neuroscience. But do they really hold up?

Music and mathematics
Music is mathematical. We all easily accept this statement. But why? Well, music is sound and sound is a wave propagating into the air. So, what you are hearing when you listen to a musical notation, let’s say middle C, is basically how many times a wave vibrates in a pitch while propagating. It’s frequency. For middle C = 262 Hz.

Frequency is key to understanding how math relates to music. The most common western musical scale equally tempers each octave by fractionating it into twelve equal semi-tones. An octave multiplies the frequency of the previous one by 2, while each note, or semitone, represents a fraction in the octave, until its frequency doubles. So, if middle C means 262 Hz, to scale up to B, you multiply 262 by 1.059463 (the twelfth root of 2) and so on, until the frequency of C is doubled and a new octave starts. So, one might say that music is fractioning frequencies. Quite perfect, isn’t it?

The science behind it
Musically trained students have been observed to have higher grades in mathematics and standardized IQ test scores, compared with students who have not studied music [1]. Ok, but why is that? There are, indeed, many similarities between music and math. Mathematically, proportions are represented in numeric values, terms or shapes. Musically, proportions can be represented in note value, scales and intervals. Proportional relationships can be explained in both mathematical and musical terms to support one core idea: fractions. This lead scientists to explore the correlation between brain areas associated with geometric relations and music training to see if there is a collaboration between music and math. And teachers were exploring this correlations for a better educational process. The so called “Mozart Effect” [1].

The Mozart Effect
Currently, almost everyone is familiar with the idea that listening to classical music would make children smarter. People used to play Mozart to unborn babies in the hope of a brighter offspring. This idea was born in the nineties, due to a paper published in Nature magazine by Rauscher et al: “Music and spatial task performance” [1].

They claimed that, after listening to Mozart’s sonata for two pianos (K448) 10 minutes long, 36 students showed better spatial reasoning skills. They found they’re mean spatial IQ scores increased 8 and 9 points after being exposed to the music. However, these surprising results only lasted for 15 minutes. In the future, everybody will be smarter for 15 minutes

This effect was attributed to brain integration [2]. While rhythm and pitch discrimination are processed mainly in the left hemisphere, timbre and melody are found mostly in the right. The exchange of information in the brain pointing to an increased spatial task could be replicated, repeating the temporary effect. This effect, after all, remains temporary [2]. As appealing as it sounds, the idea that simply listening to music would make someone smarter has no fundament. You won’t become a brilliant mathematician by listening to Mozart. You’ll have to work for your math.

Transferred learning explanation
As fun as math can be (for some), most people prefer listening to music than studying calculus. However, one can say music and math do have several commonalities. Another attempt to show music and mathematical reasoning correlate is based on transferred learning. Skills can be carried over from one training to another [2]. Such transfer occurs when learning of one set of skills influences the learning a set of a new, similar one. For example, learning how to ride a bike can help to learn to ride a motorcycle. Nonetheless, acquired abilities can also be generalized into more distant contexts or settings, such as music and math.

Transfer theories attempt to connect music and mathematics as a far-transfer through shared cognitive skills. The assumption is that musical instruction
and spatiotemporal reasoning tasks required for mathematical thinking recruit related cognitive functions (again, “The Mozart Effect”). Thus, what happens during music training may be transferred to increase your abilities in math – or vice versa [3,4].

The cost of music
Music training is a highly demanding activity. It recruits many executive functions, such as attention, motor skills, cognitive control and working memory [4,5]. It is plausible that the learning obtained by music training also generalizes, improving non-musical skills. Nonetheless, its effect is not circumscribed into mathematical skills. Indeed, music learning can boost academic performance. In general – as it sharpens cognitive skills, it translates into sharper focus, working memory, etc. Therefore mathematical knowledge is perfected; but it can also be applied, for example, in learning German. Excelling at math won’t make you a great piano player. Or vice-versa. Not without making an effort and earning it.

Shared usage of the brain
And, because the belief about the special connection between math and music won’t die without a fight, scientists decided to take it to the next level: to the scan. If music and mathematics correlate, they must, somehow, show some correlations in the brain, right? Some hypotheses suggest specific regions of the brain are used for both musical and spatial task [6,7]. “The Mozart Effect” all over again, once brain integration can be verified while listening to music (among other tasks). Those allegedly overlapping regions would then activate while musical and mathematical tasks are being performed.

Well, mathematical thinking relies on representing abstract quantities, numbers and geometric relationships. Musical thinking also relies in abstractions, noting learning and motor skills. You can assume that they might overlap up to some extent. And if you look in the right places, you can always find something. So, researchers looked into intense musical training and geometric thinking [7].

Show me that brain
Under the scan, trained musicians showed increased activity in the left fusiform gyrus and prefrontal cortex, while there was a decrease in activity in the visual association areas and the left inferior parietal lobule [7]. This brain areas are related to visual perception, shape interpretation, and abstract representations of numbers. The result is associated with notation learning and interpretation while playing music: in short, increased working memory (for more about it, see [6,8-10]). Increased activation in the left prefrontal cortex in musicians may suggest a connection between musical training and improved math performance. Unfortunately, it confounds with increased working memory for other demanding tasks, like learning German, for example - or Hungarian [5,6].

So, Myth or Fact?
Up to the day I finished this article, the mysterious link between music and math remains mysterious. We can call it a MYTH, for the sake of good rhetoric. Although, the attractive hypothesis that music and math have a special relationship doesn’t seem to be going away any time soon. How can you blame it? It is quite a compelling idea to hack our way into the dry logic of mathematics through music. And vice versa. A rational approach to music perception can help shed light over our subjective experiences. But, once again, if you want to excel in both, you better be prepared for double work.

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3. Thorndike and Woodworth, Psychol. Rev, 1901
5. Miendlarzewska, Trost Front Neurol, 2013
7. Schmithorst and Holland, Neurosci Lett, 2004
In April 2018 the European STEM-Peers Network hosted the EuroSTEM-Peers conference in Berlin. Many great speakers made this event a very special occasion for all attendees and some of them agreed to an interview with the CNS Newsletter to talk about how they transitioned from academia to their current positions.

Could you briefly detail your academic background and your career path until now?

I started my undergraduate degree in Chemistry. Around that time, the disciplines of Molecular Biology and Biotechnology were developing fast and when I learned about the exciting research being done at the University of Zürich (Switzerland) I decided to switch my undergraduate degree to Biology with the goal to train in Molecular Biology. After having obtained my Bachelor’s degree I was lucky to be accepted by Professor Charles Weissmann to pursue my Master’s degree in his laboratory and work on one of the first gene therapy projects in Europe at the time.

After my Master’s degree and moving to Boston (Mass., USA) with my young family I was offered the opportunity to work at the Cambridge Montessori School during the day and pursuing formal Montessori teacher training during the evenings. This was a happy coincidence as pedagogy had been a long-time interest of mine and with that I was able to explore this further on a professional level as well. After returning to Switzerland with a growing family I was able to found a Montessori kindergarten which offered me a wonderful way to combine family responsibilities with a professional activity I enjoyed a lot.

After a ten-year “family and exploration phase” I was able to return to research science with an opportunity to join the Friedrich Miescher Institute for Biomedical Research, a basic research institute affiliated with the Novartis Institutes for Biomedical Research and the University of Basel. For the first 6 months I was on a steep learning curve, many concepts and methods had not even existed when I received my training, but I was also very excited to be back in science and able to work in such an excellent research environment. Over the years I have been involved in several very exciting research projects which help to elucidate the mechanisms of gene regulation, including projects with medical relevance.

My teaching experience proved to be a valuable asset also in my role as certified trainer for young Novartis apprentices.

“I [...] wanted to prepare myself for potential new entrepreneurial endeavours [...]”

What were the important incidents after the ten-year break, and what were the opportunities that came up that “interrupted” your academic life?

After several years back in research science I was looking for opportunities to expand my professional network and discovered the Healthcare Businesswomen’s Association (HBA), a global non-profit organization supporting the advancement of professional women in healthcare and the life sciences. At that time the association was in the process of starting its activities in Europe, I became involved and over time held a variety of leadership roles amongst them being President of HBA Europe and HBA Global Board and Executive Committee member.

I also wanted to prepare myself for potential new entrepreneurial endeavours and enrolled at the Wharton School of Business and Stanford University for further education in finance, leadership and project management.

Researching the medical literature following a health issue, I discovered that a vegan diet might be beneficial. In a next step I immersed myself in vegan culinary classes and training in medical nutrition which opened a whole new world to me. After gaining experience for several years this gave me the confidence to start a small plant-based food business.

In my academic life I continue to work on important projects with relevance to human health. In my free time I engage in activities around my many additional interests, knowing that lots of learnings lie ahead -obstacles included-, but that also doors will open which keeps the journey exciting.

Image: Gabriele Y. Matthias
You quite often mention that during obstacles, doors will open and lead you to another path, what are your personal experiences that shaped this way of thinking?

Growing up in an entrepreneurial and creative family had a big influence on the development of my thinking. My grandfather and my father were architects and as a child I spent a lot of time sitting next to them and observing them at work, as they were drawing construction plans by hand (no CAD back then) and creating from scratch new homes for families or larger buildings which later on I would pass by on my way to school. I was also able to witness the flexibility they needed to deal with all different kinds of obstacles inherent to their business. This instilled a confidence in me that everything starts with a thought, there are always several answers to a question and with enough preparation and effort solutions will always be found and obstacles will be overcome.

It also taught me to always ask that next question and to think about how something can be made better and then look for ways to make it happen.

With both of my parents working and me being the oldest of three children it was also normal for me to take on different responsibilities from early on and to learn about the importance of contributing to the family and community. Apart from that, I also enjoyed a lot of freedom to think and to explore new things.

What prompted you to co-found iWiS, the International Women in Science?

When I was a young mother working in science the most frequent discussion topics with my friends were about the management of our diverse responsibilities and how this impacted our career advancement. Realizing that this may still present a challenge even today, I wanted to help create an environment where my younger colleagues, both female and male, receive the support they need as they are trying to develop their careers as well as their families.

With my friends and iWiS co-founders Bejal Joshi and Jolanda Groenhuijzen we wanted to provide a forum for women in science to exchange ideas, or like-minded, international associations organize joint events and support each other. It was also very important for us to include our male colleagues and drive change by fostering collaboration and creating a professional environment for everyone to thrive.

The iWiS is now one year old and still in the start-up phase, but since the beginning we started partnering with like-minded, international associations with which we exchange ideas, organize joint events and support each other. The goal is to create an inclusive and collaborative environment and to increase female participation and contribution to innovation. Once everyone brings their knowledge, experience and ideas to the table, we have access to an immense amount of combined wisdom helping us to move forward and to find answers to the big current and future questions.

Do you think there is an issue with diversity and inclusion in science?

Children are naturally enthusiastic and eager to learn. They also learn a lot through examples and this contributes to shaping their way of thinking and prepares the foundation for their future life paths. When both parents thrive in life as well as in work they will be the best and most important role models for their children. This will first and foremost have a profound positive impact on their children’s and their family’s well-being, but eventually also on society as whole.

On a different note, I would also like to point out that our children’s skills and contributions will be essential in addressing the global challenges, many of which are today not even known yet. Therefore, supporting children to specifically develop their problem-solving skills will provide them not only with important life skills, but greatly strengthen their confidence in themselves and their abilities. We can teach them already at a young age how to break-up a simple task into smaller parts and then take care of each part until the task is completed. As their ability for abstract and independent thinking grows, they will be able to apply those same principles to solving the more complex challenges.

On a more general level, I believe it is worth to look into enhanced ways of teaching the theoretical foundations, also via online formats. The time gained can be used to deepen the learning through practical application.

What do you think about diversity and inclusion in science?

While the focus of this conversation is the diversity of gender, we should not forget about the whole range of additional diversity aspects which play an important role for the achievement of diversity and inclusion.

Despite increased institutional and societal awareness we are not yet near a diverse and inclusive environment in science, or in society.

With each step further up on the academic career ladder the “women in science” are less represented so that on top of the ladder only a small fraction of
full professorships are held by women. Research has revealed that traditional processes in academic STEM careers do not take into account the life realities of many female scientists and can represent structural and institutional barriers to their career advancement. It has also been shown that when women lack the critical mass in an environment they do not only feel more isolated, but they are less empowered to build relationships and networks which play an important part in career development.

While many academic institutions have been making efforts to address these issues by providing support via different programs and new policies, overall progress has been slow. It is crucial for leaders in academia, industry, society and politics to collaborate in building an environment where professional advancement of female scientists is less dependent on whether the personal situation allows for it, but is based on true choice made possible because the necessary structures are in place.

_When it comes to women in science, there has been a recent trend of sexual harassment and do you think universities have a responsibility to prevent this?_

Any form of harassment or discrimination is absolutely unacceptable and the universities’ leadership have to put all measures in place to actively prevent this from happening. Regular monitoring of the environment is equally important so that any concerns can be voiced immediately and be addressed without delay to ensure a safe environment for study and work.

_Deepshika Arasu_  
_MSc Student_  
_Medical Neurosciences_
Gabriele’s messages to girls interested in science

For the younger ones:

- Always be open for a variety of learning experiences and explore the extracurricular STEM school activities available.
- Think about the things you enjoy doing, this will be your guide.

Later on:

- Seek opportunities to learn about a variety of different professional environments, this can also be done while engaging as a volunteer.
- Find individuals holding roles you would like to learn more about and don’t hesitate to reach out to them. You might not receive a reply in every case, but in my experience people are happy to support the next generation and with this approach you have a unique opportunity to develop your network from early on.
- Set goals for yourself, attach a timeline to them and then start your own journey.
- You will also encounter obstacles, but always remember to take them as learning experiences preparing you for the next steps.
- Surround yourself with individuals that support and uplift you.
- Find mentors from the different fields providing you with good advice and new perspectives.

In summary:

Collect experiences, learn from role models and then build your own path.
Academia is becoming increasingly aware of the fact that only a minority of doctoral candidates will proceed with pursuing an academic career. The rest of us need to face the question of what else to do with our lives and how to make a living out of it. This series aims to direct your attention to all your skills that may seem trivial to you solely as prerequisites to perform your research, yet are incredibly precious outside of the lab!

Most of us know the feeling of a 24 hour day just not being long enough. We constantly experience a lack of time to perform all the experiments that interest us, meet friends and family, hit the gym, cook and eat healthy, let alone sleep! We are pressured by deadlines and commitments, all (or at least most) of which are in our own interest, but we just can’t accommodate all of it. We struggle and then we strategize. We think through the time each task needs, how much effort it requires and which outcome/benefit it bears. We consider what we can combine (like meeting friends for sport), what we can interlace (like writing an article while waiting for your hair dye) and what needs our undivided attention (like... um, experiments?). And then again, we make decisions. We prioritize and hopefully learn how to choose what is truly important over what (or who) is just requiring our attention in a given moment. We learn to make appointments and schedule time off. We develop the awareness and (eventually) the confidence to actually judge what is important, and (let’s be honest about it) which recommendations of our supervisor can and which should definitely be ignored.

In the end, it might still feel as if a 24 hour day isn’t enough, but you suffer less because the awareness of your attempts at time management helps you to simply accept that fact. Like many things you learn during grad school, time management feels like a matter of course because learning it is just necessary to survive – yet it is nonetheless a precious skill that benefits your personal and professional life, and being aware of that can bring you the confidence you may struggle with during your PhD. Enjoy! :)

Your Dr. Brown Team

“Inequality Affects Us All”

Conference Report from “I, Scientist”

The 3rd “I, Scientist” conference took place at the TU Berlin from 20th – 21st of September this year. It is focused on gender, career paths and networking and was, for the first time, open to scientists from all disciplines. The conference took first place in 2017 and was initiated by students to raise awareness about inequality in science. Since then, the conference has grown and is now organized by the Lise-Meitner Gesellschaft e.V. [1].

The “I, Scientist” 2019 consisted of classical lecture-like talks and smaller discussion rounds as well as an activism session, a career fair and career speed dating and a networking breakfast. The talks covered a wide range of topics from stereotypes and unconscious bias to queer in science, mental health in academia and ways to foster a structural change. The smaller discussion sessions connected to these talks and offered the possibility to discuss the topics in more detail (some impressions are summarized at the end of this article). The career fair was a perfect chance to get to know different companies and job opportunities. This was complemented by the networking breakfast, where experts from different fields answered questions about their work.

The atmosphere throughout the conference was extremely open and supportive. Already before the conference all participants were informed about the code of conduct, specifically highlighting non-discrimination rules. Upon registration every participant was encouraged to use pronoun stamps to state how they want to be addressed by others, i.e. she/her, he/him, they/them, no pronoun. There were safe spaces to discuss personal experiences of sexual harassment, if needed. Espe-
cially during the very personal talks on harassment in science and queer in science, every speaker received a long and intense applause.

I personally learned a lot during this conference and became more aware of certain issues. I also realized again that there are people out there seeing the same problems and being open to join forces to solve them. Thus, I would recommend this conference to everybody – to increase general awareness of inequalities and to realize there are other people seeing the same problems. The next conference will take place in Konstanz in September 2020.

Impressions and insights of discussion sessions:

- **Gender and stereotypes in the workplace:** "Although we were a rather mixed group in terms of career stages and academia or industry position, we shared very similar experiences. For example, it seemed common in all jobs to have more men in higher rank positions and women in lower positions. I found it very interesting that some participants also said if there were women in rather male groups, they eventually changed their behavior to something considered as "male behavior" (meaning a very dominant, strict appearance). This led to the question, if this change is necessarily a bad thing or if the problem is more that this behavior is perceived as male, although this in itself is a stereotype." - Melina Engelhardt, ECN PhD fellow

- **Should I stay in academia?** "We focused on the question, how people know that they are capable of staying in academia. Our conclusion was that you can always stay in academia as long as you still feel, it is worth it. However, one should also be aware that academia is not the only path and staying in academia for the long-term is uncommon. My take-home message from the discussion section was if you were trained to be a scientist, then you ARE a scientist, no matter what you do after your PhD. You should see scientist not as a career, but a feature, a personality and an attitude of you." - Hung Lo, ECN PhD fellow

- **Improving working conditions in academia:** "I found it very interesting to hear that there are already initiatives (for example Initiative Mittelbau, GEW) that work to improve working conditions in academia. I think this is something that could be communicated more actively to young researchers. We agreed that 1) working conditions need to be communicated clearly to all young scientists and alternatives to an academic career need to be shown and 2) initiatives to improve these conditions need to be communicated as well. This means, just because someone choses to stay in academia, does not mean they need to accept the working conditions." - Melina Engelhardt, ECN PhD fellow

- **Is kindness a weakness in academia?** "You must have heard that some great PIs are not kind or friendly to work with, but our system still tolerates this. It is argued that "as long as they are doing good science, it’s fine", which enforces the "great but bad PI" phenomenon in academia. During the discussion, we shared how this masculine behavior of being rude to be successful also motivated female scientists to adapt this behavior. Though we didn’t come up with practical solutions about how to deal with unkind PIs, we think the ultimate goal is that we value more about cooperating instead of competing." - Hung Lo, ECN PhD fellow

- **Finding allies:** "I found it very enlightening to have different perspectives from individuals who were on both sides of experiencing discrimination themselves or just witnessing it (and some uniting both experiences in the same person). It was agreed upon the fact that clearly calling out discrimination and unacceptable behavior is necessary. At the same time, it is important to convince other 'bystanders' to become allies and sometimes more helpful to speak to someone in private to win them over instead of alienating them." Lara Wieland, ECN PhD fellow

**Melina Engelhardt**
**PhD Student**
**AG Pich**

Image: Sandra Schwark on I, Scientist poster
A new elective course is being prepared for masters, and PhD students and physicians. The program will provide a multi-perspective view of clinical research for those who wish to start their career in this field or to integrate it into their established fields.

Clinical research is the main systematic approach for providing evidence, on the basis of real-life outcomes. A process that starts by defined observations or assumptions, then to be translated into a hypothesis. Studying a hypothesis requires choosing or development of multiple clinical evaluation, data collection, and statistical methods. The quality of the resulting evidence depends on the procedures conducted during the clinical research process. Many considerations have to be taken before starting the research, over its journey, after its closure and even years following publishing to ensure the applicability of the results. In this program, we have integrated different themes to address the technical aspects of handling ideas, protocols, forms, data, and reports. Besides, some of these considerations touch the research subjects, which here are human beings, and others involve the researchers themselves. The clinical research does not involve the evaluation of clinical data only, but it can involve pharmacological, genetic and other biological measures too.

The learning process will be encapsulated in a behavior-changing experience. Therefore, this module is practically preparing both the scientists and physicians to work in harmony and reach a common background while sharing a clinical research project. The course will be formatted in mixed lectures, problem-based learning (PBL), simulations/practical, blended learning, including constructive and collaborative approaches. It will be provided as an optional compulsory module (Wahlpflichtmodul), with workgroups and individual activities.

Collaborative learning is not only about getting together and participating in a lecture or sharing questions and answers in a session. It involves the interaction between facilitator, participants and content. Each counterpart will add to the others and interact with it/him/her. Learning content and experience will evolve with the interaction between students and facilitators. Each student and facilitator will add to this experience by their different learning styles and ways of expressing information. The whole experience will result in cumulative learning we gather and create.

The initial face-to-face course will be provided in English in winter 2019/2020 for a maximum of 12 participants. Online participation will be limited to 24 participants in its first phase. The teaching plan includes six days (Saturdays) each is five hours beside online lectures and participation, office hours and collaborative projects and presentations.

This program is initiated to expand and continue autonomously. The e-Learning approach will allow a theoretically unlimited number of participants and without geographical borders. This will allow the project to evolve without the need for repeating the whole training program. Moreover, this will allow the candidates to learn collaboratively from asynchronous time and place.

The participation of each student will be scored on a matrix according to students’ impression of the program and other participants. Passive participation will have the minimal score. Meanwhile, the production of innovative teaching materials will gain the highest score.

Ahmed Alfaar, MD, M.Sc.
PhD student,
Medical Neurosciences
1. Basics of Clinical Research
This module will introduce the participants to clinical research, its history, and its importance. They will familiarize themselves with different topics, including study question, population, study design, blinding, randomization, and clinical outcomes. The participants shall start their projects in this phase.

3. Applied Statistics
This module will introduce the participants to survival/Time-to-Event analysis, regression modeling, handling of missing data. Moreover, it will be a space for different topics in the day-to-day data life of a clinical researcher, including research data management, secondary data, health records, and usage of machine learning with clinical data.

5. Practical Aspects of ClinRes
This module is designed to discuss the cross-talk between clinical research and other disciplines, including leadership, change management, and teamwork within clinical research teams, recruitment of patients, quality of life, and translational research. Moreover, it will offer the participants the opportunity to learn about effective communication and dissemination while finalizing their projects, including protocols, publications, and peer reviews. Besides the planned topics, the module will act as an arena for sharing thoughts about emerging topics.

2. Basic Statistics
In this module, the participants will learn the different data types and choosing the appropriate statistical test for each study question and data type. Moreover, they will apply the basics of sample size calculation.

4. Study Design
In continuation of module 1, this module will discuss clinical research phases and study designs in different study types.

6. Ethical & Regulatory Aspects
Due to the malpractice cases that happened over the last two centuries, research on human became bound with strict regulations. This module will offer the space for discussing legal and ethical aspects of clinical research and how they will affect the management of data and research on vulnerable groups.

What will the course contain?

To get updates about the program: j.mp/ClinReseachNeuro

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Call for Master’s Applications
The Medical Neurosciences Program invites bright and interested students to apply for our program. We await your application starting in December. Ideally, candidates should already have some laboratory work experience, e.g., having worked in a lab for a Bachelor’s project, or other types of work experience such as a residency as a medical doctor.

The program’s rigorous and comprehensively structured education in basic neuroscience trains students to approach questions concerning the central and peripheral nervous system. In addition to the in-depth theoretical training, our program emphasizes state-of-the-art practical lab experience, preparing graduates for continued research as PhD students.

Closing date for applications is January 15th, 2020. Final interviews will take place in March 2020 – program will start in October 2020. Details: medical-neurosciences.charite.de.

The Einstein Center for Neurosciences Berlin (ECN) Calls for Applications
The ECN member institutions promote cutting-edge neuroscientific research across a wide range of different disciplines and approaches.

The ECN provides an umbrella structure that specifically fosters interdisciplinary and collaborative research by facilitating cooperation between institutions and by promoting interaction on all levels. With more than 100 internationally recognized research groups, the ECN offers outstanding interdisciplinary training and research opportunities for national and international scientists, with research spanning from synapse to behavior, molecule to disease, and brain to mind.

Closing date for applications is January 7th, 2020. Final interviews will take place in April 2020 – program will start in October 2020. Details: www.ecn-berlin.de/education/phd-fellowships.html.

Berlin Neuroscience Meeting 2019
As members and friends of the Einstein Center for Neurosciences Berlin (ECN), we invited you to join us at the Berlin Neuroscience Meeting on October 10th.

The ECN organizes an annual Neuroscience Meeting to provide a platform for scientific interaction among Berlin neuroscientists and to give the new ECN PhD students an overview of the diversity of the neuroscience landscape in Berlin. This meeting offered an excellent venue for presenting and discussing recent work during an interactive poster session.

Congratulations to Gisela Govaart (winner) and Ana-Lena Eckert/Lara Wieland (runner-up) for securing the 1st and 2nd place during the final pitches despite a challenging field of strong competitors!

Open Innovation in Science Award
During the Berlin Neuroscience Meeting 2019 on October 10th, 2019, the Einstein Center for Neurosciences (ECN) awarded its first Open Innovation in Science Award (OIS Award). Supporting the establishment of OIS and training a new generation of young scientists familiar with its concepts and tools is one of the key objectives of the ECN. This year, the senior cohort of PhD students competed for the OIS award with their projects developed during their training period. Selected excellent project proposals were short-listed and invited to pitch their ideas to the local neuroscience community. Although this decision proved to be a difficult one given the high quality of each project, the winner and runner-up were finally selected by an external jury of experts. They received 5,000 € each to support their projects.

Elective Courses Offered by MedNeuro Faculty or PhD Students
If you are looking for elective courses, checkout our website: https://medical-neurosciences.charite.de/en/program/elective_courses/.

Neurosciences Alumni Berlin
To all current or former MedNeuros – MSc and/or PhD –, including Neuramunus students and Einstein Fellows, we warmly invite you to join our alumni platform. Since its launch in September, roughly 40% already signed up. A big “Thank you!” to the Einstein Center
for Neurosciences for the generous help and support.

We would be happy to welcome and see you there: alumni.neurosciences.berlin!

**Berlin Science Week**

“Slammin’ like there’s no tomorrow” at our science slam during Berlin Science Week! That was the motto on Friday, November 1st, as scientists tried everything to entertain their audience, regardless of whether the subject was mathematics or neuroscience. Costumes, props, movies, power-point presentations or other experimental setups – everything was allowed!

Congratulations to the winners Kazi Atikur Rahman (ECN), Prateep Beed (NC) and Susanne Wegmann (ECN, DZNE)!

**Ralf Ansorg**

*MedNeuro Office*
The Relaxing Corner

Have your holidays been too short? Or rather too long and noisy, and now you’re still recovering, back in the lab with your favorite mug of coffee? In any case, we’ve got you covered with this inviting coloring page that we hope you’ll enjoy. So, gather all the lab markers and get coloring (preferably without angering your colleagues, since that’d be counterproductive to the whole relaxation business).

Happy New Year from the entire CNS Team
Schutz? Impfung!

Mit der Techniker gesunden Urlaub machen

Wir übernehmen bei privaten Auslandsreisen die Kosten für alle empfohlenen Impfungen sowie für eine Malariaprophylaxe, gegebenenfalls abzüglich der gesetzlichen Zuzahlung.

Ich berate Sie gern:

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