



Science and Technology Committee

Corrected oral evidence: The effects of artificial light and noise on human health

Tuesday 21 March 2023

10.10 am

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Members present: Baroness Brown of Cambridge (The Chair); Lord Borwick; Viscount Hanworth; Lord Holmes of Richmond; Lord Krebs; Lord Mitchell; Baroness Neuberger; Baroness Neville-Jones; Baroness Northover; Lord Rees of Ludlow; Lord Sharkey; Baroness Warwick of Undercliffe; Lord Wei; Lord Winston.

Evidence Session No. 4

Heard in Public

Questions 40 - 54

Witnesses

Dr Alison Greenwood, Chief Executive Officer, Founder and Lead Psychologist, Dose of Nature; Alex Smalley, PhD Fellow, University of Exeter; Professor Pierre Geoffroy, Professor of Psychiatry, Université Paris Cité.

USE OF THE TRANSCRIPT

This is a corrected transcript of evidence taken in public and webcast on www.parliamentlive.tv.

Examination of witnesses

Dr Alison Greenwood, Alex Smalley and Professor Pierre Geoffroy.

Q40 The Chair: I would like to welcome the witnesses to the committee's fourth evidence session of our inquiry into the effects of artificial light and noise on human health. Today, we are focusing on the potential health benefits of light and noise and we have three witnesses: Professor Pierre Geoffroy, Professor of Psychiatry at Université Paris Cité; Dr Alison Greenwood, the chief executive, founder and lead psychologist at Dose of Nature; and Alex Smalley, a PhD Fellow at the University of Exeter.

The session is being broadcast on parliamentlive.tv and a full transcript of it is being taken. This will be made available to our witnesses shortly after the meeting to make any minor corrections. If any of our witnesses think of anything after this that they wish they had said, or of any data that it might be useful for us to see, we would be grateful if they would send us that as further evidence. That would be really helpful.

Thank you very much, all three of you, for joining us. Let me kick off by asking each of you, as you all have expertise in rather different areas, to start by giving us a brief opening statement describing the individual treatment methods and the nature of your work in these different aspects of environmental exposure to light and sound. Professor Geoffroy, would you like to start with a short statement about your work?

Professor Pierre Geoffroy: Thank you, Lord Chair. First, I would like to thank the committee for this invitation. I am very honoured to share the nature of my research at Paris and Strasbourg, and my clinical work in Paris.

As a clinician, I treat patients suffering from mood disorders such as depression, with or without seasonal patterns, and patients with or without bipolar disorders. These patients suffer from depressive episodes, alternating with a mania that is associated with an increase in mood and energy. I am also treating insomnia in patients suffering from circadian rhythm disorders, such as delayed sleep phase syndrome. My research focus as a neuroscientist is on sleep and circadian rhythm biomarkers associated with these mood disorders, and treatment made up of chronotherapeutics such as light therapy, dark therapy with blue-blocking glasses, and manipulations of sleep timing and duration.

The Chair: Thank you very much. Shall we move on to Dr Greenwood?

Dr Alison Greenwood: I would also like to say thank you very much for inviting me. I feel honoured to be here. I run a mental health charity called Dose of Nature, which improves the mental health and well-being of individuals through an increased engagement with the natural world. We take referrals directly from GPs of people with a wide range of mental health issues—for example, depression, anxiety, trauma, addiction, bereavement and, increasingly, long Covid. My doctoral research was on the mental health benefits of engaging with the natural world, and I

worked in the NHS for many years before leaving four years ago to set up Dose of Nature.

Our work is rooted in a wealth of scientific evidence that demonstrates the physiological and psychological benefits of an increased connection to the natural world. Since we set up four years ago, we have had over 800 referrals from GPs and our recovery rates are consistently higher than many comparable current NHS interventions.

The Chair: Are you able to distinguish the effects of natural light and natural sounds from the general benefits of nature in what you are doing?

Dr Alison Greenwood: Yes, a little, I think—to some extent. I shall talk today generally about the mental benefits of the whole environment of being outside in nature, but we talk quite often about knowing of six active ingredients of nature, one of which is sunlight and another of which is natural sounds. That is a third of our work, I guess.

The Chair: Those are the two areas that we are particularly interested in today, thank you. Alex Smalley, can we come to you for an opening statement?

Alex Smalley: Yes, hello, it is great to be here. I am a PhD fellow at the University of Exeter, funded by the Wellcome Trust. My research over the last five years has really focused on trying to understand more about the ways people react to spending time in nature. It is really centred on how people respond to virtual forms of nature. That is really important, for several reasons.

First, this kind of experimental work where we take people into the laboratory setting or run carefully controlled experiments can tell us an awful lot about how they respond to nature in the real world. But also, for lots of people access to the natural environment is very poor. For example, if you are recovering from major surgery you are in clinical settings or long-term care. In these cases, digital proxies for real contact can be very beneficial.

It is also important because routinely, in the UK in particular, millions of people sit down and experience nature through virtual means. I am talking about natural history documentaries: over 9 million people tuned into the first episode of the BBC's "Planet Earth II" series. That means that 7% of the UK population were experiencing nature for an hour on their sofas, via these virtual means. Over the last five years, I have worked with the BBC across three large-scale studies that looked at how these kinds of contacts can impact people. A crucial component of that has focused on sound—the sounds of the natural environment and the possible positive effects that they can have.

The Chair: Thank you. That all sounds very interesting, and I know that my colleagues want to get on rapidly to asking you about the evidence for some of these impacts.

Q41 **Lord Sharkey:** Could I ask each of you to characterise the evidence base for the potential of each of the techniques to improve health, focusing on

light and noise, the subject of our inquiry? Perhaps you could tell us what impacts these methods have and how much research has been done. I noticed, Dr Greenwood, that you mentioned in your opening statement a wealth of scientific evidence, so perhaps I could start with you.

Dr Alison Greenwood: Yes, I think there is a wealth of scientific evidence—a substantial body now, I would say. It is probably only in the last 20 years or so that we have been studying nature with any kind of scientific rigour but, over those years, there have been comprehensive, systematic reviews and meta-analyses undertaken by national Governments, our own being one of them. Japan, South Korea, Australia, Canada and the World Health Organization all now recognise that increased engagement with nature has a positive impact on human health.

Hundreds of individual studies have consistently demonstrated a number of physiological and psychological benefits of nature in general. Perhaps the committee would allow me to talk briefly about them and then specifically those to do with natural sunlight and sounds.

Generally, the physiological and psychological benefits of nature and, certainly, natural sounds will do this: activating the parasympathetic nervous system and suppressing the sympathetic nervous system. It seems to be a very well-understood phenomenon that when we go outside in nature, our blood pressure and heart rate decrease. There is also a decrease in cortisol levels, which is an indicator of stress, and heart-rate variability increases.

Those biomarkers of stress all seem quite clear but, on top of that, there are other physiological phenomena that we have probably started to understand only in the last 10 years or so: for example, looking at the blood and the increase in natural killer cells that occur when we are outside in nature, which is really important. Medical scientists are very excited about it, because it is about improving immune functioning, which is at the heart of so many physical and mental health issues.

But we are also now able to look at brain functioning and notice that when people are outside, there is an increase in alpha waves in the brain—alpha waves being an indicator of a wakefully relaxed state. We know that when we go outside, most of us will experience that feeling of being relaxed instantly. But we do not just get relaxed when we go outside, in the way that perhaps a glass of wine might help us to feel relaxed. We also seem to feel quite uplifted at the same time, which is a sort of opposite phenomenon: going outside in nature seems to both relax us and motivate us, giving us some kind of positive energy. It is the increase in alpha waves in the brain—that indicator of a wakefully relaxed state—that nature seems to be able to do very well.

There is also an improvement in psychological functioning. We know very well that when we go outside there is an increase in positive emotions and a decrease in negative emotions, which is obviously important for the effect that it has on common mental health issues such as depression and anxiety. There are also improvements in cognitive functioning and mental alertness, focus and concentration and improvements in sleep, which I

am sure Pierre will talk about later. I suppose that is the general evidence that we have consistently got from the meta-analyses that Governments have produced.

Specifically on the elements that we are talking about today, including natural sunlight, I am sure I am not the main expert in the room to talk about light, but the increase in serotonin and vitamin D are the two pieces of evidence relevant to the work that we do, given their impact on depression, sunlight being found to boost levels of serotonin, a neurotransmitter associated with feelings of well-being and happiness. Most modern SSRIs—the most common antidepressants that we use—are about increasing the amount of serotonin in our brain. Knowing that sunlight does that without all the side-effects that come with antidepressants is an important piece of evidence for us. We know, of course, that vitamin D is important for overall health and well-being and that humans get most of their vitamin D from exposure to sunlight. The World Health Organization recommends that we spend 10 to 30 minutes outside, getting natural sunlight, several times a week.

On natural sounds, it is clear that some of the effects I talked about earlier are brought about by listening to those, but there are two things going on when we think about natural soundscapes. The first is that if you are in a natural environment, it is likely that you are not in an environment with lots of noise pollutants; as we know, noise pollution is one of the biggest health hazards of modern times. Research is clear that one benefit of being in a natural environment is that we do not have those noise pollutants.

When listening to natural sounds themselves, what about this as an active ingredient? We know that it reduces stress. All those biomarkers of stress—reducing blood pressure, cortisol levels and heart rates—they all come down when we listen to natural sounds. It restores our attention, too; all of us suffer from mental fatigue and attention fatigue, attention being a finite resource. When we get that attention fatigue, what seems to restore it very effectively is being outside in nature. Listening to natural sounds has also been shown to improve mood and mental alertness, particularly listening to birdsong. Cognitive functioning has also been found to benefit from listening to natural sounds.

I would say that is a lot of the quantitative evidence. I have a little qualitative evidence, but maybe I will save that for later. I will leave it for now.

Alex Smalley: Thank you to Dr Greenwood for introducing some of the concepts that I was going to talk about. It is worth saying that a lot of the work that Dr Greenwood has referenced there really has established, as she said, a confident and robust body of evidence showing that spending time in natural environments can have a range of what we call therapeutic effects, such as stress reduction and improvements in cognition, mood and short-term emotions. Until the turn of the millennium, so much of the work of the laboratory-based studies in the field that I am in—environmental psychology—was based on understanding how people respond to different visual characteristics in

nature. There were often coarse dichotomies between urban stresses and natural environments—very coarse groupings.

We know lots about how people respond to different types of visual feature, whether that is the amount of green space, trees or blue space, water that is, and panoramic skies. We know a huge amount less about the way that sound can impact people when they spend time in natural environments. Of course, this is really important, because spending time in nature—or actually any kind of landscape, whether it is urban or natural—is a rich multisensory experience. In the last 20 years—again, this is to agree with Dr Greenwood—sound has been taken a lot more seriously in a restorative environments framework, but the idea of a soundscape was first coined by R Murray Schafer, a composer in the 1970s, who wrote the initial tome about trying to put sound on the agenda.

I am sure the committee has heard a huge amount over the last few sessions about the way noise and noise pollution are dealt with, particularly in urban settings. That framework tends to view soundscape and noise as negative, as elements to be managed. The restorative environment perspective is, “Okay, we’re not aiming for silence in these environments. What are the positive elements that should be there?” Natural soundscapes are key there.

This approach was recognised in US national park management in the 1950s and has slowly grown in prominence over there. We often talk about elements such as natural quiet, ambient silence and tranquillity when we are trying to imagine the kind of soundscape that people tend to prefer. An increasingly robust body of evidence is now showing that the elements that we want to try to protect, preserve and promote in soundscapes are the sounds of natural environments.

As Dr Greenwood said, the quantitative work in this area is growing, yet it is still in its nascent phase. I have a couple of statistics at my fingertips from recent reviews that have been conducted into soundscape and nature-based sounds that synthesise evidence from upwards of 40 or 50 papers referenced in more narrative reviews. So the evidence base that we are talking about when we think about natural sounds is much smaller than that much broader evidence base that Dr Greenwood mentioned.

However, those studies and meta-analyses show that natural sounds specifically, when they are isolated and considered separately from visual stimulus, can reduce the physiological markers of stress that Dr Greenwood mentioned, whether physiological arousal, skin conductance, heart rate, but also crucially—this is an area that I have focused on a lot—the self-reported, emotional measures: whether people feel more positive, more energised, calmer, more restored after a stressful experience when they listen to the sounds of nature.

When we talk about the sounds of nature, this broad banner, the sounds that have emerged as most valuable to people are passerine birds—classic species like blackbird, robin and wren—but also the sounds of the landscape, such as breaking waves, falling water in the sense of rain, and thunder. The two scholars in the UK, Dr Eleanor Ratcliffe and Dr Sarah

Payne, have really led this field and been instrumental in moving the evidence base on, and it is shame that they cannot be here too. They have also identified the fact that not all natural sounds are perceived this way; this is not a blanket approach that is perceived as pleasant. We see that although blackbirds, robins and wrens are highly rated by people, the more calling birds like crows and gulls or foxes at night can be perceived as quite foreboding and can have a detrimental impact on people's experiences in natural environments.

Without doubt, as soon as anthropogenic sounds in the form of noise pollution—traffic noise, flights overhead—encroach on natural soundscapes, their therapeutic potential, all the measures that we have mentioned, tend to fall. So we talk a lot about the protection of these spaces and the way in which they can provide space for all the restorative benefits that Dr Greenwood referred to.

Lord Sharkey: Thank you very much, Dr Smalley. Perhaps we can now hear from Professor Geoffroy.

Professor Pierre Geoffroy: Thank you very much. My colleagues, Dr Greenwood and Alex Smalley, have listed all the elements or ingredients of the contents of nature that can have a positive effect. There are numerous effects, as Alex Smalley has posited. There is light, which I will focus on because I am more expert in light treatment in my practice. Exercise and being offline really help anxiety and the depressive effects of just having insomnia—we have an expert on this topic—as does relaxation, meditation et cetera. There are numerous effects. The difficulty and the challenge in this field is untangling these different effects at the individual level.

The therapy that has been in use since antiquity and is the mother of today's bright light therapy is heliotherapy, which has been in use the longest and was the only one until the mid-19th century. Some therapies have been outlined in ancient Chinese, Hindu and Egyptian medicine for 15 centuries. Later, with the invention of the electric light bulb and the progress of medicine, heliotherapy shifted to two very different light treatments. The first uses ultraviolet—UV—phototherapy, which is still used today in dermatology, immunology and neonatology. Light therapy is UV-filtered light, and is used in the treatment of neurological, endocrinological and, mostly, psychiatric afflictions such as depression.

It is important to say that there is a wealth of basic studies now that attest unequivocally to light therapy efficacy. On alertness and mood, we were able to show in a recent meta-analysis that light therapy is as efficient as antidepressant treatment, as a first-line monotherapy in treating both seasonal and non-seasonal depression, and for patients with unipolar and bipolar disorders. Light therapy is an important step forward in adding new and non-pharmacological methods to the treatment of major depressive disorders.

Light therapy can also be used as an add-on or augmentation strategy to increase the response to antidepressant drugs. In our work, we also demonstrate that the combination of the two treatments—light and antidepressants—is clearly superior to antidepressants alone. There is a

clear need to change prescribing practice and to recommend light therapy as a first-line combination treatment in order to maximise and speed up the patient response rate. Importantly, light therapy also has the advantage of being effective in improving sleep, alertness and circadian rhythms, which may be altered in depression, contrary to antidepressants, which target mainly mood.

More precisely, on your question about the level of evidence, I would say that that depends on the disorder. There is a high level of evidence regarding depression with a seasonal pattern, also called seasonal affective disorder, mostly for the acute phase; we are missing data regarding light therapy's long-term efficacy. We can go into more detail if you are interested. There is also a high level of evidence for the acute phase of depression without a seasonal pattern. There is a moderate level of evidence regarding the acute phase of circadian rhythm disorders such as sleep-delay syndrome, because only a few large studies have been conducted. However, there is a high level of very robust evidence regarding the physiological effects of morning light exposure that advance the sleep-wake cycle and of the evening exposure to light that, contrary to that, leads to a delay of the sleep-wake cycle.

There is no available evidence regarding the treatment of hypersomnia disorders, even if it is used in clinical practice in some patients, although, again, there is a level of physiological evidence regarding the effects of increasing alertness—a rapid effect, and there are ongoing studies worldwide on this. About insomnia there is a low level of evidence, but we have a recent meta-analysis, accepted and in press from our group, showing that light therapy, mostly during the morning, may help to decrease the wake after sleep onset in patients. I have to say that there is a clear need for larger, good-quality randomised control trials.

Lastly, some quick points about the physiological effects. We know pretty well how light acts on the circadian rhythms, the existing core clock genes. Your previous witnesses have already detailed that. Of course, there is still a lot of work to do. We are also discovering new and more direct pathways that are very interesting—direct pathways, in fact, from the retina to the brain regions involved in mood regulation, and to sleep-wake regions. These are really new works, published in the last decade, and several international research groups are leading exciting projects in this novel field.

The first evidence of light therapy efficacy comes from basic neurosciences, in fact, reporting in 1979 that phase shifts of these circadian rhythms could have an antidepressant effect and, in 1980, that light suppresses the melatonin secretion and thus impacts circadian rhythms in humans, as it does for all other mammals. Thus the antidepressant effects of light therapy may be linked to both a phase advance and/or an alignment of these circadian rhythms, but also to more direct effects on the brain's mood regions. Indeed, these light therapy effects are associated with mechanisms that are really independent of the circadian clock and act directly on monoaminergic pathways. Dr Greenwood reminded us of the serotonin pathway, which is

a really important pathway involved in mood swings and particularly in depression.

These direct and indirect effects may explain why light exerts a strong, direct and rapid effect on mood. Light therapy also enhances alertness with a similar direct and rapid effect and increases the sleep homeostasis, which regulates the sleep intensity.

Lastly, when we talk about light its definition is very vague and broad. In medicine, when we speak about light therapy the dose is dependent on the light irradiance level, the duration of exposure, the distance and angle from the light source, the light colour spectrum, and the time of day of the exposure. Does it advance or delay the circadian rhythms, or not change anything about them?

Further research is warranted to determine the most efficient lighting parameters to use, given the depression characteristics in the groups of disorders that I detailed, as well as identifying predictive biomarkers of a response to light therapy and regarding tolerability, so as to propose a more precise medicinal approach to individuals.

Lord Sharkey: Thank you for your comprehensive answers.

Q42 **Viscount Hanworth:** Alison Greenwood, you mentioned SSRIs. What are they and what is serotonin? Is it as important as melatonin?

Dr Alison Greenwood: Serotonin is a neurotransmitter that also acts as a hormone. SSRIs are the most commonly prescribed modern antidepressants. "SSRIs" stands for selective serotonin re-uptake inhibitors; basically, they increase serotonin in the brain, which is good for our well-being and happiness.

Viscount Hanworth: So they leave more melatonin.

Dr Alison Greenwood: They increase serotonin in the brain. Melatonin is a different hormone; I think daylight has a particular effect on it. Professor Geoffroy was just explaining how to get a good patch of it. In the work that we do, we recommend that people have a walk first thing in the morning, which then stops melatonin being produced and sets the body clock for the rest of the day, so that at the end of the day you get a good night's sleep.

Viscount Hanworth: Take out the serotonin and you get more space for melatonin. Is that it?

Dr Alison Greenwood: No, I do not think that is a direct link.

Q43 **Baroness Northover:** These are follow-up questions from the one that Lord Sharkey put. Perhaps we could have some very brief responses on this question, which you have touched on to some extent. It is on the potential impacts, for which the quality of evidence is currently low but where you feel that more research is likely to change our view.

Professor Pierre Geoffroy: That is an excellent question. In fact, there is a clear need for better evidence, especially regarding larger studies and

larger populations. These are very small samples, mostly done by academic researchers, which is an issue. We also need a longer follow-up with patients. We only know about the acute effects. The longest study I know of is one of five years. It is an excellent study, but we really need more data on the maintenance phase and preventive effects of light therapy, especially seasonal affective disorder. A recent comprehensive review tried to meta-analyse all the evidence but failed to do it because of a lack of evidence, so we really need more studies.

We also, as witnessed before, have things such as the chronotype, which is the clinical manifestation of the genetic clock at individual levels—meaning that some individuals are more of a morning type and others have an evening preference. These chronotypes are not taken into account in the studies, so it is a really major issue.

There are etiologically designed studies regarding the situation of the light treatment—the box used, the patients included, the weeks of treatment, et cetera. We do not know how to escalate those bipolar patients because we go slowly to avoid a manic shift, but we are doing the best we can—there are no protocols. In fact, in clinical practice we are examining assisting with light therapy as if it was a drug, like an antidepressant. But, in real life, when you give light therapy to a patient there are also sleep-wake recommendations. We can also prescribe melatonin, for instance. There are a lot of things in the package about chronological intervention, and all its elements should be assessed as a combination treatment.

Alex Smalley: I would echo some of Professor Geoffroy's points about the fact that a lot of the work that we see in soundscapes—nature-based soundscapes, specifically—is based on small, unrepresentative samples often of university undergraduates.

There is also naturally a big difference between the way we might interpret quantitative work—with all the caveats that come with that quantitative work—and the qualitative evidence, where much smaller samples are used but it is incredibly rich and we get to learn a lot more about the context of the way in which people experience nature-based experiences and the role that sound can play in that.

We probably need a more epidemiological focus on nature-based sounds to understand the effects at a possible population level and therefore the way they can scale. That is of course different when it comes to looking at nature-based sounds as a possible clinical intervention. I would say that the clinical evidence for that is relatively light, although there has been some work in the US in clinical settings, or at least in imitations of clinical settings.

In many ways, if natural soundscapes are treated specifically on their own, as I mentioned, that evidence base is relatively nascent, yet if we treat the kind of nature-based therapy that Dr Greenwood has talked about as a holistic and multisensory experience, it will be part and parcel of that.

Dr Alison Greenwood: Yes, I would like to see more studies in the field. The kind of research that is done at the moment is mostly in laboratories. Obviously it is difficult to tease out the individual elements of nature if you are outside in the natural environment and looking at the impact of natural sounds on it without being influenced by the other elements and characteristics of that natural environment, but it would be interesting to try to see if we can compare natural sunlight and the impact that it has on brain and body with the impacts of light boxes on brain and body. As for actual birdsong compared with recordings of birdsong, I suggest there will be differences there, but at the moment that research is limited.

The Chair: Still on the topic of quality, which is something that we are very interested in, we will move on to Lord Krebs.

Q44 **Lord Krebs:** My question leads naturally from the previous one. I want to ask a bit about the quality of evidence as opposed to the quantity. Alison, you talked about systematic reviews and meta-analysis of a large body of evidence. How many of these studies meet the gold standard of being double-blind randomised controlled trials? I imagine that is extremely difficult and the answer is probably none, but I would like to hear that.

As I am sure you are aware, there is a well-known effect in the psychological literature called the Hawthorne effect. I do not know if you have come across it, but I wonder how many of the results that we are hearing about are explained by the Hawthorne effect. If people are not familiar with it, I can give a short lecture.

Baroness Warwick of Undercliffe: We all did it in first year.

Lord Borwick: Can you tell us in one sentence?

Lord Krebs: In one sentence, there was a study in the 1920s in a factory in Illinois called the Hawthorne Works where they changed the light intensity in the factory and productivity increased. It turned out that was nothing to do with changing the light intensity; it was just that the participants knowing that some change had happened got them excited and made them more productive. It is a false result.

Dr Alison Greenwood: You are right about the meta-analysis. It is difficult to look at the effects of nature in a randomised controlled trial that has really good control groups, and at the same time double-blind is also very difficult. There are plenty of studies that would categorise themselves as RCTs in terms of the comparisons. In fact, next month the London School of Economics will start what it considers to be an RCT on our intervention, evaluating the impacts of our Dose of Nature programme but comparing it to a control group that is a wait list. It is quite difficult to get really good comparisons there. You cannot not know whether or not you are in nature, so the double-blind element of this research is difficult.

On where the research has gone, the quality has improved. In the 1980s and 1990s we were reliant primarily on self-report measures and perhaps biomarkers of stress such as blood pressure, cortisol levels and, importantly, heart rate variability. More recently, importantly, we have portable electroencephalogram machines measuring brain activity now that we can get people out of the labs. Until quite recently, machines measuring brain activity had to be done in laboratory settings, but now we can get them out and about and put these portable machines on people's heads to look at brain activity. That tells us only what is being lit up and activated—it does not give us answers as to why—but, as I say, it shows this increase in alpha waves in parts of the brain. We are also looking at blood. That is the research that I guess is exciting this world more than anything, where we are noticing this increase in natural killer cells that I referred to earlier, indicating a boost in immune functioning.

So the quality of the research is certainly much improved. I suppose that is why the physiological markers are so important. If you ask people how they feel in nature, you are going to get huge biases because of the associations that we have. Perhaps we spent more time outside in nature when we were younger, so we are going to be associating some of the elements of nature, such as listening to birdsong or brooks, with having a nice picnic with our family, for example. It is difficult, particularly when we are talking about self-report measures in nature, to avoid those biases.

Lord Krebs: What about my question about the Hawthorne effect?

Dr Alison Greenwood: What particularly are you asking about?

Lord Krebs: I just wondered whether, if the interventions that you run have a beneficial effect, and you say they do, that is to do with the interventions or simply with the fact that people are being exposed to some attention.

Dr Alison Greenwood: That is a fair point. I guess that is where the randomised controlled trial comes in and you can make comparisons with other interventions. It is not easy to do those trials, but that is what we are trying to do.

Lord Krebs: Before I move on to the others, has NICE approved these treatments? You said you are referred by the NHS.

Dr Alison Greenwood: No, it has not. That is something that we are certainly working towards. We think there is more evidence that ought to be needed to get into the NICE guidelines, but that certainly would help GPs to have that level of trust.

Alex Smalley: With regard to the spectrum of work that exists regarding approaches to understanding how natural soundscapes can impact all these physiological and psychological markers—that is, stress or cognition—we have a breadth of studies that in many cases use different methods and different measures and apply to different populations. We see a need for a much more concerted approach that is possibly

standardised in certain areas so that comparisons can be made between studies. I come back to the fact that this is a nascent area of research. One of the leaders in this area, Sarah Payne, who was mentioned earlier, was the lead author of a soundscape report for Defra in 2009, which I can send over following this session, which outlined the fact that there are glaring gaps in the way that nature-based soundscapes are approached and that there needs to be some kind of standardisation.

Lord Krebs: Thank you. Pierre, do you have any comments on the quality of evidence?

Professor Pierre Geoffroy: Thank you. Regarding the Hawthorne effect, I really agree that it is a concern, because when you care for some patients, somebody will of course feel better.

Regarding a randomised control trial, you really need a credible placebo. This is a real issue for chronotherapeutics. In light therapy, the field has really high-level randomised control trials, even if there are limitations to the mostly small sample sizes, compared with the drug pharmaceutical studies, for example, which have huge populations.

The study designs use placebos, such as active placebos, to give patients the same level of intervention. Both groups should be equivalently monitored. There is actigraphy in the control group, for instance, and they also have a diary, questionnaires, MRI et cetera. There are other interventions in the first group with an active placebo, and in light therapy the most used placebos are red light—or dim light, to be sure there are no effects—or other deceptive placebo such as negative air ions device presented to patients as an active medical devices.

Regarding the number of randomised control trials, in our meta-analysis there are about 10 studies, seven of which have really high-level evidence. It depends across meta-analyses, because there are numerous studies on different populations. In our study, we looked at light therapy as a first-line treatment with an antidepressant group and a placebo group, but we clearly need more research. For instance, for more vulnerable subgroups such as children, we have studies only for children above 12 years old. There are few studies on pregnant women, and we know that depression and suicide are the first cause of mortality in peripartum, so it is a really huge issue.

In patients with neurodegenerative disorders such as Alzheimer's, late-developing dementia or Parkinson's, there are a lot of circadian rhythm alterations, so light therapy could be useful there too.

There is a lot of work to do, but in seasonal affected disorder and depression patients, it is clear that we have a high level of evidence on the acute phase.

Q45 **Lord Mitchell:** I think much of this question has been covered, but I will ask it so that we can move on. Following on from Lord Krebs's question, is more research needed and, if so, what types of studies need to be funded and conducted?

Professor Pierre Geoffroy: Regarding research, so far it is mostly academic research in the field of light therapy and light effects. It is much less supported compared to that for drugs, where pharmaceutical companies conduct or sponsor very large-scale studies. There is a clear need to help this research and to support its effect—with specific calls to support academics—as well as having industrial support for providing these devices.

Alex Smalley: There is real value at the moment in trying to understand more about the deeper emotional responses that people can experience when they spend time listening to the sounds of nature. For example, we often talk about fairly basic high-level concepts such as positive and negative effects—basically, how positive or negative you feel in emotional senses. Actually, there is research emerging on the way more complex emotional responses, such as feelings of nostalgia, can produce incredibly rich outcomes from spending time listening to nature.

However, there is also definitely a danger, when we think about natural sounds, of viewing all anthropogenic sounds as negative. Of course we think about noise, however you define it, as having a negative impact when there is actually a really rich culture of pairing spoken word or music with the sounds of nature. We need to do a lot more to understand that. It is also important to recognise the ephemerality of natural sounds; they are far from constant and can vary seasonally, even diurnally. We need to understand a lot more about that area, too.

Dr Alison Greenwood: I would like to see more research on specific interventions with specific client groups: for example, looking at how dementia patients listening to natural sounds might impact their memory or, with autistic groups, how being in natural surroundings and particularly listening to natural sounds might help with connection and relating. Perhaps there could also be research on some of the mental health issues that are traditionally difficult to deal with in the current ways in which we intervene with them. For trauma and psychosis, it would be really valuable to start looking at nature-based interventions for these kinds of mental health issues.

Q46 **Baroness Neuberger:** Thank you to our witnesses for joining us. Some of this has been covered, but I think we would like to know more, if you can tell us, about how this all works. What are the mechanisms by which these techniques improve mental health? Perhaps I could start with you, Professor Geoffroy, because you said something about the retina and the link to the mood areas of the brain. Can you say something about how you think it works, or what we know about that?

Professor Pierre Geoffroy: That is an excellent point. In fact, we know that there are different connections. First, maybe I should remind you that there has been the discovery of the melanopsin retinal photopigment, which is maximally sensitive to blue wavelengths and expressed in a subset of intrinsically photosensitive retinal ganglion cells. This particular cell allowed us to further understand the light effects on these neural pathways from the retina and the photic regulation of mood.

We think that the light effects on mood may be linked to three mechanisms: indirectly, to a phase advance or an alignment of circadian rhythms. Dr Greenwood talked earlier about melatonin, for instance, and we know that, during winter, melatonin, which is secreted during the dark by the pineal gland in the brain, lasts longer with a larger amplitude. The light during the morning removes or stops the secretion of melatonin, giving a kind of summer signal and phase advanced rhythms.

There are also direct effects. We know, for instance, from numerous studies of shift workers or patients who are sleep deprived that light therapy enhanced their vigilance and alertness. It also has a direct effect on mood. There are very interesting studies from the US, from a group including John Gottlieb, showing that even a midday exposure of light, with no effects on the circadian clock, also has an effect on mood and probably, thanks to this, to the direct pathways in the mood brain regions.

The effects are transduced by the melanopsin photosensitive retinal ganglion cells and project to the master clock of the circadian rhythms, the suprachiasmatic nuclei, located in the anterior part of the hypothalamus in the brain, and to the whole limbic system, which is involved in mood. So there are pathways going to the suprachiasmatic nuclei acting on the clock and then on the homeostatic operations, circadian rhythms, alertness and mood, but there is also a direct link without going to the suprachiasmatic nuclei. There can be situations where circadian disruptions are not addressed by traditional antidepressant drugs.

Baroness Neuberger: Dr Greenwood, can you talk particularly about sound? We have heard a lot about light and how that works.

Dr Alison Greenwood: I think it is true to say that the mechanisms are nowhere near as well understood for natural sounds as they are for light. There were a couple of theories in the 1980s that are still considered to hold merit today. The first is the stress reduction theory, which purports that nature is perceived as unthreatening and less arousing. It is a familiar environment—obviously—and as soon as we go outside there is an immediate shift towards a positive emotional state, so there are then reductions in heart rate, blood pressure and cortisol levels.

The other theory that is still quoted, and which I think has some merit, is the attention restoration theory, a more cognitive theory whereby natural surroundings—natural sounds, in this case—are restorative. As I mentioned earlier, we suffer from direct attention fatigue, so when we go into a natural environment and hear natural noises, our attention is restored because we perceive the natural environment that we are in as peaceful, calming and restorative.

There are characteristics in the natural environments that are identified as perhaps the characteristics that cause that restoration. One of those is the concept called soft fascination whereby nature—and I say again that natural sounds are very much a part of this—is interesting, but not too interesting. It is familiar to us, so it does not stress us out too much

because we have been listening to those sounds for the entirety of our evolution.

Both those theories, the stress reduction theory and the attention restoration theory, have a basis in evolutionary theory. The biophilia hypothesis is often quoted—the hypothesis that we have an innate need to affiliate with the natural world. It is in our DNA. We learn to love the environment in which we evolved, so we have a kind of biological need to connect with it, as it were.

Regarding natural sounds, Alex Smalley mentioned earlier that research has shown that the two sounds that have the greatest positive impact on us are running water and birdsong. Both of those would have a very clear evolutionary understanding: running water is obviously a sign of survival for us, so it would be critical, and we would get excited and pleased when we heard that, while it has been suggested that birdsong is a sign of a safe space where there are no predators around. So those are the theories, but I do not think the mechanisms are anywhere near as well understood as they are for light.

Baroness Neuberger: Alex Smalley, do you have anything to add on the mechanisms?

Alex Smalley: I thought that was a brilliant summary by Dr Greenwood. There were two studies where researchers took the sounds of distant waves breaking and a distant motorway and put them together to create a background of white noise, since those two sounds are very similar spectrally. When they told participants that the sound was a beach, the participants rated it highly and found it restorative, but when they told them it was were a motorway they did not.

What I am getting at here is the opposite to the evolved approach: the idea of therapeutic landscapes of culture, meaning and association. We call that top-down processing as opposed to the bottom-up processing that Dr Greenwood mentioned. Those two factors are so inextricably linked that we cannot really make a judgment about nature-based sounds without considering what people bring to this. The role of culture, whether personal or societal, and meaning and memories is crucial to this too.

Q47 **Lord Rees of Ludlow:** We have heard evidence in earlier sessions about the harmful effects of artificial light and noise. We have been told that the effects are rather subjective and vary a lot from person to person by age, social setting and so on. To what extent will that be true of the positive effects that we are discussing today? Is there variation in the extent to which different types of people will benefit from the techniques that you are working on?

Dr Alison Greenwood: Yes, absolutely. People's personal experiences and preferences will certainly impact on the way they respond to all the elements of nature that we know have positive impacts. This research has been done across cultures and across different populations and overwhelmingly shows these positive benefits, but certainly individual differences will play a huge part.

Professor Pierre Geoffroy: The research on the negative effect of noise on sleep from traffic in the street or airports is a different field from the field of light research. As clinicians, we are not studying the negative effects of light treatment but how it can be used positively as therapy. We know that too much light at night is also negative for sleep. In our field, there is a serious lack of data about response predictive markers for gender, age effects and comorbid disorders. We have talked about disorders.

We need more objective biomarkers using actigraphy and polysomnography but also electroretinography, which assesses the response of the retina to light, pupillometry, which looks at the pupille response, and studies of light-signalling pathways and their effect on the mood regions of the brain. We must also take into account age, gender and comorbidity effects. Lastly, we clearly need to support research regarding the prediction of this light response in the context of a better understanding over the last decades of these light-signalling pathways and their associated pathophysiology.

Q48 Lord Winston: I will try to keep briefly to the question of whether there are any other initiatives going on, outside the UK or within it, that are implementing these techniques. I am reminded that there are a number of music programmes that have been used; the Royal College of Music, for example, has a number of music programmes that are looking at trying to improve dementia and mental health. I do not know of any clear evidence that those work. Maybe you can advise us of other areas where there might be, either in this country or elsewhere, and what sort of studies we should be looking at, because we have to advise the Government if we are to have any impact.

Dr Alison Greenwood: That is a really important question. The music studies will come under the same umbrella as some of the nature-based studies in terms of what we in this country are looking at. There is an initiative called social prescribing—I do not know if you are familiar with it. The Government put £5.8 million into a two-year project—it started in April 2021, so we are just coming to the end of it—looking at green social prescribing. That identified seven test-and-learn sites around the country and looked at all the nature-based interventions that were going on—brilliant projects, different kinds of projects around the country—to see if we could tease out the elements that make these successful.

I would say that this was not quite the right way to go, because they are all successful. The early findings of this research are that being outside in nature in whatever way—whether you are going on a healthy walk or to a green gym, or on a conservation or gardening project, or whatever it was—will all work to some extent. The limitation on what is happening in the UK is that we are just not being ambitious enough. In social prescribing initiatives with music and nature, we are looking at supporting our overstretched GPs. When people arrive with an illness and it becomes clear that it is a mental health issue, the GP may think “Okay, this is not for me”, and pass it over to an intermediary—often called a link worker—to think about interventions that might support that person.

What is happening in other countries, and where I think we should be going, is that nature is being put right at the beginning of the process with a GP. At the moment, with a mental health issue, a GP has the options of medication, psychological therapy or “Come back and see me next week, because I’m really worried about you and know that those two haven’t worked for you”, or perhaps the waiting lists are too long or they do not want medication. If we put nature in there as a third option and have a nature prescription, which has happened in other countries around the world where a nature-based intervention is really embedded into the healthcare system—Japan is one of the leaders in this—then GPs can prescribe that right at the beginning.

Lord Winston: Is there evidence coming out of Japan that is scientifically valid?

Dr Alison Greenwood: In terms of how that intervention works?

Lord Winston: Yes.

Dr Alison Greenwood: The Nippon Medical School in Tokyo has been looking at phytoncides, the particular element of nature improving immune functioning, which has led the Japanese Government to take it on board—perhaps because it is very much based in their culture, with all the forests around Japan. They naturally and instinctively can see the benefits of getting out into the forest. GPs are just buying into that by thinking, “This is great. We’re going to do this”, and people are reporting back that it is working. They are a bit further ahead in looking specifically at the intervention, but it is probably done in a more ad hoc way than it ought to be done here. South Korea—another country that really is embedding nature-based interventions into its healthcare systems—has just spent £160 million, for example, on a national institute to look at forest therapy.

Lord Winston: Perhaps I could ask Alex Smalley the same question. What about your soundscapes? Is there any good evidence that they make a difference to human health? I understand that they might improve a feeling of happiness and well-being, but the evidence that those really make a difference to human health is relatively slight in the literature. I can quote numbers of papers that show that you might get slightly improved wound healing, you might get slightly improved immune responses to bacteria and so on, but whether it really makes a big difference is difficult to prove, as in fact Lord Krebs has just pointed out. Alex, would you be kind enough to comment on that?

Alex Smalley: I agree completely. Nature-based sounds, specifically, represent an area where we see that we are very much in the infancy of research. I would like to quote some slightly more informal evidence. If you search on YouTube for relaxing nature sounds, the top videos have had 45 million views; if you search for thunder and rain, the top videos have had 145 million and 121 million views respectively. Bose has released a pair of headphones that play only natural sounds—they are built into the headphones. Huge wellness companies, such as Headspace

and Calm, routinely pair nature-based sounds with narratives; it is their bread and butter.

We are talking about digital representations of natural sounds here, but people are taking this seriously at a broadcasting level as well. For example, the BBC now regularly makes broadcasts that target the therapeutic potential of nature, and sound is part of that. Radio 3 has a weekly slow radio slot that is just the sounds of nature. You are absolutely right that we do not have the clinical evidence in the same way that other disciplines do, but, anecdotally, there is huge support for the ways in which people are using nature-based sounds for their own well-being.

Professor Pierre Geoffroy: I totally agree that for public recommendation, prevention actions or treatment—even reimbursement, for light therapy—we need clear guidance. Regarding light therapy and the evidence for using it for depressive patients with a disorder—not for happiness or well-being, it is important to emphasise—there are international efforts on therapeutic guidelines for mood disorders, including detailing light therapy with different indications for how to prescribe it and to whom. It is important to continue this.

There are some countries that reimburse light therapy for seasonal affective disorders—Switzerland, Canada and probably others. There are publications with architectural lighting initiatives for the long winter in northern countries. There are also mostly private initiatives that propose light boxes to improve the exposure to light during the long winters of northern countries such as Sweden, Finland, Canada and so on. Lastly, there is a non-profit website for professionals and public at cet.org, which has a lot of unbiased, scientifically based information on light therapy and how to use it.

Q49 **Lord Winston:** Would any of you be kind enough to comment briefly on the sort of manmade noises that we are told are damaging to health—for example, traffic noise, building noises and that kind of thing? Alex, you must have some views on this.

Alex Smalley: In the soundscape literature, often the studies conducted—particularly the more rudimentary, earlier studies—showed that urban soundscapes, whether as traffic noise, noise within a building or noise in clinical settings, can have negative impacts on the way a natural soundscape is perceived. There is a flipside to that coin, which is that several studies have artificially increased the way that natural sounds can be heard in urban environments. What we actually see is a masking effect there. It is relatively common for the sound of water through fountains to try to mask traffic noise, particularly in urban squares. But it has also been shown that natural sounds can reduce the negative impact of traffic noise, for example. That has been shown by literally piping in nature-based sounds and with music, too.

There is an interesting flipside there, related to biodiversity. People can sense biodiverse soundscapes versus soundscapes that are more basic.

We think there is a role there for the way more urban landscapes are perceived, when biodiversity is heard rather than seen.

Q50 Lord Borwick: Do you have any evidence of how these techniques might compare in efficacy, cost, or side-effects terms to existing methods of treatment for ill-health?

Dr Alison Greenwood: Yes, some of this is quite obvious, and I guess some of it is things that we are finding out. For mental health, as I referred to earlier, the two treatment options at our disposal at the moment are medication and traditional psychological therapies, and we know that both of these have problems. Many people are turning against medication and too many people have been stuck on it for far too long when it is clearly not working, because they are still on the medication and it has not got them better. More and more people, GPs included, are unhappy about some of the side effects that come with psychiatric medication.

The efficacy rates for those medications are also quite low; traditionally, we think of it as about a third of people. They support some people some of the time and about a third of people find them very helpful. For a third of people there seems to be no difference, and for another third the negative impacts seem to be greater.

Psychological therapies are, of course, expensive, and waiting lists are very long. When I was working in the NHS I did assessments, and the thresholds were ever higher, so people would not reach a threshold, and after a psychological assessment they would be turned away and be told, "I'm sorry, go away and get a bit poorer, then come back and we'll do something"—or else they were too poorly and needed to be referred on to another service, such as trauma therapy or a specialist service.

We need new options, and I really think nature-based interventions will be the answer. They are very cost-effective. Although I am not going to say that nature is a free resource, it is certainly cheaper as an intervention. It is something that we can all access. It is a sustainable option; if people get used to going outside and spending more time in nature and getting all the benefits that we have just talked about, they can continue to do that at any point they want, in an accessible way, without another person or a GP checking up on them, and if they get into that habit, that is a sustainable resource that they have for the rest of their lives.

It is difficult to compare the efficacy rates if we are not taking the same measures that other psychological therapies are taking, so we at Dose of Nature take the same pre and post measures for depression and anxiety that a typical comparable CBT intervention would take. The national recovery rates are somewhere between 33% and 50% for a typical CBT psychological intervention, but our recovery rates are consistently higher than 70% in the 800 referrals that we have had. Given all those factors—cost-effectiveness, recovery rates and side effects—I think nature will be a great way forward to support our NHS.

Professor Pierre Geoffroy: Regarding light therapy, these treatments in the general population and in patients are very well tolerated. They are also cheap, involving the one-time purchase of a light lamp or light glasses, which should be reimbursed. There is often polymedication in our patients suffering from psychiatric disorders, but light therapy combines well, with no interaction with drugs; there is no hepatic or renal elimination, for instance. Light therapy also has an additive effect with antidepressants, with no increase in side effects, which may help to increase antidepressant and oxygen intake. The side effects of light therapy mostly consist of visual glare, headaches, agitation and nausea for a very few patients, but they usually disappear after a few days. So there are great benefits with few side effects at low cost.

More globally, it is important to say that light exposure is essential for human mental health and that the population is mostly light deprived, especially during winter and in environments, such as at work, where illumination is quite low.

A quick note regarding light deprivation: a lot of individuals are now wearing blue light-filtering glasses. This filter may be helpful to prepare for sleep but may also increase light deprivation in the morning or during winter, since the blue spectrum, as we detail, is physiologically very useful for circadian rhythms, wakefulness and mood. This is also an important prevention point.

Q51 **Lord Borwick:** I have a follow-up question for Alex Smalley. About 20 years ago I was working on electric vehicles, and it is perfectly clear that the silence of electric vehicles is downright dangerous in the squashing of inattentive, deaf or blind pedestrians. Have you a strong opinion as to what sound an electrical vehicle ought to make, from your consideration of the range of different sounds that exist? I know that one electric vehicle manufacturer suggested that he should play the sound of a diesel engine in the front of his vehicle, but that seemed to me like kitsch rather than anything else. What is your opinion regarding what sound an electric vehicle ought to make?

Alex Smalley: That is a really good question and not something I have considered. In a spectrum analysis-sense, work has been done to try to understand the similarities that exist between different types of nature-based sounds and the way they are perceived. I could easily see merit in an approach that tried to fuse some of those elements into that kind of sound. It may be that you could create an electric vehicle sound that did not compete with natural sounds, if you were trying to promote those. If we are thinking about greening our cities as well as electrifying transport, one wonderful thing about creating green corridors, protecting biodiversity and protecting habitat is that natural sounds are a wonderful by-product of all the flora and fauna existing.

Lord Borwick: So you would recommend the sound of the seashore or something like that for the sound of an electric vehicle?

Alex Smalley: I am not sure I would recommend that, but I would certainly recommend understanding how people responded to that kind of sound.

Lord Borwick: That was very helpful. Thank you.

Q52 **Baroness Neville-Jones:** This is the last question to our experts. I want to continue the questions on the relationship between the work you are doing and the world of policy-making. There are two aspects that I am interested in. We have heard a lot of evidence, so obviously I will ask you not to repeat something that you have already told us, but where do you think policymakers could usefully support work—that is to say, spend public money—to support the various therapies, research and interventions that you are engaged in?

The reverse question is: are there particular therapies and interventions that are not part of public health policy where you think the work you have been engaged in could usefully be incorporated in public policy? Some of them are used, but not in the sense of being part of the public agenda.

Dr Alison Greenwood: That is a great question to be asked—to think that there might be some kind of influence. First, we need to protect our natural soundscapes and enshrine that in law. America does that, so those are legally protected.

On noise pollution, perhaps we should be considering not just the impact on the people who are going to suffer from, say, living near a third runway, but the impact it might have on our natural parks and on the millions of visitors who are using them for their restorative benefits to their own mental health. We need a much broader look at the impacts of noise and protecting our natural soundscapes for all the people coming from urban environments to large parks to get the mental health benefits and indeed all the health benefits.

Secondly, and I feel quite strongly about this, we need to put more money into ensuring that everyone can access the natural world. A lot of the research at the moment, which we have talked a bit about today, looks at what we can do for people who perhaps cannot access natural spaces: dementia patients, prisoners, schoolchildren stuck in schools, older adults in community centres and mental health patients. We need to change the way we are thinking about that and put some policies in place to ensure that all those people can access natural spaces.

It is interesting to look at Singapore, a very tiny country that is the third most densely populated country in the world. Its green space has increased. It is putting green walls, vertical allotments and roof terraces everywhere, ensuring that its hospitals, for example, are built around atriums. It has a beautiful new hospital with lush green tall trees in the middle of it so that all the hospital patients have access to that green space. The Koreans are taking off ceilings from their schools and ensuring that natural sunlight comes through, so that children can access nature.

We do not want to put wallpaper of trees in our prisons; we want to make sure people get outside and have time for that.

Professor Pierre Geoffroy: Regarding light, in support of that field it could benefit from multi-centre studies funded by government agencies, to be independent of commercial lighting firms. We also need stronger interaction between the academic teams and private partners working on light devices to validate these medical devices and get reimbursement. It is important to note that each medical device needs to be validated on its safety and efficacy, with a specific indication, and each medical device has to claim reimbursement.

There is also probably a need for public information, starting with the schools, on the benefits and risks of light exposure at home or in public places so as to optimise lighting and maximise darkness—in fact, all chronological stresses such as seasonal or light exposure changes. This is a really important issue, mostly to protect from aberrant light exposure.

Very simple things could be proposed, like public health initiatives to valorise sleep and times offline, especially for proper sleep; a specifically targeted public initiative for vulnerable populations such as small children and adolescents to avoid light exposure, in particular two hours before bedtime; and, probably, education on how to modulate or avoid the rich blue polychromatic white light in LED screens by using a nightshift, et cetera, mostly in the evening; to use protective eyewear in the evening to ensure circadian darkness; also dark therapy, but for patients with circadian disorders.

Lastly, I propose a collaboration with interior design and architectural branches to ensure projects modulating light in an optimal way throughout the day—in home lighting, lighting at work et cetera. For shift work, it is also a really important issue in mental health to avoid it when possible. If it is necessary, there is a clear need for collaboration with shift-work experts to optimise lighting in work environments.

Baroness Neville-Jones: Thank you. That is an interesting reflection on the built environment.

Alex Smalley: I would like to finish by saying that natural sounds specifically depend on the protection of habitats and biodiverse ecosystems. By protecting our natural environments and making them available, in more rural as well as urban settings, we will preserve the sounds and, of course, the range of ecosystem services—among them, the therapeutic potential of nature and nature-based sounds. This is not just a one-way perspective, because audible natural sounds are also intrinsic to the health and well-being of non-human species. It is important to bear that in mind too.

Q53 Lord Holmes of Richmond: I will start with Dr Greenwood. Thank you for all the work you are doing in this area. We have heard a lot about what I think you described as sounds of nature and natural sounds, but I do not think we have had any definition. How would you define this in a sentence? If we needed to get hold of it in a more methodological way,

what would your definition be?

Dr Alison Greenwood: Of a natural sound?

Lord Holmes of Richmond: Yes, or sounds of nature. You have talked about both, so how would you define this? What parameters would you put around it?

Dr Alison Greenwood: I suppose they are biological sounds made by animals, birds and insects, and geophysical sounds—wind and water.

Lord Holmes of Richmond: Would you think that all this is necessarily certain sounds of nature in certain contexts, related to specific people? For example, if you heard a lion that would not necessarily be particularly beneficial.

Dr Alison Greenwood: It probably would be if you heard that sound first, because it will give you a chance to get your fight or flight flowing and run away from it. That is the evolutionary theory of this idea that we have an innate affiliation with the natural world, and we are evolutionary predisposed to react to them appropriately.

Lord Holmes of Richmond: Fine. Would you say that a lark would be more beneficial to mental health than “The Lark Ascending”?

Dr Alison Greenwood: That is a very interesting question. Actually, alpha waves are activated by listening to beautiful music as well, so it would be interesting to do a comparison with that. Listening to music certainly seems to have a similar impact to listening to natural sounds.

Lord Holmes of Richmond: Thank you. Finally, and building on Lord Krebs’s questions perhaps for future research you could look at the Hawthorne effect. Dr Smalley, could you briefly add to those points, please?

Alex Smalley: We have just done a study with the BBC that looks at the way in which music and nature—natural sounds—interact. A working definition of the way natural soundscapes are composed is provided by the field of soundscape ecology, which does exactly what Dr Greenwood says; it splits out the constituent elements of a soundscape according to what is referred to as biophony—the sounds of all living organisms—and geophony, which is the sound of the landscape, however manifested, and anthrophony, which is the sound of human-induced noise.

Lord Holmes of Richmond: Professor Geoffroy, any final thoughts?

Professor Pierre Geoffroy: No, thank you. This is not my field and I am absolutely convinced by the response of my colleagues.

Q54 **Baroness Warwick of Undercliffe:** I have a very quick question. Given the benefits that you have all described, are there any specific barriers—in funding, possibly—to extensive research to get the large-scale studies that would be more convincing?

Dr Alison Greenwood: Just the limited amounts of funding available for any kind of research.

Baroness Warwick of Undercliffe: There is nothing specific in relation to this.

Dr Alison Greenwood: Perhaps in the medical profession. More research on getting into the NICE guidelines that Lord Krebs has just referred to would be critical for our work to move forward on a national level.

Baroness Warwick of Undercliffe: Alex Smalley, I noted that you are funded by Wellcome.

Alex Smalley: Yes, I am funded by the Wellcome Trust. It is increasingly apparent that these kinds of conversations have to take place at a sort of cross-council level, so multidisciplinary and transdisciplinary studies are the way to approach these mixed-method designs. It is about having more of those cross-council calls and making them clearer. From a funding perspective, that is one area that would really help.

Baroness Warwick of Undercliffe: Professor Geoffroy, I wonder if France does it differently.

Professor Pierre Geoffroy: Yes, there is already a high level of clinical and physiological evidence about light, but there is psychiatric resistance to this non-commercial, therapeutic side that Dr Greenwood just mentioned. If the treatment is natural, this resistance usually results from a lack of knowledge of mechanisms and response rates, related to the reference drugs they are using. Physicians are also more used to prescribing drugs—not to treatment coming from other fields, such as physics for light. But there is a clear need for a training course and teaching in medical schools and congresses, et cetera, as well as simple education about light's effects on the sleep-wake health of children in school, as well as in interior design, architecture et cetera.

Regarding the barriers to implementation that need to be overcome, of course reimbursement for patients is one, especially in health systems like that of France and the UK, as well as a better implementation of these techniques in therapeutic guidelines. But there is progress. In the last decade, new treatment guidelines have appeared. As I mentioned, probably the biggest barrier is a lack of large-scale therapy, such as therapy trials as we would do for the development of new drugs. These are the kinds of measures on implementation that we could propose.

The Chair: Thank you very much to all our witnesses for an interesting session today. I think some of you have offered to send us some further information and we would be glad to receive that additional evidence, so thank you very much.