Trials of a protocol to support LFN sufferers in the UK

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Summary

The paper reports experience from a research project funded by Defra (Department of Environment Food Rural Affairs) in which a network of support centres for LFN sufferers was set up throughout the UK on a trial basis. During the trials a treatment protocol was developed aimed at reducing agitation caused by the perceived LFN and encouraging habituation to it. This form of treatment was based on an understanding of the reaction to troublesome sounds which is now widely applied in the treatment of tinnitus and hyperacusis. In effect, the basis is a model of the perception of, and reaction to, unwanted sounds. The hypothesis adopted in the trial was that a similar model can be applied to the distress caused by perceived LFN, particularly in cases where no external source can be identified. In the paper, after a brief description of the trial, the proposed model of perception and reaction is presented together with the resulting treatment protocol. The success of the model is discussed in the light of the results of the trial.

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1. Introduction

Many Environmental Health Officers (EHOs) in the UK, and around the world, receive occasional complaints about low frequency noise (LFN). Whilst such cases are thought to be few in number, they can be difficult for EHOs to handle and extremely distressing for the complainant who feels that they are besieged by a noise that they cannot ignore or shut out.

There have been various surveys of LFN complaints, including those by Persson et al [1], Mirowska [2], Moorhouse et al [3], Moller and Lydolf [4], Pedersen et al [5] which are reviewed in the main project report [6]. There are also good reviews by Leventhall [7] and Berglund et al. [8]. From these surveys one can identify different categories of LFN complaint as listed in Table I. The first and second categories include cases where the EHO considers the noise to be causing a nuisance and those where a noise is detected but not considered an actionable nuisance. The third category includes cases where no external noise can be found that could be responsible for the complaint i.e. all possible avenues to find a potential source have been explored and proved negative.

Table I. Categories of LFN complaints

Description	**Short name**
A LFN complaint where LFN has been identified which correlates with the complainants' description but which is judged not to be causing a statutory nuisance by the EHO	No Nuisance
A LFN complaint where LFN has been identified and is considered to be causing a statutory nuisance.	Nuisance
A LFN complaint where no noise has been found (by the EHO) that could be responsible for the complaint	No Noise Found

Anecdotal evidence also suggests that there are further categories where a LFN was present but has disappeared by the time of the investigation although the disturbance continues. A likely mechanism for the delayed responses in such cases is a cycle of increased auditory gain and anxiety which is discussed in Section 2. In practice such cases are unlikely to be distinguishable from 'No Noise Found' cases.

The 'No Noise Found' cases were the main focus of this study. Since there is no prospect of external control of the perceived LFN in such cases, the motivation for this study was to propose and test an alternative means of mitigating the disturbance to the sufferer. The proposed therapeutic approach draws on an understanding of the mechanisms involved in troublesome tinnitus and hyperacusis which has developed significantly in the last decade or so (there is no implication that LFN complainants are necessarily caused by tinnitus). Models for reaction to troublesome sounds, ported from the field of tinnitus and hyperacusis are presented in section 2 and their adaption to LFN complaints is described. Section 3 describes the network of audiology clinics that was established and the subsequent trial referrals of LFN complainants. In section 4, the therapeutic protocol used during the trials is described. In Section 5 the results of the trial are summarized and conclusions are drawn in section 7.

2. Models of reaction to troublesome sounds

In this section we briefly present some aspects of current auditory neuroscience understanding of human hearing and the possible implications for LFN complaints. A modern understanding of human hearing considers not only the traditional auditory pathway, from cochlea to auditory cortex, but also the interfaces between hearing and systems of emotion and reaction. It is believed that these have developed due to the function of the auditory system as an early warning danger detection system, able to rapidly activate systems of reaction and arousal to an intrusion or potential danger. An underlying proposal of the project was that this understanding of hearing could be mapped on to the experience of LFN complainants, and that this might lead to a novel approach to assistance in that situation.

A modern understanding of hearing takes into consideration the connections between brainstem hearing centres and systems of reaction and arousal. Specifically, these involve the sympathetic autonomic nervous system, which instigates a fight or flight reaction to a threatening sound, and the reticular formation, which regulates arousal and sleep under the influence of sound.

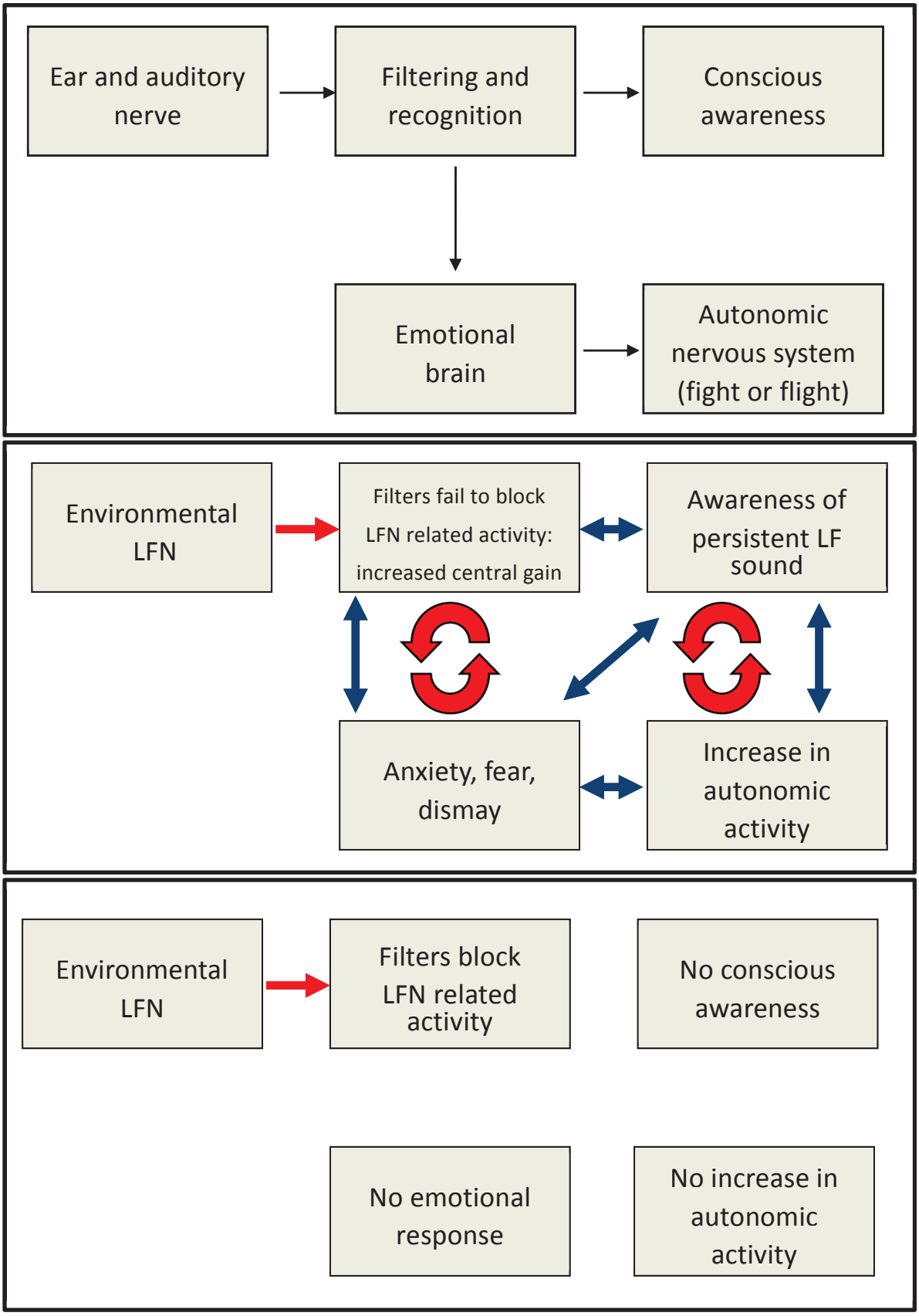

Figure 1. Schematic diagrams of the development of distress and arousal to a perceived sound and to LFN. Adapted from (McKenna L; Baguley DM; McFerran, 2010).

One only has to briefly consider how sounds affect human arousal and agitation to see how fundamentally these interactions between hearing and reaction can influence arousal and behaviour. An example is the immediate agitation and arousal associated with thinking one has heard an intruder when lying in bed at night. These interactions occur below the level of the ascription of meaning in the sense of speech or music, but we are able to recognise sound as potentially intrusive or threatening. In the case of predators, sound generated by a successful animal would be of very low intensity, and a potential prey animal would need a vigilant auditory system to detect and rapidly react to such sounds.

This view of human (and mammal) hearing has largely derived from the study of patients with troublesome tinnitus. Such persons can be very agitated and distressed, and the extent of their distress bears little relation to the cause or matched intensity of their tinnitus [9]. Whilst many people who experience tinnitus seem not to be troubled by it, those who are become to exhibit a perplexing mixture of agitation, poor concentration and insomnia, and there is a consensus that this is best explained by models that invoke links between the auditory system and the emotional brain. Whilst there is no one-off intervention that inhibits the perception of tinnitus percepts completely and permanently (hence "no cure"), there are therapies involving sound, counselling and relaxation that can improve quality of life in such cases. What such approaches hold in common is their invocation of the principle of habituation: that being the process by which human senses filter out background and non-threatening stimuli (including sound).

Habituation

In Figure 1 (a) the relationship described above between hearing and systems of reaction is illustrated. The situation in which unremarkable LF environmental sound is filtered by the auditory system, and thus evokes no emotional or behavioural reaction is illustrated in Figure 1c: essentially the system has habituated to whatever background activity there is. In a person in whom this filtering has failed and/or in whom there is increased auditory sensitivity to LF environmental sound (thus a similar situation to hyperacusis, but to LF sound only), substantial emotional and physical responses may develop, and may further exacerbate the LF awareness, and these vicious circles are illustrated in Figure 1b. Once these vicious circles have been set up the role of the ear may become less important.

The similarities between LFN complaint and the experiences of people with tinnitus and hyperacusis may lead to an opportunity to improve the situation. As described above, whilst the ability to completely inhibit tinnitus eludes the clinical world, therapies do exist to promote habituation. The following section describes the proposed protocol for LFN complaints.

3. Therapy protocol

The above discussion, and in particular Figure 1c, leads to the hypothesis underpinning the project which is that, irrespective of the (unknown) cause of the LFN perception, the perception may be lessened through application of techniques specifically adapted from the field of tinnitus therapy. It is hoped that the lessened perception would lead to an improvement in habituation and the interruption of the self-reinforcing vicious circles illustrated in Figure 1b. An improvement in the quality of life for complainants would then be expected to follow.

The main points of the therapeutic approach were developed during discussion in the early part of the trial with audiologists from the nine audiology centres involved (see Section 4).

The main points of the developed protocol were:

- The exclusion of treatable disease by clinical history, otoscopy, audiometry (performed according to British Society of Audiology Recommended Procedures, and local medical opinion)
- Discussion of the distress and agitation evoked by the perceived LFN
- Sound therapy (introduction of controlled background noise) to reduce the starkness of the signal
- Relaxation therapy to reduce the arousal and agitation associated with the signal
- Identification of those individuals with clinically significant anxiety and/or depression and referral to Psychological Services (using the Hospital Anxiety and Depression Scale [10])

The envisaged course of therapy typically consisted of three visits, the first of 1 ½ hours and subsequent appointments of around one hour. A special test was developed specifically for the project to determine if the client became aware of their LFN within a quiet room which could indicate low frequency tinnitus as a cause. Full details are described in [6]. A similar approach employing an online protocol was conducted by Leventhall et al [11].

Outcome measures were based on a combination of validated questionnaires for general health, anxiety, depression, tinnitus handicap (with LFN substituted for tinnitus) and hyperacusis, combined with visual-analogue scales specifically developed for LFN to measure the pitch and loudness of the perceived LFN and the associated distress. Qualitative and open questions were also used. The following outcome measures were adopted and performed at the start and end of therapy:

a. Hospital Anxiety and Depression Scale (HADS) questionnaire
b. Tinnitus Handicap Inventory (THI) questionnaire, but with LFN descriptors substituted for tinnitus descriptors
c. Hyperacusis was measured using a validated 14 item self report Khalfa questionnaire.
d. EQ−5D questionnaire, a measure of general quality of life
e. Visual analogue scales for: LFN loudness, pitch and distress.

At the present time there is no specific questionnaire for LFN complaints available and the above group of validated questionnaires were selected that each catch one aspect of the LFN complaint experience.

4. The LFN Network Trial

Nine audiology centres, selected on the basis of their experience in handling tinnitus and hyperacusis cases, took part in the study. They were located in various parts of the UK as illustrated in Figure 2. The therapy protocol, as described above, was first developed through a series of discussions between acousticians with experience of LFN assessment and the audiologists with expertise in tinnitus and hyperacusis therapy.

Once the treatment protocol had been developed a referral pathway was established consisting of the following steps:

- The client registers a complaint about LFN with their local EHO
- The EHO investigates the complaint, preferably using the Defra LFN procedure [12]
- If the case is judged to be a Nuisance case (see section 2.1) the EHO proceeds with their usual protocol
- If the case is judged to be a No Noise Found or No Nuisance case (see section 2.1) the EHO informs the Client and offers participation in the study
- The client has 28 days to accept the offer
- Upon the Client's acceptance of the offer, the EHO refers the Client to their doctor with a copy to the Audiology centre and enclosing an information sheet for the doctor
- The doctor refers the Client to the Audiology Centre (possibly via Ear Nose and Throat according to local practice)
- The Audiologist applies the LFN protocol as described in the previous section.

Figure 2. Locations of the nine audiology centres that participated in the trial

5. Results of the trial

A total of 11 LFN complainants were referred by EHOs using the referral pathway described in section 4. Another 3 were self-referred making a total of 14 who received therapy according to the protocol described in section 3.

Half of the complainants had a clear idea about the origin of the perceived LFN, the remainder being unsure, although all had thought about various possibilities. The likely sources mentioned were digital TV, factories or works, neighbours using machinery, fish tanks or hot tubs, water pipes or heavy duty pumps, telecommunication masts and refrigerators.

EHOs investigated the complaint in all referred cases and generally made measurements in the complainants' property. In some cases investigations were also carried out in neighbouring properties or by the utilities companies. In half of the cases measurable LFN was recorded but was not considered actionable by the EHO (No Nuisance cases). Other cases were assessed as No Noise Found.

Some participants reported current and previous health issues including labyrinthitus, brain surgery, Seasonal Affective Disorder (SAD), whiplash and headaches and pressure on the ears. Sleep disturbance was significant with 12 subjects (86%) reporting disruption to sleep, no results being recorded for the remaining 14% of cases. Generally, the LFN disturbance was perceived as worse at night and in some cases, only present at night. Some participants reported getting anxious before going to bed and even 'dreading' going to bed knowing that they would have to listen to the noise. Measures to try to help sleep included sound generating devices issued by the audiologist (which generate soothing, masking sound) and which were reported to be helpful. A similar type of intervention was to use a radio which was reported to help sleep. Some subjects were reliant on medication to sleep and some had been wearing ear plugs which they were advised to discontinue.

The influence of the perceived LFN on mood was reported in some cases with participants finding it draining and trying to avoid being in the home as much as possible. Others said that as the source was a mystery any 'sense of peace' was gone and the noise was intruding on personal space.

Quantitative evaluation of the outcome measures revealed a mixed picture with some subjects showing consistent improvements across the range of measures with others showing no improvement. The mean value of most measures moved in a favourable direction but statistical significance was only achieved in one measure and then only at the $p<.05$ level.

A qualitative evaluation of the benefits to EHOs and the experience of audiology therapists showed that EHOs found the network useful and wanted it to continue.

6. Conclusions

The model put forward in section 2 for the development of LFN associated distress appears to be consistent with the high levels of distress and anxiety in the subject population. There are indications that the proposed involvement of the sympathetic autonomic nervous system, and of the emotional brain, are likely to be a faithful representation of the clinical situation. The suggestion that a feedback loop exists between stress /agitation and noise awareness is harder to evidence from the results but may have some value.

The general impression from the results is that some of the subjects benefitted from the intervention with others showing little change, although no statistical test of this hypothesis has been conducted due to the small sample size. The factors likely to influence success are the quality of the referral by the EHO, the quality of the audiology input and the attitude of the complainant.

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