**Peer-Review**

Huang, Sophie Y. 2026. “Contrasting Urban and Natural Soundscapes: Implications for Child Development, Cognitive Functioning, and Physical and Mental Health.” *Journal of High School Science* 10 (2): 296–328. https://doi.org/10.64336/001c.162718.

Please incorporate and discuss the following content in the manuscript as appropriate to your title. Please add relevant references.

1.Instead of only asking what sounds do physiologically, you could introduce a framework of acoustic socialization. For example, how children are taught to interpret sounds within cultural narratives, economic systems, religious traditions and historical memory. For example, Church bells vs. alarm sirens, Factory whistles as prosperity vs. oppression, Train whistles as migration trauma vs. opportunity, Fireworks as celebration vs. war trauma. You could argue that meaning moderates physiology. This would extend Stephen Kaplan’s Attention Restoration Theory and Roger Ulrich’s Stress Reduction Theory by introducing interpretive mediation rather than assuming evolutionary universality.

2.You currently imply humans are “biologically adapted to nature.” This is simplistic. Humans evolved in Storms, Predator-rich environments, Insect swarms, Fire crackling, Tribal vocal noise. So the argument cannot simply be “natural = safe.” Instead, perhaps what matters is:Meaningful signal vs. meaningless mechanical repetition, Biologically interpretable acoustic patterns, Adaptive relevance. You could incorporate predictive processing theory: Brains reduce stress when they can model and predict incoming stimuli.

3.Habituation and Plasticity: Children growing up in cities may develop enhanced selective attention, show altered auditory cortex development, exhibit adaptive filtering mechanisms. Some studies suggest cognitive resilience in chronically noisy environments.You briefly mention adaptation — this could become a full theoretical section:Neural plasticity, Resilience vs. cumulative burden and Differential susceptibility.

4.Is sound exposure during infancy different from middle childhood? Puberty? in terms of Sensitive periods for auditory system development, Prenatal exposure effects, Adolescence and dopaminergic sensitivity. What are the implications of having the unborn child listen to classical (or other kinds of) music or sounds?

5.Not everyone responds the same way to sound. Factors that influence this soundscape responsivity could include Neurodivergence, Noise sensitivity as a personality trait, Trauma history, Urban vs. rural upbringing and Cultural background.

6.Sound as information versus sound as energy: Current research treats noise as: Energy (decibels), Frequency and Duration. But humans interpret sound as:Information, Meaning and Social signal.

7.Moralization of Sound: There is a subtle normative bias in environmental psychology literature, viz. Nature = good and Industry = harmful. You could include a meta-critique section asking the question: Are we conflating aesthetic preference with biological necessity?

8.Do soundscapes aligned with circadian expectations reduce stress? class ending or beginning bell, on the hour church bells, sounds of cooking (pots/pans/plates), sounds of lullaby, ….

9.. Your argument seems to be context independent. For example, mental, physical health, conitive functioning may depend on HOW the soundscape is taught to be perceived. For example, if the sound of an engine is taught as progress (overcoming the limitations of distance and time that otherwise nature would impose); the sound of a steam locomotive or train taught as eliminating border and constraints on goods and services; the hum of the refrigerator or airconditioner as creating more conducive functioning environments to free up thinking for higher-value purposes… etc. then anthropogenic sound may not be as detrimental to health as it otherwise may be. In the same vein, the sound of a waterfall may just as well be taught as associative with drowning, the gentle bubbling of a stream or the ryhthmic crashing of sea waves may just as well be taught as being associated with lethargy and timeless inaction and languishing idleness, and the sound of wildlife may just as well be associated with predation, disease and fear. As you mention in your paper, lightning can be taught to be associated with scientific phenomenon that can be understood

and harnessed for use; it can also be taught to be associated with the fear of god. The point I am trying to make is that the notion that natural soundscapes are 'naturally' mentally soothing and that anthropogenic soundscapes are organically mentally disturbing may not be true. They are instead, dependent on the context in which they are taught to be perceived by children. You will need to include discussion on this topic in the manuscript, because, as written, your manuscript presents content in the public domain. This is not enough for publication of a review paper as described in the Journal's guidelines. See https://jhss.scholasticahq.com/for-authors, types of manuscripts, review papers. Of course, you are free to think of other as-yet-unrecognized angles or thought avenues." do you have any other non-obvious content or ideas that you can think of to include in this manuscript?

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Thank you for your constructive feedback and comments on the manuscript. Below, please find more detailed responses to your comments, and find all changes made in the manuscript referring to your comments highlighted in green.

1. Instead of only asking what sounds do physiologically, you could introduce a framework of acoustic socialization. For example, how children are taught to interpret sounds within cultural narratives, economic systems, religious traditions and historical memory. For example, Church bells vs. alarm sirens, Factory whistles as prosperity vs. oppression, Train whistles as migration trauma vs. opportunity, Fireworks as celebration vs. war trauma. You could argue that meaning moderates physiology. This would extend Stephen Kaplan's Attention Restoration Theory and Roger Ulrich's Stress Reduction Theory by introducing interpretive mediation rather than assuming evolutionary universality.

Thank you for this insightful suggestion. I agree that cultural background, personal experience, and learned associations could influence how individuals interpret and emotionally respond to sounds. For example, someone who has experienced a traumatic event associated with water may not find river sounds relaxing, and fireworks may be perceived as celebratory in some cultural contexts (such as Chinese New Year traditions) while being experienced as disruptive or distressing in others. These examples illustrate how meaning and prior experience may shape subjective responses to sound.

At the same time, much of the existing literature suggests that broad patterns still emerge across populations and age groups in responses to urban and natural soundscapes. The evidence that I present in my manuscript reflects responses seen across global populations. Because environmental policy is typically designed to benefit the general population rather than individual cases, identifying these broader patterns remains important. However, I agree that understanding how cultural narratives, personal memory, and other contextual factors interact with physiological and psychological responses to sound is an important direction for future work. In response to the reviewer's suggestion, I have expanded the Future Research section to discuss the role of individual and cultural variation in soundscape perception and the need for further research on how these factors may moderate restorative or stressful responses to sound environments (lines 533-544). This question is also relevant for policy development, as determining whether and to what extent cultural meaning can mediate physiological responses may influence how soundscape interventions are designed in different contexts.

2. You currently imply humans are "biologically adapted to nature." This is simplistic. Humans evolved in Storms, Predator-rich environments, Insect swarms, Fire crackling, Tribal vocal noise. So the argument cannot simply be "natural = safe." Instead, perhaps what matters is: Meaningful signal vs. meaningless mechanical repetition, Biologically interpretable acoustic patterns, Adaptive

relevance. You could incorporate predictive processing theory: Brains reduce stress when they can model and predict incoming stimuli.

Thank you for bringing this to my attention. I agree that describing humans as simply "biologically adapted to nature" risks oversimplification, and we appreciate the reviewer highlighting the complexity of human acoustic environments during evolutionary history. Many human-generated sounds, such as voices, laughter, and cooking, have also been part of human environments for millennia. In response to the reviewer's comment, we have clarified our definition of the word "natural" in the introduction (lines 51–54) to emphasize that the term does not imply "non-human" sounds.
I also wish to clarify that the manuscript does not argue that all natural sounds are inherently safe or restorative. As noted in Table 2 (line 123), certain natural sounds, including thunderstorms, loud winds, and animal distress calls, can be perceived as stressful. Instead, the paper suggests that some commonly studied restorative sounds (such as birdsong, soft rain, or rustling leaves) may be calming in part because of their acoustic structure, including relatively repetitive, predictable, and moderate-intensity patterns, rather than just the sounds being "natural."
The reviewer's suggestion raises an important question about whether restorative effects are driven primarily by acoustic structure or by the ecological meaning that sounds may signal. For example, certain sounds could historically convey information about environmental conditions (e.g., the presence of fresh water, environmental stability, or potential threats). Distinguishing between these mechanisms is an important direction for future research. In response to the reviewer's suggestion, I have expanded the Future Research section to discuss the need to examine how acoustic structure, ecological meaning, and predictability may interact to shape physiological responses to sound environments (lines 577–594).
3. Habituation and Plasticity: Children growing up in cities may develop enhanced selective attention, show altered auditory cortex development, exhibit adaptive filtering mechanisms. Some studies suggest cognitive resilience in chronically noisy environments.You briefly mention adaptation — this could become a full theoretical section: Neural plasticity, Resilience vs. cumulative burden and Differential susceptibility.

Thank you for this thoughtful comment. I agree that the concepts of habituation, neural plasticity, and differential susceptibility are important for understanding how individuals adapt to chronic acoustic environments. In response, I have added a paragraph to the Future Research section in lines 619-633 discussing how prolonged exposure to urban noise may shape auditory processing, selective attention, and stress responses over time. The revision also considers the possibility that individuals raised in chronically noisy environments may develop adaptive filtering mechanisms or attentional strategies, while others may experience cumulative physiological or cognitive burdens. This addition highlights the need for future research examining how early-life acoustic environments influence neural development, resilience, and long-term health outcomes.

4. Is sound exposure during infancy different from middle childhood? Puberty? in terms of Sensitive periods for auditory system development, Prenatal exposure effects, Adolescence and dopaminergic sensitivity. What are the implications of having the unborn child listen to classical (or other kinds of) music or sounds?

Thank you for this insightful suggestion. I agree that developmental stages may play an important role in shaping how individuals perceive and respond to sound environments. While a substantial body of research has examined prenatal auditory exposure and early auditory learning, relatively few studies directly compare the effects of sound exposure across developmental stages such as infancy, middle childhood, and adolescence. In response to the reviewer's comment, I have added a paragraph to the Future Research section from lines 676-691 discussing how the effects of sound exposure may differ across phases of development, including prenatal auditory learning and

potential sensitive periods associated with auditory system maturation. This addition highlights the need for future research examining whether the positive or negative effects of sound environments may be more pronounced during particular developmental windows.

5. Not everyone responds the same way to sound. Factors that influence this soundscape responsivity could include Neurodivergence, Noise sensitivity as a personality trait, Trauma history, Urban vs. rural upbringing and Cultural background.

Thank you for raising this to my attention. I agree that individual differences may significantly influence how people perceive and respond to soundscapes. While the original manuscript already discussed neurodivergence and noise sensitivity as factors that may shape soundscape responses, I have expanded this section to also consider the potential influence of trauma history as well as environmental and cultural upbringing. These factors may affect how individuals interpret and physiologically respond to certain sounds, potentially altering the health effects of both natural and urban sound environments. This discussion has been added to the paragraph addressing neurodivergence and noise sensitivity (lines 660–674).

6. Sound as information versus sound as energy: Current research treats noise as: Energy (decibels), Frequency and Duration. But humans interpret sound as:Information, Meaning and Social signal.

Thank you for this thoughtful suggestion. I agree that sound can be interpreted by humans both as a physical stimulus (e.g., energy, frequency, and duration) and as a source of information that conveys meaning or social signals. While cultural context and learned associations may shape how certain sounds are interpreted, responses to sound are not always fully conscious and may also involve automatic physiological reactions to acoustic properties. At present, relatively little research has examined how cognitive interpretation and physiological responses interact in shaping human reactions to sound environments. In response to the reviewer's suggestion, I have expanded the Future Research section to discuss the need for studies that examine how acoustic structure, meaning, and contextual interpretation jointly influence responses to soundscapes. I also highlight the importance of investigating these mechanisms across different ages and cultural contexts. This discussion appears in lines 502–508 and 510–531 of the manuscript.

Moralization of Sound: There is a subtle normative bias in environmental psychology literature, viz. Nature = good and Industry = harmful. You could include a meta-critique section asking the question: Are we conflating aesthetic preference with biological necessity?

Thank you for this thoughtful comment. I agree that it is important to consider whether the environmental psychology literature may contain implicit normative assumptions. While existing research provides evidence that certain acoustic characteristics commonly found in natural environments may support stress reduction and attentional restoration, I agree that it is valuable to examine whether these responses reflect biological processes, aesthetic preferences, or an interaction between the two. In response to the reviewer's suggestion, I have added a paragraph to the Future Research section from lines 545-558 discussing potential normative biases in soundscape research and proposing experimental approaches that could help disentangle acoustic effects from contextual interpretation, such as manipulating participants' expectations about sound sources.

However, it is important to note that this bias is most likely evidence-based. In many areas of psychology, it is important to think about normative bias. But in this specific case, I started this paper wanting to examine whether we overestimate how negative urban environments are. The evidence turned out to be very overwhelmingly in favor of one direction rather than another.

There is no doubt still a lot of work to be done in pulling apart the interactions between culture and biology, but the evidence seems to be pointing in a certain direction.

7. Do soundscapes aligned with circadian expectations reduce stress? class ending or beginning bell, on the hour church bells, sounds of cooking (pots/pans/plates), sounds of lullaby, ….

Thank you for this insightful suggestion. I agree that both the timing of sound exposure and its alignment with circadian expectations may play an important role in shaping how soundscapes are perceived and processed. In addition to timing, different sounds vary in their acoustic characteristics and rhythmic structure, which may influence whether they are experienced as restorative or attention-demanding. For example, background sounds such as steady traffic or cooking often have more continuous, predictable, and monotone patterns, whereas sounds designed to prompt action—such as alarms or bells—tend to be sharper, more salient, and acoustically structured to capture attention. As the reviewer notes, many sounds also occur within predictable daily patterns, and alignment with these expectations may further shape responses. In response, I have added a paragraph to the Future Research section discussing how circadian timing, predictability, acoustic structure, and functional purpose of sounds may jointly influence stress and attentional responses, and I propose examining whether alignment with expected daily sound patterns contributes to reduced stress. This addition appears in lines 635–645 of the manuscript.

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Thank you for this thoughtful comment. The present review primarily focuses on how the acoustic properties of sounds may trigger subconscious physiological and cognitive responses that influence stress, attention, and mental health. In this framework, reactions to sound are not assumed to arise from explicit judgments about sound sources (for example, a judgement that “cars are harmful”), but rather from lower-level auditory processing and learned associations with certain acoustic patterns. For instance, some anthropogenic sounds may share acoustic characteristics with naturally threatening sounds such as thunderstorms or animal distress calls, which could contribute to stress responses.

At the same time, I agree that contextual interpretation and learned associations - including cultural narratives, upbringing, and personal experiences - may influence how individuals perceive and respond to sound environments. In response to the reviewer's suggestion, I have expanded the Future Research section to address these issues. Specifically, I added a discussion of potential hypotheses explaining why certain sounds may be perceived as more beneficial or harmful (section 3.2, lines 454–479). I also expanded the discussion of how acoustic structure, meaning, and contextual interpretation may jointly shape responses to soundscapes and proposed research examining these mechanisms across different ages and cultural contexts (lines 510–531 and 577–594). Finally, I added discussion of how individual differences, including cultural background and personal experience, may moderate soundscape responses (lines 533–544).
Please see table 4 for a list of main points I have discussed in the future research section.

These additions aim to clarify that responses to sound environments may emerge from interactions between acoustic properties, subconscious processing, and contextual interpretation, and I highlight the need for future research to better understand these mechanisms.

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I want you to introduce another section into the manuscript that will enable a quantitative claim (see below). The chatgpt file with a more mathematical formalism is attached (you do not have to include mathematics if you don't want to).
This section will elevate your manuscript and add rigor from the viewpoint of mathematical falsifiability. Please make sure you agree with the content and then re-write into the manuscript.
The section follows:
3.2 Computational Framework for Soundscape Perception
Traditional soundscape research has largely relied on categorical distinctions, most notably the contrast between "natural" and "urban" environments, to explain differences in human cognitive and physiological responses. While this framework has been useful for organizing empirical findings, it may obscure a more fundamental principle: that human responses are driven not by the semantic identity of sounds, but by their underlying acoustic structure.
We propose a computational framework in which soundscapes are represented as structured signals that can be decomposed into a set of measurable acoustic features. These features include temporal predictability (the extent to which a sound follows stable, repeating patterns), spectral entropy (the degree of randomness in frequency content), harmonicity (the presence of organized tonal structure), and intermittency (the frequency and intensity of abrupt changes or bursts). Together, these properties capture the statistical and perceptual characteristics of sounds that are likely to be processed by the auditory system.
Within this framework, sounds are not assigned to discrete categories such as "natural" or "urban," but instead occupy positions within a continuous, low-dimensional perceptual space defined by these acoustic features. For example, sounds such as flowing water or steady rainfall tend to exhibit high predictability and low entropy, while disruptive sounds such as traffic or construction noise are characterized by higher intermittency and irregular temporal structure. Importantly, certain urban sounds—such as music or human voices—may share key acoustic properties with natural sounds, placing them in similar regions of this space and helping to explain their often-reported restorative effects.
This perspective provides a unifying explanation for inconsistencies in the literature. Studies that treat sound categories as homogeneous often overlook substantial variation within those categories. Not all natural sounds are calming, and not all urban sounds are harmful. By focusing on acoustic structure rather than labels, the proposed framework accounts for this variability and allows for more precise predictions of human response.
A key advantage of this approach is that it enables the use of machine learning models to learn mappings between acoustic features and human outcomes, such as stress, attention, and emotional state. By training models on large datasets of sound recordings paired with physiological and subjective measures, it becomes possible to identify which combinations of features are most

strongly associated with beneficial or harmful effects. This shifts soundscape research from descriptive comparison toward quantitative prediction.
Beyond prediction, the framework also enables causal testing through controlled manipulation of acoustic features. Rather than comparing entirely different sound categories, researchers can modify specific properties of a sound—such as increasing its predictability or reducing abrupt fluctuations—while preserving its overall identity. Observing how these targeted changes affect physiological and cognitive responses provides a direct test of underlying mechanisms.
Taken together, this framework reframes the central question of soundscape research. Instead of asking whether natural environments are inherently better than urban ones, it asks which acoustic features drive human responses and how those features can be optimized. This shift from categorical classification to feature-based modeling provides a foundation for more precise, mechanistic, and actionable approaches to designing sound environments that support human health and cognitive functioning.

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Thank you for this thoughtful suggestion. I appreciate you highlighting this part of my argument, as it was something I had mentioned but not emphasized as much as I could have. In response, I have developed this idea further and added a new section from lines 676-715 that focuses on a feature-based framework for understanding soundscapes. In this section, I highlight both the potential for computational approaches, such as modeling relationships between acoustic features and human outcomes, and the use of empirical experiments that isolate and manipulate specific acoustic features to test their effects.
I also appreciate the mathematical formalism you provided. While I recognize that it could add rigor, I did not include those specific formulations, as they were not something I derived myself and I would not feel comfortable presenting them as my own work.
Instead, I incorporated the underlying ideas in a way that fits the scope and style of the paper. I hope this revision better reflects the quantitative direction you suggested while remaining clear and accessible.
In addition, I have added sub-sub headings to section 3.3 Future Research Directions in order to organize research themes.

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Thank you for addressing my comments. Accepted.