Auditory Perception and Health Effects of High-Frequency Animal Repellers Across Age Groups

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Environmental pollution poses significant threats to ecological balance and human health, with noise pollution often overlooked despite its pervasive presence. High-frequency animal repellers, designed to deter wildlife through high-frequency sound, are widely used but may inadvertently affect human populations, especially those sensitive to high-frequency sounds. This study aims to assess the impact of ultrasonic animal repellers on human auditory perception and discomfort, focusing on how these effects vary across age groups. Participants from diverse age ranges were exposed to a high-frequency repeller emitting a frequency of 15 kHz, and their responses to auditory perception and discomfort were recorded. Results revealed that individuals under 50 were more likely to detect the sound, while those under 30 reported heightened discomfort. A significant decline in both perception and discomfort was observed with age, with older participants displaying overall lower levels of sensitivity. This study further explored the relationship between pre-existing hearing conditions and sound perception, finding that individuals with hearing issues were less likely to detect the high-frequency noise. These findings raise concerns about the unintended psychological and physiological effects of high-frequency deterrents, particularly on younger individuals and those with prior sensitivity to such sounds. This study calls for further research into the short-term and long-term impacts of high-frequency devices on human health and well-being.

Keywords: Noise pollution, Mechanical deterrents, High-frequency sound, Human auditory perception, Effects of high-frequency sound on human health

Introduction

Environmental pollution is a challenge that poses significant threats to our planet's ecological balance and human well-being. It encompasses various forms of contamination that adversely affect the environment and living organisms, with pollution manifesting in different types, such as air, water, soil, light, and noise pollution[1]. While much attention has been given to the former categories, noise pollution—defined as unwanted or disturbing sounds—often remains an overlooked yet pervasive environmental concern because it cannot be seen, tasted, or smelled[2], encompassing excessive or disruptive sounds that intrude upon the natural acoustic environment[3]. Sources of noise pollution vary widely, ranging from industrial machinery and transportation systems to animal repellent devices emitting high-frequency waves purportedly innocuous to humans, which have often been neglected.

Mechanical deterrents represent a novel approach in mitigating various gardening issues, particularly in deterring specific wildlife without impacting humans directly by emitting high-frequency sounds, which are defined as having frequencies between 8 kHz and 20 kHz[1]. Manufacturers advertise such devices as "silent to most humans"[4], revealing that parameters for the perception of high-frequency noises emitted are ambiguous.

Due to animal repellers installed in public spaces, many individuals have found these noises not only audible but also irritating.While previous research has extensively examined the efficacy of high-frequency deterrents on wildlife[5,6], limited studies have explored their impact on humans. Specifically, there is a lack of empirical evidence regarding whether these repellers remain inaudible to all humans and whether the perception of their emitted frequencies can be harmful. High-frequency noises possess the potential to induce distinct discomfort, often resulting in heightened irritation and difficulty concentrating due to their piercing and intrusive nature[7]. Therefore, while these deterrents aim to be inoffensive to humans, the potential repercussions for those sensitive to these frequencies warrant careful consideration and further exploration into their long-term effects on human health and behavior.

The proliferation of repellent devices and gaps in research have raised questions: are humans truly unaffected by these high-frequency devices? By examining the extent to which individuals across various age groups can detect high-frequency noises, this study aimed to provide empirical evidence on the unintended effects of these devices with regard to humans.

The study involved installing a high-frequency animal repeller in a relatively quiet location and recruiting pedestrians of various age groups to assess their auditory responses to the device. It was hypothesized that younger individuals are more likely to perceive high-frequency noises emitted by animal repeller devices and experience higher levels of discomfort compared to older individuals, with a decline in both perception and discomfort as age increases. Additionally, individuals with pre-existing hearing conditions and high-frequency exposure will demonstrate lower sensitivity to these sounds.

Results

Results indicated that the perception of high-frequency sound varied significantly by age. Younger participants were more likely to detect the sound emitted by the iMounTEK high-frequency animal repeller compared to older participants. The highest audibility was observed among the 10-19 age group (94%), followed closely by the 0-9 age group (92%). Audibility then steadily declined with age, dropping to 38% in participants aged 70 and older (Fig. 1). Participants who perceived the sound also reported varying levels of discomfort on a 5-point Likert scale. Discomfort was rated highest in the 10-19 age group (4.0), followed by the 0-9 age group (3.5) and the 20-29 age group (3.7). Discomfort ratings continued to decline with age, reaching 1.1 in the 70+ groups (Fig. 1).

Figure 1. *percentage of participants in each age group who reported hearing the high-frequency sound and their corresponding average discomfort ratings on a 1-5 scale*

Age Groups	Sample Size (n)	Heard the Sound (%)	Avg Discomfort Rating (1-5)
0-9	12	92	3.5
10-19	15	94	4.0
20-29	20	85	3.7
30-39	18	73	2.1
40-49	15	74	1.7
50-59	14	43	1.3
60-69	10	40	1.3
70+	8	38	1.1

Notably, the sharpest decline in perception occurred between the 40-49 and 50-59 age groups while that in discomfort occurred between the 20-29 and 30-39 age groups (Fig. 1a), suggesting a potential threshold where high-frequency sound becomes significantly less perceptible and irritating.

Statistical tests supported the observed trends. A Chi-square test (x^2=22.27, p=0.0023) confirmed a significant association between age and sound perception. An independent two-sample t-test (t=4.49, p=0.0144) indicated a significant difference in discomfort ratings between younger and older participants (Fig. 3).

A higher prevalence of pre-existing hearing conditions was noted in older participants, particularly aged 40 and above, where over 30% reported hearing issues (Fig. 2). A negative correlation (R=-0.7757, p=0.0239) was observed between hearing perception and pre-existing conditions, indicating that individuals with hearing conditions were significantly less likely to perceive the high-frequency sound (Fig. 3). Similarly, prior exposure to high-frequency sounds, which was most prevalent in the 40-69 age range, appeared to have a correlation to perception (R=-0.6424, p=0.0861), though it is weaker and not statistically significant.

Figure 1a. *combined visualization of hearing perception and discomfort ratings across different age groups*

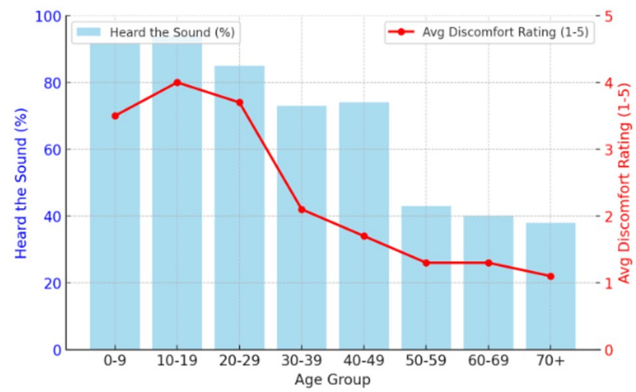

Figure 2. *percentage of participants in each age groups with pre-existing hearing conditions and their high-frequency sound exposure history*

Age Groups	Hearing Conditions (%)	High-Frequency Exposure (%)
0-9	8	0
10-19	6	6
20-29	10	20
30-39	11	17
40-49	33	27
50-59	36	43
60-69	20	30
70+	38	13

Discussion

The data suggest that high-frequency animal repellers are commonly audible to individuals under the age of 50, and the discomfort experienced by participants was remarkably higher in age groups below 30. Furthermore, individuals with pre-existing hearing conditions were less likely to detect the high-frequency sound, while previous exposure to the high frequencies did not appear to correlate with perception.

The discomfort reported by individuals under the age of 30 when exposed to high-frequency animal repeller devices high-

Figure 3. key statistical tests and their corresponding p-values (p<0.05), including the Chi-square test, independent two-sample t-test, and Pearson's correlation coefficient, analyzing perception, discomfort, hearing conditions, and high-frequency exposure

	Statistic	p Value
Chi-square (Perception)	22.27	0.0023
t-test (Discomfort)	4.49	0.0144
Pearson's R (Hearing Conditions)	-0.7757	0.0239
Pearson's R (High-Frequency Exposure)	-0.6424	0.0861

lights that these devices are not as harmless as they may seem. This raises concerns about the potential adverse effects on their health, given the high levels of discomfort that participants reported. Those residing near a yard equipped with an animal repeller might experience unforeseen ramifications on their health over time.

This study reinforces trends observed by Fletcher et al., where it was found that participants exposed to very high-frequency sound and ultrasound reported higher levels of discomfort compared to a 1 kHz reference stimulus. Additionally, it was also found that individuals who had previously experienced symptoms attributed to high-frequency noise, such as difficulty concentrating and annoyance, reported exacerbated effects during subsequent exposures when exposed to frequencies between 13.5 and 20 kHz, compared to a 1 kHz reference stimulus[8]. While these effects were more pronounced in those with prior sensitivity, the elevated discomfort ratings among the general population suggest that prolonged or repeated exposure could lead to the development of similar symptoms, indicating that even individuals without a history of sensitivity may be at risk of experiencing negative effects from high-frequency noise over time.

A broader review of literature, spanning from the 1960s to 2018, categorized the effects of low-frequency airborne ultrasound into auditory and non-auditory effects, including subjective, physiological, and thermal impacts. Historically, studies have shown that high-frequency exposure, when intense enough, can cause a syndrome marked by nausea, headache, vomiting, disturbed coordination, dizziness, and fatigue[9]. This aligns with findings in a study conducted in 2016, which posited that prolonged exposure to frequencies ranging from 8 to 20 kHz causes the same symptoms merely after a few minutes[1].

Moreover, a study examining adult individuals with dizziness and fatigue showed that such symptoms are associated with HRQL (Health-related Quality of Life), anxiety, and the ability to perform daily activities. Participants with dizziness reported worse HRQL and lower balance confidence, along with higher levels of anxiety, which may be exacerbated by fear of falling. This fear can lead to avoidant behaviors, isolation, and reduced participation in physical activities, further diminishing mental health and quality of life[10]. As discussed above, exposure to uncomfortable high-frequency noises from deer repellent devices may induce consequent feelings of fatigue and dizziness, potentially posing more serious health complications to individuals. Additionally, given that as many as 25% of dizziness cases have no clear medical cause[11], the same could apply to discomfort caused by such devices, leading to psychological stress and reduced well-being due to the lack of a clear explanation for the source of the distress. This underscores the importance of considering both the physical and psychological impacts of high-frequency exposure in residential environments.

The methodology of this study, however, may have limitations due to the relatively small sample size obtained, particularly for certain age groups such as 0-9 and 41-50. The absence of longitudinal data means that the study cannot assess the effects of prolonged exposure to high-frequencies. While the study accounted for some confounding variables, individual hearing thresholds were not pre-tested due to time and resource constraints, which could influence perception results. Furthermore, the study relied on self-reported discomfort levels, which could be affected by subjective bias, and the use of a binary "heard vs. not heard" metric may not fully capture variations in perception.

It is imperative to conduct comprehensive research specifically targeting the short-term and long-term impacts of these frequencies on the mental and emotional health of age groups under 30, especially considering the scarcity of substantial recent research on the implications of high-frequency noises on human well-being[9].

Methodology

The experiment was conducted on a selected sidewalk area with acceptable ambient noise interference, avoiding heavy pedestrian traffic, construction, or other distinct auditory distractions. To objectively confirm low background noise levels, ambient sound pressure levels (dB SPL) were measured using a calibrated sound meter every 20 minutes throughout the experiment. The measured ambient noise was averaged to be 45 dB SPL, which is within the expected range for a quiet suburban environment and unlikely to affect high-frequency sound perception[12].

The iMounTEK high-frequency animal repeller was used in the experiment, emitting frequencies adjustable between 13.5-45.5 kHz[13]. The specific frequency used during the testing was 15 kHz, which was the default setting of the device. A calibrated frequency analyzer was utilized to verify the emitted sound spectrum, ensuring no unintended lower-frequency harmonics influenced participant responses.

Participants were recruited using a stratified random sampling method to ensure diverse age representation across the following groups: 0-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70+. Recruitment occurred at different times of the day to prevent potential bias related to pedestrian demographics. To ensure true randomness, a systematic sampling approach was used, selecting every fifth passerby who met eligibility criteria. If a selected passerby declined to participate, the next passerby was not approached immediately; instead, counting resumed as if the rejected individual had participated. For example, if the fifth person declined, the next approached participant would be the tenth passerby, maintaining the systematic interval.

Informed consent was obtained orally from all participants after a clear explanation of the study's purpose. Given the ethical considerations regarding minors (0-9 years), explicit parental consent was secured before participation. Additionally, participants with known hearing impairments, history of occupational noise exposure, or ear-related conditions were documented to account for potential confounding variables.

The experimental protocol involved individual positioning of participants at a designated distance from the animal repellent device (5 meters). Each participant was exposed to the device for a predetermined duration of 30 seconds based on concerns that brief exposure may not capture the full auditory impact. Participants were blindfolded to eliminate visual bias and minimize placebo effects. Testing conditions were randomized by alternating between the device being on and off in a control condition, with participants unaware of whether they were being exposed to ultrasound or silence. Participants were immediately presented with a few questions that obtained information about whether they heard a high-pitched noise, whether they experienced discomfort (rated on a 5-point Likert scale; 1=No discomfort, 5=Extremely irritating), their age, their known hearing conditions, and prior exposure to high frequency sounds (e.g., workplace noise).

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