Music and Noise: Towards a Politics of Sound Ecology

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Paper presented at the 4th European Forum on Music, Bern, Switzerland, June 19 to 22, 2014.

This contribution deals with music and sound and their mutual relationships. But what is sound and what is music? Can we conceive of them as distinct categories, or in terms of complementary modalities of common vibratory phenomena? Some listeners typically like noisy music, while others experience it merely as noise. The question should be raised, therefore, as to the definition of noise. Is this to be equated with annoying sound and what, then, is annoying? Can we speak in objective terms of noise pollution, or should we take also subjective factors into account?

The questions are related to actual discussions about critical sound levels for music festivals and music consumption in general, which can be harmful to the ears. Technology, in fact, has provided the means to increase the level of sound intensity to unprecedented heights. This same technology, however, has also furthered the digital revolution, which has enabled the production and reproduction of music at the highest levels of perfection. It makes little sense, therefore, to condemn unequivocally the acoustic power of much contemporary music. It is much more fruitful, on the contrary, to reflect in objective terms on the possibilities and pitfalls of music technology.

It is arguable, at first, to consider a number of developments, which are related to the ways how people cope with sounds. The biological bases of how music is perceived are most important here (Koelsch 2014; Peretz & Zatorre 2003; Reybrouck 2008; Schneck & Berger 2010), but other mechanisms can intervene as well. There are, e.g., social constraints which have been institutionalised in an almost canonical way and which determine to a large extent what especially young people want to listen to. It is not cool for teenagers to listen to music that does not fit with the taste of the peer group and many radio stations use restrictive criteria with respect to their programming policy. Musical taste, therefore, is not gratuitous, but is conditioned by media indoctrination and social pressures. The music industry, further, does not rely on pedagogical concerns but on economical laws of supply and demand. This may be legitimate to some extent if, at least, there is also an additional programming which should not be constrained by economical incentives. This holds true especially for those institutions, which are responsible for education and training.

Music, however, is important. It is a quasi-permanent companion in young person's daily lives and it plays a major role in the building up of their identity. The question should be raised, therefore, what kind of music they listen to and also how they listen to their music? The musical universe, in fact, is wide in its range and cannot be revealed without effort, both with respect to the breadth of supply and the depth of processing. People's ways of listening, should not be gratuitous and it seems arguable to try to intervene in this behaviour, both in a positive and negative way. On the positive side, it is possible to try to broaden the listening horizon; on the negative side, attention should be paid to the restrictions of the hearing apparatus and the danger of hearing damage or hearing loss. Exposure to stimuli that are too loud can be harmful to an extent that causes damage that is irreversible, even after single exposure to the sounds. The human ear can cope with these constraints, and has innate mechanisms for protection again stimuli that are beyond the zone of optimal stimulation. It is possible, however, to ignore the signals of the body and to learn to like those stimuli that the body qualifies as nocuous. This phenomenon of bad conditioning is known as *medical decadence*. Violent music is a typical example besides intoxicating liquors and lust inducing means as alcohol, medication and drugs. The products themselves are not necessarily harmful, but their doses may exceed a critical threshold and become harmful. Music of extreme loudness is situated in this zone of discomfort. All noisy sounds, however, are not necessary harmful even at high levels of volume. They have some characteristics, which make them apt for many kinds of experiments as has been obvious from the early experiments of futuristic composers in Italy and France.

Music and sound: from bruitism to computer software

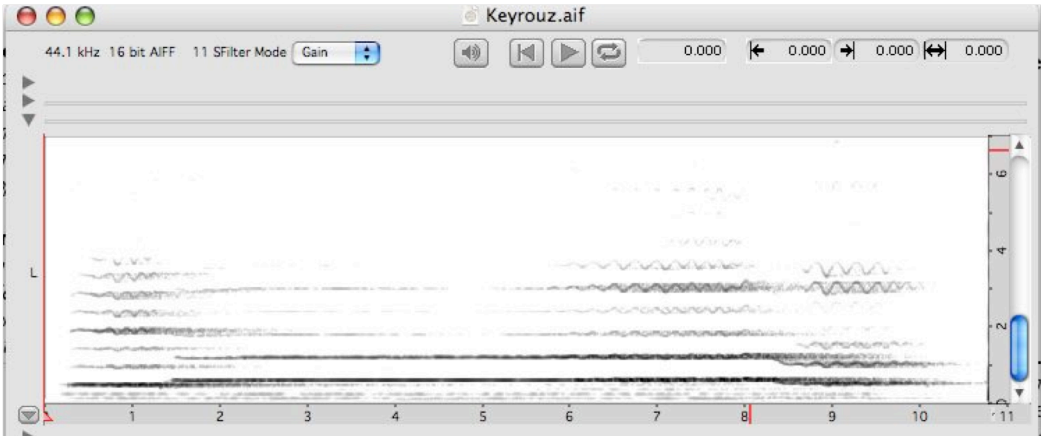
When Russolo sent his futuristic manifest “L’arte dei Rumori” to his friend Pratella in 1913, he argued that the human ear had adapted itself to the speed, the energy and the sound of the modern urban and industrial soundscape. He conceived of this new sonorous palette of sounds as an important extension of the limited variety of timbres of a traditional orchestra, thus giving rise to an important tendency of 20th century music aesthetics. This *bruitism* aimed at opposing the established culture through *noise concerts* with a preference for modernity and/or violence, with key terms as energy, novelty, strength, constant stimulation, rejection of traditions, and the cult of the machine, which symbolised the urban and industrial society. What was meant was a vitalistic palette with sound symbolising the intensity of life.

One century later, Russolo's prophetic words have not lost their relevance. Many modern and contemporary composers have made the transition from the cult of harmonious sounds to a broader spectrum of shrill, strange and dissonant sounds and have integrated musical noise in their sonorous palette. According to Russolo this evolution was self-evident due to the increase of mechanical sound production in the 19th century. Music and sound came closer to

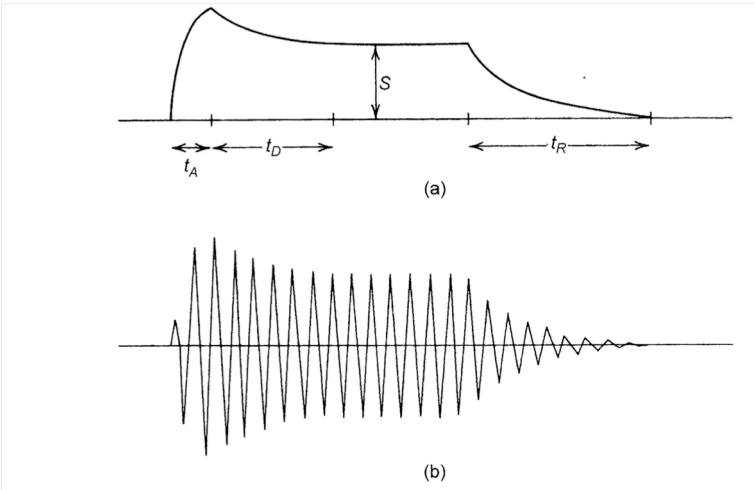
each other and Russolo's musicalisation of sound was only a first attempt to break through the limitations of traditional instruments. Cage and Varèse, in turn, should contribute substantially to the emancipation of sound, not at least by stressing the possibilities of generating sounds electronically. They conceived of *organised sound* rather than of music in an attempt to liberate musical sound from the limitations of musical conventions, which were related principally to instruments and tone systems. Using electronic instruments, on the contrary, should allow composers to manipulate all musical parameters in their smallest details: duration, pitch, timbre and dynamics. The whole domain of electronic and electroacoustic music is, of course, a typical example. Besides, the domain of concrete and extramusical sounds did find a place in the emancipation of the sound as well, with as most typical example the idea of *musique concrète,* as introduced by Pierre Schaeffer in the 40ies (see Risset 2004 for an overview).

These developments have been fruitful as an experiment. Due to the technicity of the realisation, however, they did not find their way to the musical idiom of the vast majority of composers. Up to now, there is a tension that remains between sound engineers and acousticians who deal with music in a rather technical way and composers who deal with music in a rather musical way. The problem, however, cannot be reduced merely to technicity. The coherence of the raw musical materials should be taken also into account. Sound, in fact, covers a rather broad spectrum: everything what the ear can detect is sound, and musical sounds are only part of it. In a narrower sense, however, sounds are qualitatively distinct from musical sounds. Natural sounds, e.g., are not stationary, but change from moment to moment. Their pitches can vary, but also their strength and timbre. These changes can be fast or slow, regular and irregular, but these factors are responsible for the properties of the sound. They determine to a great extent whether we experience the sounds as either sound or music. Musical sounds, as a rule, are characterised by some kind of regularity, which is not to be found, e.g., in noise.

The figure below can serve as an example. It depicts the spectrogram of three sung notes, which clearly show a regular pattern of vibration frequencies (the horizontal lines) with a rather regular course. What is depicted are the partial tones, which constitute the timbre of the voice. The vibration frequencies, further, show harmonic relations to each other and give rise to a typical musical sound.



Acoustical sounds, further, are built up of four phases which can be distinguished from each other: *attack* or the duration, necessary to reach the highest amplitude; *decline,* in which the level becomes more or less stabilised; *sustain,* with a constant level and *release*, in which the sound fades out.

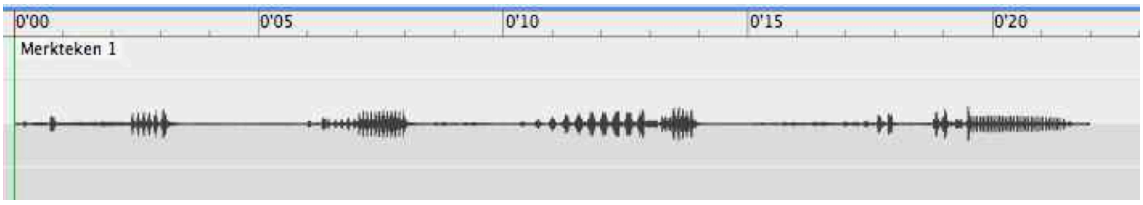


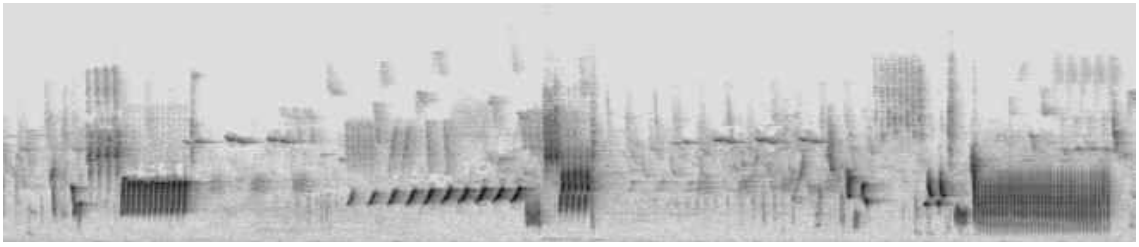
The result is a kind of envelope of the amplitude, which is very important for the distinction of the timbre of the sound. When the attack of, e.g., a piano or trumpet sound is cut off digitally, the instrument can hardly be recognised because the sound of the hammer against the strings, or the attack of the lips on the embouchure which are so typical of these instruments cannot be recognised any longer.

Sounds in general or noises do not, as a rule, show such patterns of regularity. As such, they are less useful for composing. Yet, sounds and noises can be very interesting. The sound of ocean waves, e.g., is different from the sound of a waterfall or the gentle ripples of a babbling

brook. In this sense, it is possible to listen to the sounds of nature with a musical ear. But also living beings provide an infinite source of sounding material. Singings birds such as the thrush or the nightingale are typical examples besides the howling of the wolves and the sounds of the whales.

The figures below show a visualisation of the song of the nightingale made with computer software (Sound Studio for Mac and Audacity for PC). The upper figure shows a waveform notation with the size of the vertical deviation from the horizontal reference line being related to the intensity of the sound. The lower figure shows a spectrogram of the same sound fragment, but here the individual vibration frequencies are depicted as well so that we can listen *microscopically* to the music. As can be seen, there is a considerable acoustic complexity in what can be labelled belittlingly as a mere bit of birdsong. Listening repeatedly to such a fragment, aided by this visual support, shows clearly how we can learn to make distinctions with respect to the spectral richness of these songs. It illustrates the level of sensitivity that can be shared by both the ornithologist and the composer, and which is easily disregarded when musical listening is considered as a way of listening that is qualitatively different from the natural and exploratory way of listening that is used for examining the natural environment.





These considerations bring us to the main function of hearing: to assess and to recognise the sounding environment that surrounds us. Our hearing system, accordingly, has an important adaptive value because it allows us to gather information about the kind and localisation of sound sources in the immediate environment, which can be potentially threatening for life. The importance of this *detection apparatus* is obvious from its enormous sensitivity, with an enormous range between the hearing threshold and the threshold of pain. The proportional strength of these thresholds is in the order of 10^{12}. This means that the loudest sound that we

can hear without damaging our ears is one billion times as strong as the faintest sound that the ear is able to detect. The ear, as is commonly known, is the most sensitive organ of the body. The sound intensities, however, that our ears must cope with, are situated frequently in the zone of danger that exceeds the threshold of pain with possible ear damage as a result. This happens, ironically, at moments, which are labelled as leisure time (pop concert, going to the discotheque, using iPods with earphones) with an overall effect on the body that is more strengthening than relaxing. It makes sense, therefore, to consider an *ecology of listening*, which means that the ear should be aroused preferentially within the optimal zone of stimulation and not at the boundaries of discomfort. The insight that the ear is subject to an excessive amount of stimulation, however, has been recognised only recently as a problem and there is still a long way to go before we can conceive of a widely accepted social support for an *ecology of listening* and *ear hygiene*.

From sound to noise: soundscapes and acoustic ecology

Noise and noise pollution are recent phenomena that are subjective to some extent. Not every listener experiences the nuisance in the same way, even for exposure to the same sound with the same level of decibels. What causes discomfort for the one can be enjoyed by the other. The underlying reason is that noise nuisance is not merely dependent upon the number of decibels but also on factors that are not acoustical. The level of control one has over the nuisance, e.g., is an important factor in experiencing its effective nuisance. The person, who is exposed to the noise, may have the feeling that the noise happens to him and that the source alone can benefit from it.

The factors that are responsible for the feeling of nuisance are well-known. They embrace fear, dependency on the source, sound sensitivity, deliberate exposure, control over the living quality, manageability of the exposure, predictability of the exposure by providing information, confidence in the responsible authorities and the relation between sound intensity and hindrance. There is, in fact, no direct causal relation between sound intensity and nuisance, what means that the reduction of the intensity level of sound does not automatically diminish the nuisance.

Yet, there are two factors that are important here: the *intensity level* and the *kind of sound*. As to the second, there is a distinction between natural and artificial sounds with a corresponding connotation of value: natural sounds should be experienced as beautiful and charming, while artificial sounds should be experienced as disturbing. Though there is some legitimacy to this distinction, there are also some concerns. Musical sounds, e.g., are not natural but artificial sounds and the whole history of instrument building has been one long search for gaining

control over natural sounds in an attempt to make them perfect by intervening in the production and the modulation of sound. As such, a lot of ingenuity has been shown with respect to the sounding materials and playing techniques.

With respect to the intensity and kind of sounds, further, it is possible to map and to define acoustic *biotopes*. A major attempt in this sense has been done by Murray Schafer (1969, 1977) who coined the term *soundscape* as the sum total of sounds and combinations of sounds that are part of typical surrounding environments. The study of these soundscapes is the subject matter of *acoustic ecology* with the concept referring to two kinds of acoustic environments: the 'natural' environment, consisting of natural sounds (birdsongs, sounds of the weather such as thunder, wind, rain, and other natural elements) and the 'artificial' environment which consists of sounds that are created by humans. Examples are music, sound design and other human activities such as talking, working and sounds with mechanical origin that are the result of using industrial technology such as traffic and machines.

Natural or artificial soundscapes, further, can be useful as places to relax and quiet down. People mostly view them as preferential locations for holidays or relaxation. Holidays, however, are associated also frequently with noisiness, but this is an intentional noisiness. As such, industrial areas and highways are not on the top of the preferential lists for holidays. Noisy cities such as New York, on the contrary, are. There is, however, a difference between the kick of a short and noisy city trip and the long-term effects of exposure to noise, which often can be harmful.

Dealing with sound: overstimulation or refinement?

How do we deal with our sounding environment? And to which extent are we equipped to do so? This is the basic question of the *ecological* approach to music perception. Ecology, in fact, is the science of the interaction of an organism with its environment. As such, it is possible to conceive of listening as a kind of adaptive behaviour with sense systems that have adapted themselves to cope in a meaningful way with a rich and challenging environment. It brings us to the sensitivity of the ear, which enables us to make distinctions in the diffuse sound carpet that constitutes our acoustic environment. The ear, in fact, is able to perceive vibrational frequencies from about 16 to 20.000 cycles per second. Two things are of importance here: the actual range of the frequencies (hearing range) and the possibility to distinguish two frequencies that are very close to each other (discrimination). Besides, also the intensity of the vibrations has its role.

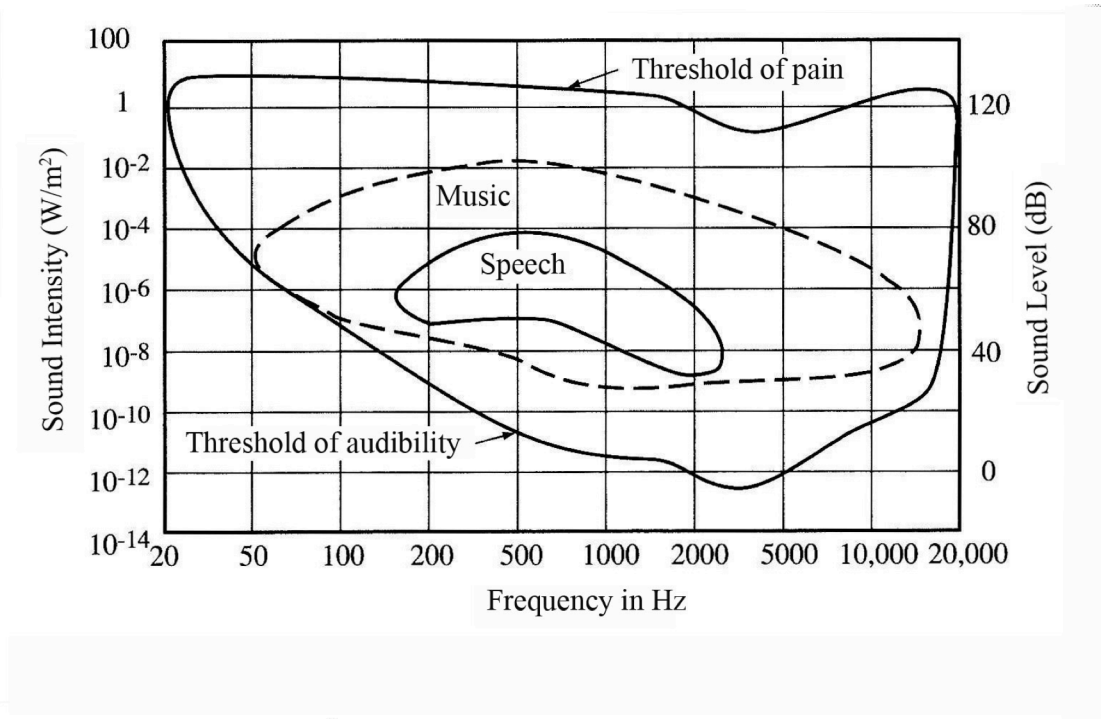
The *frequency range* of the ear is very broad. The relationship between the highest and lowest frequency is about 10^3 or more than 9 octaves. The eye, also, is very sensitive, but its sensitivity does not equal the sensitivity of the human ear, with only one octave as its range (from 4×10^{14} until 7×10^{14}). Within that single octave we can perceive more than 7 million different colours. One can imagine, therefore, the astronomical numbers for the ear. The number of possible tone distinctions is really unimaginable (see Rossing 1990 and 2002 for an overview).

The same holds true also for *sound intensities*. Also here, there is an enormous range with a very high sensitivity for minimal changes in air pressure. The difference in pressure in a loud sound is only 10^{-5} of normal atmospheric pressure, and some vibrations at the level of the eardrum encompass only 10^{-8} mm (one tenth of the diameter of a hydrogen atom). The vibrations in the inner ear are even 100 times smaller.

The combination of perceivable frequency and intensity range yields a lot of *discriminable distinctions*. In concrete numbers this means a sum total of 280 x 1400 = 392.000 detectable differences. It is thus possible to deal with sounds in a very subtle way and education of the ear should be directed at learning to make distinctions with listeners becoming sensible also for the smallest nuances.

The whole hearing range is depicted in the figure below. The vertical axis plots sound intensity (expressed in Watt/m^2) and loudness level (expressed in decibel); the horizontal axis plots vibration frequencies (expressed in Hertz). The range of speech is only a subset of this range. The musical domain is considerably greater**,** but is still smaller than the whole range of hearing. But not all what we can hear has musical relevance. Hence the restriction to this range.

In case of extreme levels of loudness, the upper dotted line is crossed and the range moves in the direction of the threshold of pain, with damage as a possible result. Whether damage effectively occurs, is dependent upon the intensity and duration of the exposure, but with very high intensity there can be irreversible harm even after a single exposure.



Against this background, we can raise the question whether listeners deal consciously with this innate sensitivity. Do they listen to sounding stimuli which are located in the zone of optimal stimulation and which should be the preferential one, or do they prefer the risky zone of the upper boundary?

This upper boundary is experienced in principle as a painful sensation (threshold of pain). Strong stimuli, however, can induce many reactions and against this background we should take into consideration the mechanism of *medical decadence*. This means simply that listener fool themselves in thinking that they like those stimuli, which the body does experience as cumbersome and harmful. When such forms of psychic conditioning become widespread, there is, of course, a problem.

Music, which is extremely loud, is located in the risky zone of harmful stimuli. Apart from the intrinsic value of much good popular music, there is a problem of overstimulation. Young people who attend a pop concert with earplugs illustrate this in a cynical way and a bit of common sense learns that there is a wrong conditioning here, which cannot be left to the commercial media who operate merely from an economical point of view. The question, however, can be raised where this need of overstimulation comes from, and this brings us to the question as to the origins and functions of music (Reybrouck 2008, Wallin, Merker & Brown 2000).

Music as adaptive function: evolutionary claims

Why do people listen to music? The science of music is just beginning to formulate answers to this question, relying on the research about evolutionary foundations of music. It is a new and challenging field that raises the question as to the origins of music and that has become a hot topic in current musicological research.

Music has no survival value in a strict sense and as such it has no biological relevance. This means that we can live without music. On the other hand, music is very important in the life of many people and this is obvious from the economic impact of the music industry. More money has been spent on musical products than on pharmaceutical ones and the biggest export industry of America until recently was not technology but music. The highways of many countries are musical highways as most of the drivers listen to music while they are driving. As such, it makes sense to conceive of *music consumption* as a common human behaviour. Music should make us happier, or calm us down, but even make us aggressive or competitive. It is difficult, in short, to conceive of a life without music.

But where does this need come from? Why are we looking for constant stimuli for our ears? And what is the relation with other stimuli, which are necessary to survive? Eating, drinking and sex are pleasurable activities with survival value which allow us to adapt to our environment and to survive as species. They are connected to lust or reward centres in the brain in order to guarantee a sufficient frequency of them. According to the *NAPS theory* (Non-Adaptive Pleasure seeking Theory) there are non-adaptive kinds of behaviour as well which are connected to the same centres. A classical example is the use of drugs as heroin or cocaine, and there are some provisional findings that music also activates these centres. The NAPS theory, however, is still controversial up to now (see Huron 2003 for an introduction). On the other hand, it has been shown that music can release hormones such as oxytocin, the hormone that stimulates milk production in young mothers and that is involved in sexual arousal as well. It is known as a kind of 'eraser' in the sense that it deletes contents of memory and facilitates the storage of new contents. The most obvious effect, however, is its coupling with the activities of the limbic system, which is the principal anatomical centre of the emotional brain and which is activated particularly by heavy stimuli.

The overall image that emerges in this context is a continuous search for states of higher activation. In physiological terms this is coined as *arousal,* i.e. the sum total of reactions that we can observe, e.g., when we are confronted with a dangerous animal that threatens us or when we are looking for an escape from a burning house. Music of deafening intensity comes very close to such arousal-raising experiences. But music is able also to lower the arousal. As such we can distinguish two poles within this dimension: one that increases and one that

lowers the arousal. And this brings us to the challenging domain of the *emotional effects* of music (Juslin & Sloboda 2001, Juslin & Västfjäll 2008). It is an important domain of research in current psychological research on music, which does not focus mainly on the effects of loud stimuli, but rather on the effects of intense emotional experiences that cause goose bump moments at large**.** These moments of emotional resonance are known as *chills and thrills* and the underlying mechanisms activate the same zones in the brain, which are activated also by sex and drugs.

Research has provided evidence that musical dissonance activates the same structures as negative emotions in general. These insights are important and provide major perspectives for the feeling of wellbeing of many contemporary listeners. It is clear, in fact, that the immersion in a constant stream of sound, which activates certain zones of the brain, can be of influence for the way we experience our mental and bodily functioning in daily life. The research, however, is not yet established sufficiently to draw more general conclusions on this. Yet, it is clear that the contemporary musical landscape is characterised by stimuli, which can be qualified as arousal-raising rather than arousal-lowering. This should not necessarily be problematic in itself, as long as there is an arousal-lowering dimension as well and that the strong stimuli are not located in the risky zone of damage for the ear.

The phenomenon remains remarkable, however. It is known that a minimum of sensory stimulation is necessary to survive. This stimulation should be provided preferably within the zone of optimal stimulation, below the upper limit, which is harmful and above the lower limit under which nothing is perceived. But what motivates listeners to move so frequently to this upper limit? Upper limits are used frequently in many kinds of *torture*. There are, in fact, odours and tastes, which are unsupportable. Some acerbic liquids are used in African initiation rituals and are perceived as being harder to support than heavy pain, and the smell of decomposing bodies calls forth a very professional attitude of the forensic pathologist**.** But sounds can be threatening as well: an example was the music death in ancient China, with a form of atonal music that induced cardiac arrest. But even contemporary techniques of torture rely on deafening intensities of sound in combination with continuous and excessive exposure to light. But how do we cope with music genres such as 'speed metal' or 'death metal'? Should we conceive of them as torture, or as a kind of self-chastisement? It is clear that these stimuli are outside the optimal zone of stimulation, but there is, nevertheless, a kind of social standard which accepts this kind of self-chastisement to some extent. We stress again, in this regard, an important factor of sound nuisance: listeners are very tolerant for sound volumes, which they themselves control. For volumes they are exposed to, this is mostly not the case.

Perspectives

The contemporary musical standards have overstimulation as their norm. Music must be spicy and less pregnant stimuli are easily perceived as not satisfying. On the other hand, there is a growing need for silence and reduction of the continuous stream of stimuli that function as a kind of acoustic carpet to fill in emptiness**.** We argue, therefore, for an education of the sense of hearing which aims at exploring the richness of the sound, rather than relying exclusively on the loudness and the speed of stimuli. Besides activation and arousal, there is the openness for stimuli, which calls forth mechanisms of attunement and resonance. This is a plea for an *ecological* way of listening with music being defined as a sounding environment and the listener as an organism that extracts meaningful elements from this environment. The extraction process is innate to some extent, but it is possible to intervene in this process as well. Education of the sense of hearing, therefore, should intervene in what is supplied and also in the way how listeners deal with this supply. Two things are really important here: the widening of the listening horizon and learning to make distinctions with more refinement and subtlety. We are opposed, therefore, to a cautious conception of cultural correctness that considers education of the masses as a taboo subject. It is possible and even desirable to intervene in the way how people deal with music.

To do this, it is possible to rely on the findings of *developmental psychology,* which state that it is possible to challenge a child in the zone of stimulation that is just a little bit above what it can do without intervention. As such, there should be a complementary supply to what the media provide. The latter, especially, conform to a great extent to social acceptance and shared standards of taste and preference. What the media supply is regulated strongly through standards of listening with lots of formats that determine the policy of programming of the music. All music that does not conform to these standards is mostly not programmed. This holds true for the music itself but also for the way how musical parameters are filled in in the sounding music. Most of commercially conceived music is in common time (4/4, musical meter), there is an almost obligatory accentuation of the afterbeats, the music is mostly tonal, relying preferentially on major keys and the instruments and singing style are mostly very stereotyped.

Against this background it makes sense to formulate some recommendations with respect to media and school, not from the wish to remain overly attached to some reactionary prerogatives, but starting from some recent insights from science. We argue for a more important role for the institutions of education, both the regular school and the music academies, with a major emphasis on the skill of listening. Some major goals should be mentioned here: an attitude of precision, sensitivity for the quality of sound, the openness to listen to music that is not known and to base value and meaning on the structure of the music.

It is interesting to complement them with these attitudes that can be considered as the conditions for listening ability: readiness to be silent, openness to listen, willingness to listen, the ability to recognise structures, willingness to postpone fast and uncritical identification with the music and the ability to consider and to analyse critically the social and economical conditions of music. What matters, in fact, are conditions (willingness to be silent and to listen with concentration) and learning goals (the ability to recognise structure in the music).

Generalising a little, it is possible to argue for a supply of music that is characterised by balance and diversity with the richness of the musical stimuli being more important than their intensity. This means that there must be a sufficient part of this supply that is outside of the normal expectation pattern of the listener, that some taboos should be eliminated with respect to the programming of music that is not conform to the dominating canon and all this within the limits of hearing hygiene. Besides, we argue forcefully for the restitution of the receptive component of musical education. School, but also the media, have a role in opening the listening horizon. To do this, there should be a distribution of forces between the media, the regular school, and the music academies, with walls that divide them to be overthrown.

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