

## REGAINING THE LEGEND OF SILENCE:

### On Noise Sensitivity, Superfluous Noise and Noise-Induced Hearing Loss in Today's World.

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*Abstract:* Our everyday environments have been growing more noisy in the last generation, and now pose considerable risks for many people of noise-induced hearing loss. At the same time, a considerable proportion of people claim that they are disturbed by excessive noise levels. In part this is a completely unrecognized, yet common form of perceptual disability. Combining these two problems we have a recipe with enormous potential to create social divisions, and acrimonious, even violent confrontations. Even if decisive action were to be taken now, it would be a long time before the related problems would be properly addressed. Greater awareness is needed of this looming, major public health problem. This is the first step, before any action will be possible at a political level. At the same time, greater recognition is needed of the very great differences between people in their individual “perceptual style”, and the levels of sensory stimulation in which they function at their best.

#### **A: Introduction.**

In this essay I draw attention to three topics which, in principle are separate, but in practice become closely intertwined: One is sensitivity to excess sound, perceived as “noise”, a source of annoyance for many people. This *might* be regarded as a little recognised disability (although the drift of my argument raises questions about this); the second is the increasing levels of noise – which is not just the *intensity* of sound - in today's world, escape from which becomes increasingly difficult to achieve. This has now reached such excesses that the hearing of many people is being permanently damaged. Thus, the third issue is noise-induced hearing loss. I argue that this is now a major unrecognised public health issue, which can only grow in years to come, even if decisive action to be were taken now.

## **B: Noise sensitivity.**

For some people, loud noises, especially if they are sustained and inescapable, can be distressing, may elicit strong emotional responses, the likes of which are never seen otherwise, and indeed can be completely disorienting. As a personal example, let me recall an incident when I was a research student in Glasgow in the early 1970s. The folk in the lab went to a performance of the rock musical *Hair*, this being the early days of electronic amplification used to ramp up the volume of sound. The show was so loud that I failed to notice its most critical detail - that everyone on stage was stark naked! Clearly, noise sensitivity can be a considerable social disadvantage.

Of course, when I write like this, I am playing for laughs. I like to do that. Perhaps it is my favourite sport. The description of the incident I have just given is nevertheless the literal, ungarnished truth. In truth, noise sensitivity is a serious issue, about which at present little is known. Here are a few more “first person” accounts of experiences of noise sensitivity<sup>1</sup>:

“I’d hear every footstep, and I’d hear the cupboard door opening and they wouldn’t even have to be slamming it . . . You’d hear everything, and everything was magnified. That’s kind of hard for people to understand. It’s like you’re living in the world with micro or speakerphones strapped to each side of your head. You just can’t get away from it.”

“You can’t choose the sound you want to hear”

“In a conversation group, where three or four different people are talking, I can’t handle it . . . I don’t receive the message. I completely blank off what’s happening and stand there like a stuffed dummy”.

“It’s just overwhelming; there’s just too much stimulus going on.”

These descriptions convey more than excessive sensitivity to the actual *intensity* of sound. Most of us are aware of only a small fraction of the sounds going on around us, but switch off attention, or censor things that are somehow taken as irrelevant to us. These quotations indicate that, in

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1 Landon,J, Shepherd,D, Stuart,S, Theadom,A, Freundlich,S. (2012) Hearing every footstep: Noise sensitivity in individuals following traumatic brain injury. *Neuropsychological Rehabilitation*, iFirst, 1-17.

addition, the writers have difficulty in sorting out one sound from another, so that they can attend just to the sounds or voices of interest. These quotations came from people who have had some form of traumatic brain injury (TBI). However, more-or-less the same experience is reported by people who have never had such injury. The problem is probably quite common. A recent large research study asked participants their response to the following lines: "People experience noise in different ways. Do you experience noise generally as very disturbing, quite disturbing, not especially disturbing, not at all disturbing, or can't say?" 38% of the sample answered "yes" to either of the first two categories ("very disturbing", and "quite disturbing"). From studies of people who have had mental illnesses of one sort or another, such problems are more common than in the general population (but no specific diagnosis is implicated). I would be one of those. However, the majority of cases of noise sensitivity probably occur in people who have had neither TBI, nor psychiatric problems. When I read those quotations, I cannot distinguish my own experiences and those quoted from people who have had TBI, although they often seem to describe experiences more severe than my own. However, people who have had TBI will be able to compare their perceptions before and after their injury, which makes them more vividly aware of their difficulty than I am of mine (having never known anything different). There *may be* differences yet to be discovered between noise sensitivity due to TBI and that which arises spontaneously; but we do not yet know.

Noise sensitivity seems to occur as often in men as in women. The problem may sometimes decrease with age (but definitely not for me). Some situations make the problem worse, such as anxiety, stress or tiredness. I have noticed occasionally that sedatives make the problem worse, although most medicines used in psychiatry have little effect, for better or for worse. In noise-sensitive women, I have heard that in certain phases of the menstrual cycle the problem is worse. It is hard to tell if these are effects on the basic process leading to noise sensitivity, or on the way a person reacts to it. Anxiety may make things worse not by changing the basic process but by modifying a person's reaction (the annoyance due to noise in sensitive people).

Quite apart from TBI, or links to diagnosable mental disorders, noise sensitivity does seem to be associated with some personality traits. This has been suspected for many years. The nineteenth century German philosopher Arthur Schopenhauer was noise sensitive and believed that "the amount of noise that anyone can bear undisturbed stands in inverse

proportion to his mental capacity and therefore regarded as a pretty fair measure of it.” This is probably not literally true; Schopenhauer may have been expressing a degree of frustration. However, modern research links noise sensitivity with a variety of personality traits, some apparently positive (friendly, generous etc), others negative (anxious, aggressive). The research literature is confusing, partly because, in describing the respective traits, terms used are hardly objective and scientific, but seem to cast personal judgments on the people so affected (for better or worse). In addition, it is not easy to separate personality traits whose cause is closely linked with noise sensitivity itself, and those which are secondary consequences of having lived for many years with noise sensitivity (such as the need to seek privacy, a strong tendency to harm avoidance, and sometimes, aggressiveness).

One aspect of noise sensitivity which cannot be ignored is its near-total neglect by medical specialists: There is a general lack of understanding of the problem, perhaps because it is completely invisible. When patients raise it with their doctors, it is seldom taken seriously. So, one noise-sensitive patient wrote about “having to find it out for myself”. Another writes “So, my experiences of the first 8 years [after TBI] was basically self-management. I knew something was wrong, but didn’t know what”. Sometimes the neglect of this issue appears to amount to active denial by clinical staff. One noise-sensitive patient wrote” “I was told, in effect, that I was a neurotic housewife and I had to go home and get over it.”<sup>2</sup>

Of course, similar dismissive attitudes and lack of comprehension are well known in other areas of medicine. Currently, this arises in relation to chronic fatigue syndrome (myalgic encephalomyelitis - ME) as it has for most mental disorders, where the reality of a disorder or disability is invisible, revealed only by subjective first-person reports. In former days, when there were few objective tests, this issue arose in most areas of medicine. This is why doctors have separate terms for “symptom” – what a patient complains about - and “sign” - an objective piece of evidence of illness, originally obtained during a clinical examination. As more and more medical assessment becomes objective, by use of sophisticated technology, we tend to forget the history of medicine when much was based on subjective reports of experiences, conveyed from patient to doctor. Sometimes – and there is a long tradition of this - it was doctors

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<sup>2</sup> These quotations come from: Landon,J, Shepherd,D, Stuart,S, Theadom,A, Freundlich,S. (2012) Hearing every footstep: Noise sensitivity in individuals following traumatic brain injury. *Neuropsychological Rehabilitation*, iFirst, 1-17.

themselves who gave the first detailed description of experiences associated with particular disorders from which they themselves suffered.

Commonly there is a pejorative (non-objective) style in terminology in research papers. There may be a more-or-less explicit suggestion that those who complain have a personality problem, perhaps linked to their tending to be pugnacious or aggressive. On one occasion when I tried to describe the issue of noise sensitivity, it was suggested that I was being “selfish”. It may also be suggested that noise sensitive persons should wear ear muffs. That is unlikely to help: Ear muffs inevitably lead to muffling and distortion of sound. Since noise sensitivity is in part a problem with separating different sounds, rather than simply detecting them or identifying them in isolation, ear muffs are likely to make matters worse.

The severity of noise sensitivity is commonly measured in terms of the degree of “annoyance” caused by sounds. This is hardly the most objective and precise term. Somehow the first-hand experience of noise sensitive people is rendered less real with phrases such as “self-reported noise sensitivity captures evaluative rather than sensory aspects of auditory processing”. There seems to be an implied hint here: “You ought to toughen up a bit, eh?” Perhaps instead one should ask “What is actually going on here?” Perhaps annoyance reflects the fact that a person is aware that his or her mental functions are being interfered with. This is clearly stated by some first-person reports<sup>3</sup>:

“It’s disrupted my thinking, it disrupts my peace, it disturbs my concentration . . .It’s changed the way I live.”

“I can’t block them, and I’m getting frustrated with myself, because I can’t think the way I want to think”.

If we try to be dispassionate, we could call the problem, in part at least, not “annoyance” but “disturbance of sensory processing, or of “sensory analysis”. There may be another added trait, which determines how annoyed people become, when they face *any* sort of sensory disruption, or indeed any stressful or adverse event.

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<sup>3</sup> Landon,J, Shepherd,D, Stuart,S, Theadom,A, Freundlich,S. (2012) Hearing every footstep: Noise sensitivity in individuals following traumatic brain injury. *Neuropsychological Rehabilitation*, iFirst, 1-17.

To fill in some detail here I should explain the term used for sound intensity and the scale used to measure it. The basic unit of sound intensity is the “Bel”, and is generally divided into tenths or “Decibels” (“dB”). However, the scale is not a linear one but a logarithmic one. What that means is that a shift upwards of ten decibels is not an *addition* of ten units of sound intensity, but a ten-fold *multiplication* of intensity. From this it follows that a 20 decibel increase in intensity is a 100-fold (ten times ten) increase in intensity or physical power of the sound. The Table below gives some indication of common situations at which different levels of sound may be experienced.

<b><i>Decibels</i></b>	<b><i>Common situations</i></b>	<b><i>Relative power</i></b>
50 dB	Comfortable speech	1
80 dB	Employers to provide protection (UK)	1000
85dB	Employers to take action, if averaged through working day (UK)	~3200
87dB	Not allowed, even with protection if averaged over working day (UK)	~5000
90dB	A person cannot be heard without raising their voice. Above this level, permanent hearing loss may occur with prolonged exposure.	10,000
100-105dB	Common sound level in Walkman/MP3	100,000
105-115dB	Common sound level at discotheques	320,000-3,200,000
110 dB+	Common sound levels at rock concerts	1,000,000+
140dB	Typical for explosions, gunshots etc	1000 Million

The term “annoyance” has driven research studies which show vast differences between people in how intense a sound has to be before a person considers it to be annoying – over a 100-fold difference (ranging from 75 to 97 dB in different people) in one study, in which people had to identify a noise level that was “fairly annoying”<sup>4</sup>. Susceptibility to noise-induced annoyance clearly varies greatly from one person to another. What could be going on to create such big differences?

More precise than “annoyance” is “acceptance of background noise”. This is defined as the difference in sound intensity between the most comfortable listening level for speech, and the highest background noise level that is acceptable when listening to and following a story<sup>5</sup>. This definition focuses on conditions of perception needed for comfortable

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4 Moreira,NM, and Bryan,ME (1972) Noise annoyance susceptibility. *Journal of Sound and Vibration* 21, 449-462.

5 Nabalek,AK, Tampas,JW, Burchfield, SB (2004) Comparison of speech perception in Background noise with Acceptance of Background Noise in aided and unaided conditions. *Journal of Speech & Hearing Research*, 47, 101-1011.

listening and speaking, not on annoyance created when outside this comfort zone. Often this measure is used to help decide whether hearing-impaired people would benefit from wearing a hearing aid. However, data have also been published for people with no hearing impairment<sup>6</sup>. Amongst such people, those least sensitive to noise can cope with unwanted noise with intensity only 2-8 dB less intense than the speech to which they are attending (presented at 50 dB). For those most sensitive to noise a difference of over 20 dB is needed for comfortable listening. If the attended speech is presented at a lower intensity, that is below the “most comfortable” level, people are less sensitive to extraneous noise; but if the attended speech rises above the “most comfortable” level, even greater differences in intensity are needed between it and extraneous noises before comfortable listening is possible: For speech presented at 76 dB, an average difference of ~25 dB is needed for comfortable listening; and within this average are included the most sensitive people, for whom a difference of well over 30 dB – that is a difference in power of the competing voices of over 1000-fold – may be needed before comfortable listening is possible.

Once we have more precise concepts, we can analyse the processes further, perhaps in terms of brain science. However, before broaching that topic, two other matters should be clarified: First, we need to separate processes occurring in our sense organs (in this case our inner ear), from the subsequent sorting out of sensory messages in the auditory parts of the brain. This is the distinction between sensation and perception (taking the latter term in its broad meaning). Second, in study of perception two styles of perception are relevant – “augmenting” and “reducing” tendencies. To explain these, suppose we were to measure the size of a response to a stimulus, as the intensity of the stimulus was gradually increased. A variety of measures could be taken for the size of the “response”. Usually, in research studies, it is the size of the electrical response to the stimulus, recorded with electrodes on a person’s scalp. In principle, the same description should apply to a subjective response – the “impact” a stimulus has on a person. In such an experiment, we might expect that size of the response would increase in direct proportion to the size of the stimulus. Generally this is so, but the relationship can depart from expectations in two ways. For perceptual augmenters, the size of the

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6 Burchfield, SB, Franklin, CA, Nabalek, AK, Thelin, JW. (2006) The effect of speech presentation level on acceptance of background noise in listeners with normal hearing. *Journal of the American Academy of Audiology*, 17, 141-146.

response increases out of proportion to the intensity of the stimulus; for reducers, it fails to “keep pace” with the intensity of the stimulus, and may even tend to reduce as the stimulus intensity continues to increase. So, as the intensity increases, extreme reducers tend to minimise the impact of sensory stimuli, compared with its objective intensity; for extreme augmenters, the impact may be exaggerated for high intensity stimuli, compared to truly objective perception of the stimulus.

An added effect is that, if stimuli are maintained over a period of time, for instance during a continually noisy party, many people adapt to the intense stimulation, and no longer notice how loud the prevailing noise has become; others may not adapt, and, over time, may even grow more sensitive to prevailing sound levels. The extent of individual variation has not been well studied. In part this adaptation depends on an automatic reaction of a tiny muscle in the middle ear, which responds to loud noises by adjusting transmission of sound, so that the inner ear is protected from very loud sounds. However this automatic response only protects the inner ear for some frequencies, does not sustain its protective effect well over a long periods, and its effectiveness varies greatly from one person to another. Much of our ability to adapt to loud noises depends on processes within the brain. Differences between people who adapt or become sensitized to repeated stimuli may well be related to the differences between reducing and augmenting tendencies in perception of stimuli of different intensities. However, this like many other questions on noise sensitivity, has not been well studied.

The differences in annoyance produced by intense sounds in different people is no doubt partly due these basic perceptual traits. However, they may be compounded by different tendencies of some people to get easily annoyed, regardless of the source of the annoyance. This possibility is supported by studies which show that part of the manifest annoyance produced by stressful sensory stimuli is common to a number of different stimuli - noises, odours, tobacco smoke, and in one study<sup>7</sup>, exposure to a very cold strong air blast in the person’s face<sup>8</sup>. General sensitivity to annoyance may also have links with personality – in the latter case, with

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7 LeBlanc,J, Ducharme,MB, Thompson,M. (2003) Study on the correlation of the autonomic nervous system responses to a stressor of high discomfort with personality traits. *Physiology & Behavior*, 82, 647-652.

8 Some studies fail to identified such a “general annoyance” trait: Ohrstrom,E, Bjorkman,M, Rylander,R. (1988) Noise annoyance with regard to neurophysiological sensitivity, subjective noise sensitivity and personality variables. *Psychological Medicine*, 18, 605-613.



extroversion. Interestingly, in one study<sup>9</sup>, it is introversion which is linked with noise sensitivity, not extroversion.

In noise sensitive people there is no difference from other people in sensitivity at the level of sensation, that is in the functioning of the inner ear. The quietest sounds which can be detected do not differ between noise-sensitive and other people. There is no difference in a person's ability to discriminate between the intensity of sounds, nor in how loud he or she judges them to be<sup>10</sup>. However, the last finding has only been made at sound levels below 80 dB. Above this level noise sensitive people may experience sounds as louder than other people. The evidence on this is limited; and it has not yet been explored at all in relation to intensities above 95 dB. Despite the scarcity of evidence, the limited evidence which is available is a clue that there is a process within the brain, rather than in the sense organ for hearing, which normally limits the subjective impact of a intense sounds. This process appears to be less effective than normal in noise sensitive people.

It was already mentioned that psychoactive drugs have little effect on the experience of noise sensitivity. Most such drugs act by modifying the action of the chemical messenger substances ("neurotransmitters") by which one nerve cell acts on another. Their lack of effect makes it unlikely that noise sensitivity has much to do with neurotransmitter chemicals. A more likely possibility is that it has a basis in the structure of the brain, especially the detailed cellular structure. Two clues add to this suggestion: *First*, noise sensitivity is a remarkably stable characteristic for some people, changing little over the course of their whole life. (The personal anecdote I recalled 35 years ago in Glasgow, testifies to this – little has changed for me.) Moreover, living in a noisy environment (such as near a major airport) has a negligible effect on the basic sensitivity<sup>11</sup>, although continual exposure to noise may progressively increase the degree of annoyance and emotional distress a person experiences as a result. The same would occur for any other continued and unavoidable source of annoyance. *Second*, from a study of twins<sup>12</sup>, noise sensitivity does seem to have a substantial genetic component. Neurotransmitters in the brain are

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9 Weinstein,ND (1978) Individual differences in reactions to noise: a longitudinal study in a college dormitory. *Journal of Applied Psychology*, 63, 458-466.

10 Ellermeier,W, Eigenstetter,M., Zimmer,K (2001) Psychoacoustic correlates of individual noise sensitivity. *Journal of the Acoustic Society of America*, 109, 1464-1473.

11 Henk, ME, Miedema,HM, Vos,H. (2003) Noise sensitivity, and reactions to noise and other environmental conditions. *Journal of the Acoustic Society of America*, 113, 1492-1504.

12 Heinonen-Guzjev,M, Vuoinen,HS, Mussalo-Rauhamaa,H, Heikkila,K, Koskenvuo,M, Kaprio,J. (2005) Genetic component of noise sensitivity. *Twin Research, Human Genetics*, 8, 245-249.

forever in a state of flux, always subject to change, unlike cellular components of brain structure. The amount of neurotransmitter active in the brain is thus not under direct genetic control, as is cellular structure. For such reasons, it is likely that noise sensitivity has a structural basis in the brain, rather than a basis in transmitter chemistry. What could it be?

One little-considered aspect of the brain which may be relevant is the large number of “axons” or nerve fibres, which convey electrical signals from one part of the brain to another, sometimes over distances of many centimetres, to the point where they release their transmitter substances. The velocity of conduction of these signals along an axon is closely related to its structure, especially its diameter. Conduction of these electrical messages along axons, and the velocity of conduction, is not affected by any drugs used in psychiatry. The only class of medicines which do influence axonal conduction are the local anaesthetics. Outside the brain, these are useful when locally injected, for instance in dental surgery, but of course cannot be used within the brain. The role of axonal conduction in accounting for differences in perceptual and cognitive styles, and as underlying factors in some mental disorders has long been an interest of mine: My account of many aspects of the disorder called schizophrenia<sup>13</sup> rests on assumptions about the range of conduction velocities found in populations of axons, and how these differ from normal in schizophrenia.

These suggestions about structural differences in the brain which give rise to noise sensitivity are not proven. In any case, we certainly have no means at present of detecting or measuring them in individual people. They are likely to be subtle and small-scale changes. One may then ask why the noise levels causing annoyance, or in accepting background noise during conversation differ so widely between people. We have some metaphors to illustrate the sort of relationship which may exist between a small basic problem, which is somehow amplified to produce a major one. One of these is a very old English proverb:

For want of a nail the shoe was lost.  
For want of a shoe the horse was lost.  
For want of a horse the rider was lost.  
For want of a rider the message was lost.

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13 Miller,R. (2008) *A neurodynamic theory of schizophrenia and related disorders*. Lulu Enterprises, Morrinsville, North Carolina).

For want of a message the battle was lost.  
For want of a battle the kingdom was lost.  
And all for the want of a horseshoe nail.

In modern times, conveying the same message, we have the “butterfly effect” – the scenario where a butterfly flapping its wings in one part of the world becomes a critical event, which, in due course, unleashes a tornado, far away in another continent. Such extreme amplification of small effects is most likely to occur in complicated situations, especially ones where different processes are set up in competition against each other. That is exactly the situation where noise sensitivity shows up, in this case as competition within the brain: When a person is asked to make sense of one signal – one source of speech – in the face of competing sources of sound, small differences between people in brain processes may lead to vast differences in sensitivity to disruption, and in some people to disruptive effects out of all proportion to the original problem.

Sensitivity to *noise* is not the only issue to be considered here. There are more general issues of sensitivity to a variety of sensory stimuli, associated with perception in any of our senses. Most of these are also poorly understood, summed up under the heading of “differences in perceptual style”. These may include a disturbing sensitivity to light, to motion as perceived visually (which is something of an issue for me), or to odours, or to touch sensations. These topics are at the frontiers of our current research knowledge, or beyond those frontiers; but for the many people affected by them, they are immediate realities, and by no means just academic niceties. As with noise sensitivity, they almost certainly are linked with a variety of other psychological traits, manifest as differences in personality and in “cognitive style”. If we could understand them better, the implications for educational systems and employment would be vast. Better understanding might then lead to better matching of students for their university courses and career choices, and better matching of employees for their jobs.

### **C: Excessive and Dangerous Sound Levels in our Environment; Excessive Perceptual Stimulation in Today’s World.**

I am by no means the first to point out the hazards of excessive levels of noise and other forms of perceptual stimulation in everyday working and social environments. In heavy industries in previous generations (but still often today), noise levels are so high that they pose a definite health risk: Hearing sensitivity may be permanently reduced. Historically, deafness

amongst blacksmiths was well-known. One of the noisiest work places has been underground mining: Machinery used in confined spaces produces very high noise levels. Noise levels in such settings have been published<sup>14</sup> from a coal mining district in the USA (Pittsburgh) for years prior to 1983. The highest levels, produced by pneumatic percussion tools averaged 117 dB. Most equipment produced mean noise levels above 95 dB. This review stated that “There is no doubt that the majority of miners are exposed to hazardous levels of noise, most exceeding a safe level over an 8-hour shift of 85 dB, and sometimes the peak exposure standard of 140 dB.” The extreme figure of 140 dB reflects the fact that underground mining involves controlled explosions in confined spaces, as a part of routine operations. However, more recent statistics<sup>15</sup> (years 1999-2004) after safety regulations had been introduced showed that work in many other industries exposed a high proportion of employees to hazardous noise levels. These levels were defined as “noise so loud that a raised voice was required in order to be heard”, which is roughly the potentially hazardous noise level of 90 dB. Industries where dangerous noise levels prevailed (other than underground mining) are forestry/wood product manufacturing, repair/maintenance, motor vehicle operators, and construction trades.

Such evidence is cited for comparative purposes here. The real focus of my essay is the noise level in everyday non-industrial settings, including social gatherings, in today’s world. From a perceptual point of view, it is clear that our everyday environments have been growing steadily more complex and confusing in recent decades. This was pointed out in the early seventies by Lipowski<sup>16</sup>, referring to the inevitable effects of urbanization. Thirty seven years later the situation is far worse than Lipowski described. The increase in sound levels made possible by electronic amplification is one factor, but not the only one. Mobile phones which require people to speak louder than in face-to-face conversation, are coming to be recognised as a source of widespread annoyance<sup>17</sup>, and their use is forbidden on Japanese bullet trains. Continual, inescapable sound

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14 McBride,DI (2004) Noise-induced hearing loss and hearing conservation in mining. *Occupational Medicine*, 54, 304-310.

15 Tak,SW, Davis,RR, Calvert, GM (2009) exposure to hazardous workplace noise and use of hearing protection devices among US workers = NHANES, 1999-2004. *American Journal of Industrial Medicine*, 52, 385-371.

16 Z.J. Lipowski (1975) Sensory and Information Inputs Overload: Behavioural Effects *Comprehensive Psychiatry*, Volume 16, 199-221.

17 Marina Hyde (*Guardian*, 5th July, 2013) “The revolution is over: the rude mobile phone users have won.”

has become a necessary part of our culture: I walk into a supermarket, to be met by such a cacophony of musak, that I am unable to remember what I came to buy. I go into a retail outlet for electronic equipment to be faced with a barrage of large-screen TVs, with endless meaningless visual movement, meaningless in itself, but also preventing one from having any private thoughts. Regardless of my own reactions, which may be idiosyncratic, I am moved to ask: Is it good business?

Today, we have very high noise levels in Walkman/MP3 systems, at Discotheques and Rock Concerts, and often in cinemas. (I was recently in the foyer of a cinema in New Zealand which advertised its showings with the phrase “extreme entertainment”.) What noise levels are produced in such settings? For MP3 players, intensities are usually set around 100 dB. The usual sound level at Discotheques has been rising since the 1970s, is now commonly as high as 105 dB, and may be up to 115 dB. At Rock Concerts it may also well exceed 110 dB<sup>18</sup>. Of course the exact level depends on many factors such as how far people are from loud speakers, setting of amplifiers, and so on. However, these levels are well within the range of the most hazardous heavy industries, even for relatively brief exposure. Admittedly, participants are not exposed to such noise levels on a daily basis throughout the working day. Nevertheless these statistics make the issue of permanent noise-induced hearing loss a major concern. At these levels a person’s auditory threshold is raised afterwards for 24 hrs or more, and there may be more enduring elevation of thresholds. The question needs to be asked, as it was asked long ago about heavy industry, whether such noise exposure causes permanent damage to the hearing of those so exposed. I answer the question, as before, first from evidence about heavy industry, and then from recent evidence in other settings, including the social situations just mentioned.

Sound is a mechanical vibration. Studies on experimental animals show that intense sound causes physical damage to the fine structure of cells in the inner ear – the organ of hearing. Much of this damage is not a direct consequence of the physical impact of excessive sound vibrations. The inner ear has complex mechanisms, involving several neurotransmitters.

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18 See for instance: Petrescu,N. (2002) Loud music listening. *McGill Journal of Medicine*, 11, 169-176; Lawrence,N., Turrentine,A. (2008) Examination of noise hazards for employees in bar environments. *Journal of Safety ,Health & Environmental Research*, 5, no 3.

[www.asse.org/academicsjournal/archive/.../docs/winter08-feature04.pdf](http://www.asse.org/academicsjournal/archive/.../docs/winter08-feature04.pdf)

Levey,S, Fligor,BJ, Ginocchi,C. (2012) The effects of noise-induced hearing loss on children and young adults. *Contemporary Issues in Communication Science and Disorders*, 39, 76-83;

Excessive sound levels cause a number of biochemical changes in cells of the inner ear, partly involving excessive release of transmitter substances. These changes are an immediate cause of structural damage to these cells. In the short term, repair of damage can occur over a period of a few days. The result is that, at least initially, there is recovery from noise-induced hearing loss. Very intense explosive sounds, such as those from gun-shots cause damage to the inner ear in a different way, by direct physical impact of the sound. Repeated exposure to loud noises, or single very intense explosive sounds, leads to hearing loss which increases progressively, and becomes permanent.

Noise induced hearing loss (NIHL) can be recognised in an audiogram (which assesses a person's hearing sensitivity at various frequencies). The first characteristic sign is loss of sensitivity at around 4000 cycles/second, which deepens and expands to neighbouring frequencies as noise exposure continues. Routine testing uses various cut-off criteria, often "a loss of sensitivity of 25 dB or more at specific frequencies" (e.g: "the mean for such loss over 500, 1000, and 2000 cycles/sec").

Statistics are available for the prevalence of NIHL in major industries where it is known to occur. Comparison between industries and countries is difficult because different criteria are used. However, the following figures<sup>19</sup> use similar criteria (loss of sensitivity of 25 dB or more): For the white South African gold miners, in a study published in 1987, 21.6% met this criterion of hearing loss at age 58; for mine workers in the USA, as many as 90% met the criterion by age 50. Figures cited for British coal miners seems to indicate a lower prevalence of NIH. They may not be very reliable, since statistics similar to those in South Africa and the USA are available for mine workers in Europe and Russia. The coal mining industry in Britain largely disappeared twenty years ago, so the topic is now becoming history. Nevertheless many instances of former miners seeking compensation for noise-induced hearing loss have come before British courts in recent years. Health risks associated with coal mining are well known, notably lung problems linked with the dusty working environment. Second only to such problems is NIHL, which is far more common than in people of the same age not exposed to intense noises.

In recent years, noise-induced hearing loss is found in a substantial proportion of young people, and is becoming more common. Using the same criterion as in the above studies of mineworkers (loss of sensitivity

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19 McBride,DI (2004) Noise-induced hearing loss and hearing conservation in mining. *Occupational Medicine*, 54, 304-310.

of 25 dB or more), figures from the USA for adolescents aged 12-19 years showed hearing loss to this extent in 14.9% of persons in the years 1988 to 1994, increasing to 19.5% by 2005-2006<sup>20</sup>. Several papers provide details of harm done by noise in modern recreational settings. A two-part study from Argentina<sup>21</sup> could directly attribute hearing loss to noise exposure at social gatherings. Over three years, adolescents whose hearing sensitivity fell tended to have had more recreational exposure to loud noises than those whose thresholds underwent normal age-related changes. (There were some exceptions, people who were relatively unaffected.) There is no reason to think the issue is any less in many other countries. Hearing loss in rock musicians has also been identified<sup>22</sup>, and, although less severe than in workers in heavy industries, has been shown to be worse in those who take no protective measures. Sadly, many people whose hearing has been impaired are unaware of their growing problem. Often such people can be recognised by their speaking with a rather loud voice.

That such findings are made in research studies is hardly news to many of those young people. In a recent lecture by Cory Doctorow, a Canadian blogger and author on copyright and IT issues<sup>23</sup>, a comment was casually dropped in, as an aside: “I’m part of the walkman generation, and so I’m reconciled to the fact that I will be wearing a hearing aid when I in get older”. This is absurd. It is also true.

Other comments on this theme are expressed in more poetic, yet none-the-less stark terms. Jean Arp was originally from Alsace, but moved to Switzerland during WWI. As a sculptor he came to prominence as part of the Dadaist movement, reacting against the horrors – and noise - of the Great War. He penned the following lines<sup>24</sup>: “Soon silence will have passed into legend. Man has turned his back on silence. Day after day he

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20 Niskar,AS, Kiszak, SM, Holmes, AE, Esteban, E, Rubin, C, Brody, DJ. (2001) Estimated prevalence of noise-induced hearing threshold shifts among children of 6-19 years of age: The Third National Health and nutrition Examination Survey, 1988-1994, United States. *Pediatrics*, 198, 40-43; Shargorodsky, J, Curhan, SG, Curhan, GC, Eavey, R. (2010) Change in prevalence of hearing loss in US adolescents. *JAMA*, 304, 772-778.

21 Serra,MR, Biassoni, EC, Richter,L, Minoldo,G, Franco,G, Abraham,S, Carignani,JA, Joekes,S, Yacci,MR (2004) Recreational noise exposure and its effects on the hearing of adolescents. Part I: An interdisciplinary long-term study. *International Journal of Audiology* 44, 65–73. Part II: Development of hearing disorders. *International Journal of Audiology* 44, 74–85.

22 Schmuziger,N, Patscheke, J, Probst, R. (2006) Hearing in nonprofessionals pop/rock musicians. *Ear and Hearing*, 27, 321-330.

23 University of Westminster School of Law (Centre for the Study of Law, Society and Popular Culture); series entitled “Entertainment Law: Theory Meets Practice.

See: <http://www.westminster.ac.uk/law-society-popular-culture/news/cory-doctorow-speaks-at-the-university-of-westminster>

24 Arp *on Arp: Poems, Essays, Memories*, Viking, 1972, p. 231.

invents machines and devices that increase noise and distract humanity from the essence of life, contemplation, meditation.”

The issues about which I write were known long ago. Safety guidelines have been introduced since 1980: Usually employers are required to take action for daily or weekly average noise levels in the workplace of 85 dB or more. In Britain, there is a lower limit of 80 dB, at which an employer has to provide information and training and make hearing protection (such as ear muffs) available. There is a higher limit of 87 dB, to which no worker can be exposed (even taking hearing protection into account). Such regulations now apply to most industrial workplaces in many countries. Similar guidelines were recently introduced for kindergartens in New Zealand. For heavy industries such as coal mining, the issue now is not recognition of the problem, and establishing appropriate regulations, but in implementing those regulations. There is recent concern about the lack of effect of safety guidelines, and in particular the failure of many employees to take up the opportunity of wearing ear muffs to protect their hearing<sup>25</sup>. Hearing impairment remains as the most prevalent disability in most Western societies<sup>26</sup>. Nevertheless regulations *do* exist, and may be more widely implemented in years to come. Laws also exist in many countries to regulate noise in public places (under the heading of “noise abatement”), aiming to avoid annoyance and stress for the general public. In striking contrast, in most parts of the world, there is complete lack of safety guidelines to protect the participants themselves, in such noisy social and recreational events, or users of Walkman/MP3 systems. There, the real issue is not just annoyance, but permanent loss of hearing. Except amongst a few specialists, there is scarcely any public concern. The exception is the European Union, where legislation does exist to limit sound levels at such events<sup>27</sup>. This includes MP3 systems, although, since enforcement is difficult, these are recommendations at present, rather than definite regulations.

The conclusion is inescapable: There is a major public health issue here, which has scarcely begun to be recognised publicly, let alone debated and suitable action taken. Already, there are likely to be many

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25 Daniell WE. Swan SS. McDaniel MM. Camp JE. Cohen MA. Stebbins JG (2006) Noise exposure and hearing loss prevention programmes after 20 years of regulations in the United States. *Occupational & Environmental Medicine*, 63, 343-351.

26 Borchrevink, HM (2003) Does health promotion work in relation to noise? *Noise Health*, 5, 25-30.

27 <http://www.newscientist.com/article/dn17871-european-law-could-limit-ipod-volume.html#UfJEgr5waUk>;  
[http://www.cenelec.eu/pls/apex/f?p=WEB:NEWSBODY:956015551221456::NO::P300\\_NEWS\\_ID:24](http://www.cenelec.eu/pls/apex/f?p=WEB:NEWSBODY:956015551221456::NO::P300_NEWS_ID:24)  
<http://www.bbc.co.uk/news/health-21294537>



people whose hearing has been permanently impaired, yet are unaware of the fact. The problem has grown insidiously since the time, a generation ago, when highly-amplified sounds started to be used in recreational settings. Even if action were to be taken now, and regulations were to be put in place, it would be years before they were fully implemented. Many young people derive a thrill from noisy social environments, and yet are increasingly losing the sensitivity of their hearing. As their hearing is lost, it is likely that they will demand ever louder music in social gatherings to get the same thrill. Thus, in the years before effective regulations are put in place and implemented, the problem is likely get far worse before it starts to get better. It may be many years before we have escaped from this problem. We thus appear to have a major issue, which has already been unfolding for many years, slow to set in motion, and slow to resolve, one which must be left for future generations to address. There are however some signs of the beginnings of public awareness<sup>28</sup>.

#### **D: The Emotional Impact of Intense Noise; The Combination of Noise Sensitivity and Excessive Noise Levels.**

As already mentioned, loud noises have an emotional impact on anyone, but especially on noise-sensitive persons. At low sound intensities (such as music in supermarkets and other retail outlets) noise causes confusion and annoyance: At higher intensity, or in noise sensitive people, this shifts to definite distress. Well-known measures of stress (increase of heart rate, blood pressure etc) are known to be increased as noise levels rise<sup>29</sup>. Many noise-sensitive people find it hard to avoid feeling that other people are insensitive or unreasonable in the noise they make<sup>30</sup>:

“People talking on their mobile phones, because they think they need to yell into them.”

“Depending on what situation I’m in, in a lot of cases I would excuse myself away.”

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28 Luisa Dillner: *Guardian*, 13.05.2013: Should I wear earplugs to concerts?

29 Jansen,G. (1969) Adverse effects of noise on physiological state. *American Speech and Hearing Association Reports*, no 4, 765-782.

30 Landon,J, Shepherd,D, Stuart,S, Theadom,A, Freundlich,S. (2012) Hearing every footstep: Noise sensitivity in individuals following traumatic brain injury. *Neuropsychological Rehabilitation*, iFirst, 1-17.

“I stopped going to church because it was just too hard, with the singing . . . it was very hard, because it made the frustration greater . . . and going to church . . . was an avenue that was closed to me”.

“I learnt to go shopping either late in the evenings or early in the mornings”.

Obviously the people who wrote these words were taking forethought to avoid situations in which their frustrations might boil over. Clearly they had civilised attitudes, and were not habitually pugnacious or aggressive. The quotations were from people whose noise sensitivity was related to TBI. They could just as well have been written by other people with no such definite triggering injury, but who would take all the same steps to avoid noisy environments which they know might bring out the worst in their behaviour. Such people are not likely to suffer noise-induced hearing loss: Since they avoid noisy environments, they are the ones to retain the acute hearing they had as children. The brain processes which make their perceptual experience – the “impact” of the sound – excessive, also serve to protect their inner ears from damage.

In sharp contrast are those people who are not distressed by loud noise at social gathering, who adapt to it quickly, and who may get a definite sense of excitement – a “buzz” – out of these extreme environments. These are the people most likely to suffer progressive hearing loss. Even if, at some level they realise that the sound levels are damaging their hearing, they may shy away from admitting this, because of the attraction to them of those social events. So, they may continue to join similar gatherings, which further impair their hearing. Although not really an addiction, there is something similar going on here akin to an addiction - an attraction to a type of event which is damaging, and at the same time, leads progressively to tolerance to events which cause the damage. The one difference from true addictions is that, as far as I know, there are no special withdrawal symptoms related to missing the loud-noise party scene. Given the subtle and not-so-subtle pressures we are all under, there may come times when noise-sensitive people cannot escape the difficult situations the above writers were so keen to avoid. What happens then?

It is well known that very loud noises are severely aversive. Police use them as a very effective means of crowd dispersal. Several research

studies used loud noises to study aggression in adolescents<sup>31</sup>. Loud music has been used as a form of torture at Guantanamo Bay, despite this practice being banned by the UN Convention against torture. Groups whose music has been used in this way have publicly expressed their opposition to such uses of music<sup>32</sup>. In extreme circumstances, where there are very loud sustained noises, people may develop powerful and extreme emotional reactions, uncharacteristic of them at every time. Medical staff knew this when helping soldiers traumatised in the trenches in WWI. In Britain this was called “shell-shock”. On the other side of the frontline, psychiatrists in the German-speaking world had for some time been interested in what was called hysteria - a condition whose name goes back to the ancient world, and was thought to occur mainly in women. In WWI, this occurred in large numbers in men<sup>33</sup>, basically the same reaction as in any frightened animal. No doubt this had many contributing causes, amongst which was massive sensory over-stimulation. Unbearable noise, light and physical vibration were identified as factors of importance<sup>34</sup>. It is not known how much noise sensitivity contributed to shell-shock; but it is plausible to suggest that it often did. In normal civilian life, when a person finds him- or herself in a situation of inescapable intense noise, and when noise sensitivity combines with an “augmenting” style of perception, emotional responses analogous to shell-shock - short-lived and relatively mild perhaps - may suddenly arise, leaving all within earshot surprised, shocked, not a little hurt or frightened; but who was initially frightened?

We can refer this argument to a single story: Earlier in this essay the nineteenth century philosopher Schopenhauer was mentioned, as one who was quite noise sensitive. While living in Berlin, Schopenhauer was named as a defendant in a lawsuit initiated by a woman named Caroline Marquet. She asked for damages, alleging that Schopenhauer had pushed her. According to Schopenhauer's testimony in court, she deliberately annoyed him by raising her voice while standing outside his door. Marquet alleged that the philosopher had assaulted and battered her after she

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31 Poorman,P, Donnerstein,E, Donnestein,M. (1976) Aggressive behavior as a function of age and sex. *Journal of Genetic Psychology*, 128, 183-188; Donnerstein,E, Wilson,DW (1976) Effects of noise and perceived control on ongoing and subsequent aggressive behavior. *Journal of Personality & Social Psychology*, 34, 774-781; Sherrod, DR, Moore BS, Underwood,B. (1979) Environmental noise, perceived control and aggression. *Journal of Social Psychology*, 109, 245-252.

32 <http://hungryhorde.blogspot.co.uk/2010/03/massive-music-torture-attack.html>

33 Kretschmer,E. (1923/1961) *Hysteria, reflex and instinct*. Philosophical Library, New York.

34 Ellenberger,H. (1970) *The Discovery of the Unconscious: The history and evolution of dynamic psychiatry*. Basic Books, p. 826.

refused to leave his doorway. Marquet won the case and Schopenhauer had to make payments to her for the next twenty years.

Let us consider how all the factors so far considered might combine in a plausible social situation. Suppose there is a party which starts to get a bit out of hand, and noise levels start to creep upwards to levels which some people find distressing. Suppose also, in the room there is a mix of people with different perceptual styles, including both reducers and augmenters, in other words, some who are relatively insensitive to noise and easily adapt to rising noise levels, and who then do not realise how much they have adapted, nor how loud the noises actually are. Alongside them are ones who are very noise sensitive, do not adapt to rising noise levels, and may even become progressively sensitised to the loudness of the noise, are acutely aware of the real noise levels, and who become progressively more and more distressed. Add a further component, also quite plausible, that the ones who can tolerate the noisy environment have already lost some of their hearing sensitivity, due to noise-induced hearing loss, but who do not realise their own hearing impairment. When these excited, noise-adapted, and somewhat hearing-impaired people, possibly hyped up by alcohol, find themselves in the same room as distressed, noise-sensitive people who have retained the acute sensitivity to sound they had as children, and have failed to adapt to prevailing noise levels, we have a truly dangerous social mix. In short, in this quite plausible scenario, where the public health issue of excessive sound intensity combined with the fact of great diversity in perceptual styles (and the potential disability issue of noise sensitivity in some people), we have an issue which is potentially and enormously socially divisive.

Already this issue is causing public demonstrations, with potential for violence: An Australian University-sponsored blog (“The Conversation”) recently hosted a discussion entitled “Live Music in Australia: Offensive Noise or Good Vibrations?”<sup>35</sup> An introductory statement included the following sentences: “In this week’s news from Planet 21st Century, the musicians who perform at Playbar, a small venue in the inner-city Sydney suburb of Surry Hills, have been silenced by Sydney’s ‘offensive noise’ laws after complaints by Greens senator Lee Rhiannon, whose electoral office is in the same building.” The introduction to the blog is reasonable

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35 20<sup>th</sup> April, 2013: <https://theconversation.com/live-music-in-australia-offensive-noise-or-good-vibrations-13530>

and balanced, giving both sides of a difficult issue; but to indicate how severe confrontations might become, it is illustrated with a photograph of a recent demonstration somewhere in Australia, where the front line of demonstrators used as a slogan “Don’t Kill Live Music”, with a noose strung prominently in front of their midst. The caption for the photo read: “Live music in Australia has been under renewed threat in recent years over noise and liquor licensing complaints”. Clearly the issue has an explosive potential. Until it is recognised, and addressed by an intelligent set of policies, this can only get worse.

Fifty years ago, as an adolescent in Britain, I have two relevant memories. First, in many shoe shops, X-rays machines were available: Anyone could look at the bones in their own feet, as X-rayed through such machines, used with no thought of regulation or control. This was many years after scientists had identified the hazards of ionizing radiation. On one occasion, I was introduced to a man who had used his own hand for demonstrating the potential of such an X-ray machine, over and over again, before a fascinated audience. Sadly, his hand was, at the time I met him, severely and permanently burnt, and somewhat misshapen from the radiation dose he had received. The practice of including X-ray machines in shoe shops did not last, for obvious reasons, backed by solid science.

About the same time (late fifties) we heard the first suggestions that cigarette smoking caused lung cancer. The science was not then clear cut. In due course it became so; yet, even today, fifty years later, we have not got rid of cigarette smoking in our own “civilised” countries; and in many parts of the world this very important public health message has hardly begun to be heard. In heavy industries of former times, such as coal-mining, severe, sometimes life-threatening health problems were known for centuries in Britain; yet only after WWII did an attempt to avoid them, and compensate those affected, come on the national agenda<sup>36</sup>. The tardiness in producing an effective response is very striking. With regard to the public health issue of excessive sound intensity, and noise-induced hearing loss, are we going to look back, in fifty years time, survey all the unnecessary hearing loss that occurred in previous decades, shake our heads sadly, and say “How ever could we have let this happen?”

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36 An uncle of mine died early as a result of long-time work in Nottinghamshire coal mines. In the years after his death, his wife had an annual holiday in the Caribbean, subsidized by the relevant government ministry, in recognition of the fact that his early death was the result of the unhealthy environment in which he had worked.

## **E: Strategies for Action.**

There are several ways in which this difficult subject can be opened up for rational discussion and intelligent action. *First*, widespread discussion of the issue is needed. This is likely to be done via the internet, especially in discussion on web-blogs. These vary greatly in their style. Some are well controlled, and civilised. Others are unedited, unmediated, inevitably acrimonious, and even personally abusive. This is merely an exaggeration of the acrimonious debate typical in the past on many other controversial and personal issues. Obvious examples are the debate about smoking and health, or about risky sexual behaviour in days after the AIDS epidemic emerged. Those who understand the serious nature of the issue must be prepared for this messy and sometimes brutal politics. It will not be easy.

*Second* the great diversity in perceptual styles found in any group of people should be more widely recognised. As explained in the last section, this diversity compounds the public health issue of excessive levels of sound, or other sorts of perceptual over-stimulation in today's world. The emphasis in this essay is of course on noise sensitivity. However, many other differences in perceptual style can be recognised, as relatively limited yet serious impairments of function, by no means equating to impaired general intelligence. Sometimes extremes within this diversity are classed as definite "disability". However, the line separating "within the normal range of variation" and categorical disability is a shifting frontier, dependent on how we construct our societies and social policies. For instance, dyslexia is a recognised disability, dominated by visual problems which make reading difficult for some people; but it would not be designated as a disability if our society did not place such emphasis on the written word. Likewise noise sensitivity, and other forms of perceptual sensitivity might not be a disability if we had a better understanding of the problem, and if noise-sensitive people did not live amongst many others whose hearing is impaired, in part due to current *lack* of understanding. The issues should be discussed by employers' associations, educationists, and in other forums.

*Third*, better regulations are needed for noise control in entertainment events, social gatherings, and if possible, for Walkman/MP3 playback systems. There may be a place for regulations defining areas designated as free from mobile phone use. There is undoubtedly great complexity in framing such regulations. Political debate will be intense. Nevertheless, the parallel with other areas of disability is inescapable: For people who need to use wheelchairs, their disability is obvious. It is now accepted that special provision should be made to help them participate as equal

members of society. Regulations requiring wheelchair ramps, alternatives to staircases, have been introduced. If noise sensitivity *is* to be regarded as a disability (which might be questioned), then similar thought should be given to measures allowing people so disabled to be equal participants in society. At present, such not-far-from-normal aspects of human diversity act as severe barriers to participation in the majority of social events.