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Individual and Cultural Differences in Sound Perception: An Exploratory Study

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Abstract

Most studies on sound perception use a two-dimensional arousal–valence model, plotting responses along pleasant–unpleasant and calm–excited scales. Despite being a valuable method, it oversimplifies auditory experience, often neglecting links to shapes, colours or memories. Moreover, most research on sound perception has focused on participants from Western, Educated, Industrialised, Rich, and Democratic (WEIRD) societies, leaving many cultures understudied. For example, little research has examined how Algerians experience sounds. Similarly, uncommon sound types such as infrasound or recordings from space have received negligible attention. This study explores how Algerian and international participants perceive a diverse set of sounds, considering not only emotions but also sensations, memory recall, and cross-modal associations, through testing the influence of neurodivergence, musical training, age and gender. An online survey was conducted among a diverse sample (N=94) with strong representation from Algeria. Participants were asked to listen to ten sound clips and report their experiences. The analysis shows low awareness of neurodivergence in Algeria, while geophonic and classical sounds more often trigger memory recall. Neurodivergent participants express greater tolerance for low-frequency sounds and also exhibit distinct colour–shape mappings along with stronger musical training. These results suggest that cultural background, neurodivergence, and musical training all influence how people perceive sound. Instead of relying solely on traditionally “calming” sounds, therapies, educational programmes, and learning environments, they could benefit from more personalised approaches that consider unconventional frequencies and textures, which may be particularly meaningful or enjoyable for certain groups.

Keywords: Sound perception, culture, neurodivergence, musical training, cross-modal associations

Individual and Cultural Differences in Sound Perception: An Exploratory Study

Sound is a vital channel for communication in the human experience. It is a mechanical wave that is defined by its frequency, amplitude and wavelength. Yet, its perception is far from a passive reception of these vibrations. In fact, the journey of a sound wave from its source to our conscious experience is one of the most intriguing transformations. Upon reaching the auditory system, this complex waveform is deconstructed into neural signals, and this raw data is then processed through neural networks. It shifts from simple mechanical oscillations into a complex reaction shaped by cognition, emotion and cultural

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context (Oxenham, 2017; Herre & Dick, 2019). Understanding how people perceive sounds requires a simultaneous examination of multiple dimensions.

For decades, the dominant framework for studying emotional responses to sound has been the arousal-valence model (Russell, 1980). This model plots subjective experience along orthogonal axes of arousal (calm to excited) and valence (pleasant to unpleasant), which itself is a valuable tool for comparing emotional responses. Nevertheless, its widespread use has come at a cost since it oversimplifies auditory perception. For instance, it cannot easily capture the vivid personal memory triggered by a specific piece of music or the well-documented cross-modal correspondence demonstrated by the bouba-kiki effect, wherein people overwhelmingly associate rounded shapes with sounds like “bouba” and spiky shapes with sounds like “kiki” (Gomez et al., 2013).

A further critical limitation of the existing literature is its overwhelming reliance on participants from Western, Educated, Industrialised, Rich and Democratic (WEIRD) societies, only representing a thin slice of the global psychological diversity (Henrich et al., 2010). This bias severely constrains our understanding of how humanity across the globe perceives sound, with culture being a powerful factor in how it is interpreted. By the same token, Lee et al. (2023) explored emotional responses to Hangul phonemes in Korean and Chinese women and found significant cultural differences in both arousal and valence ratings. Koreans tended to show higher arousal and varied valence patterns compared to the Chinese participants. This indicates that even at the level of individual speech, culture impacts perceived emotions, which proves that research limited to WEIRD populations fails to capture the full diversity of the emotional spectrum of sound.

In Algeria, publicly available datasets on perception and psychology are almost nonexistent, and sound-related studies remain scarce, limiting the development of locally relevant applications in therapy, education and urban design. A few studies have begun to address this gap. For example, research has been conducted on urban soundscapes in coastal cafés using binaural recordings and surveys to analyse how sounds affect social comfort, particularly post-COVID-19 (Berkouk et al., 2023). Other studies examined how Algerian dialect speakers adjust their speech in loud environments to improve intelligibility (Ykhlef & Bouchaffra, 2022), as well as the Sawt El-Djazaïr project, which created a voice database covering 12 regional dialects to support speaker recognition technology (Zergat, 2023). Despite these contributions, the broader and more nuanced ways in which Algerians perceive sound in daily life have not yet been explored. The country still falls short of generating the data needed to inform inclusive practices with regard to sound perception.

At the same time, a limited awareness of neurodivergence further restricts opportunities for developing inclusive approaches to sound perception and its social implications. It is yet another gap reflecting a broader issue in Algerian psychology, which has historically depended on Western models that do not necessarily align with the local culture. Consequently, they often fail to incorporate the distinctive social representations and lived experiences of the Algerian people. This calls for establishing more culturally grounded psychological frameworks capable of better understanding local realities (Mosbah, 2022).

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This study addresses the lack of diverse sound perception datasets by collecting responses from both Algerian and Western participants. More precisely, it examines how participants perceive a variety of both novel and familiar sounds, testing emotional, cognitive, and cross-modal responses (such as memory recall, shapes and colours). It also considers how individual factors, such as musical training, personality traits, and neurodivergence relate to the responses. The research questions guiding this study are as follows: (1) How do Algerian participants differ from international participants in their emotional and cross-modal responses to different sound types? (2) Which categories of sounds most strongly trigger emotional reactions, memories or other cross-modal associations? (3) How do factors such as neurodivergence, musical training, age and gender shape the perception of sounds?

Together, these queries guide an exploratory investigation into how cultural and individual factors shape the perception of a broad range of sound types.

Methods

Participants

The recruitment approach for this online study was the snowball sampling method (Baltar & Brunet, 2012). The link to the survey was shared across multiple social media platforms including Facebook groups focusing on psychology and music, Discord servers and Reddit communities. It was also shared through academic networks in Algeria and Poland, as well as through personal contacts to reach a wider age range. The statistics were as follows:

Table 1. Participant Characteristics

Category	Subcategory	N (%)
Total responses	Completed	83 (56.1%)
	Dropouts	65 (43.9%)
Country	Algeria	97 (65.54%)
	Germany	14 (9.46%)
	Poland	12 (8.11%)
	France	7 (4.73%)
	United States	6 (4.05%)
	Canada	3 (2.03%)
	Netherlands	2 (1.35%)
	Spain, Brazil, South Korea, Romania, Malaysia, Saudi Arabia, Sweden	1 each (0.68% each)
Age	18–24	56 (37.84%)
	25–34	47 (31.76%)
	35–44	34 (22.97%)
	45–54	4 (2.70%)
	55+	7 (4.73%)
Gender	Male	77 (52.03%)

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	Female	70 (47.30%)
	Non-binary	1 (0.67%)

Materials

Sound stimuli: Ten carefully selected sounds were played to the participants. The goal was to include both familiar and unfamiliar sounds to get broader perceptions.

Table 2. Sound Stimuli Characteristics

#	Stimulus Name	Type	Duration	Source
1	Algorithmic Ambient	Synthetic	15 s	Generated with Max/MSP
2	Classical Music	Musical	15 s	Tchaikovsky, "Swan Lake" (excerpt)
3	Rock/Metal	Musical	15 s	Metallica, "Enter Sandman" (excerpt)
4	18 Hz Tone	Infrasound	15 s	Synthesised
5	Space Sounds	Electromagnetic	15 s	NASA recordings of Saturn emissions
6	Overtone Singing	Vocal	15 s	Tuvan throat singing (Batzorig Vaanchig)
7	7.83 Hz Tone	Resonance	15 s	Schumann resonance
8	Microtonal Music	Musical	15 s	Sevish, "Gleam" (excerpt)
9	Industrial Sound	Soundscape	15 s	Factory field recording
10	Geophony	Environmental	15 s	Geyser field recording

Survey measures

The survey gathered several types of information.

Table 3. Collected data. Personality traits were measured using the 10-item Big Five Inventory (Rammstedt & John, 2007)

Variable	Components
Demographics	Age, gender, nationality, native language
Music Expertise	Formal training (Yes/No); Years of practice (1–2, 3–5, 6–10, 10+); Music theory knowledge (None, Beginner, Intermediate, Advanced)
Personality	BFI-10 inventory (10 items → Big Five traits: Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism); responses on a 5-point Likert scale
Neurodivergence	Self-report of diagnosis or suspicion (Yes/No/Unsure)
Sound Responses	Emotion (10 options), physical sensations (13 options), memory recall (Yes/No), colour association (17 options), shape association (14 options)

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Cultural Background	Nationality and native language
Final Feedback	Most liked sound, most disliked sound, most stood out sound; open-ended comments

Procedure

-Participants first completed demographic questions, followed by musical background, neurodivergence, and finally personality measures.

-Participants were asked to use headphones and remain in a quiet environment for better sound perception, though this could not be fully verified.

-The 10 sound clips were presented in a randomised order to reduce order effects and prevent bias.

-After each sound, participants completed rating questions to describe their reactions to each
sound clip.

Data Analysis

Data Cleaning

The dataset was analysed using Python (v3.13) in a Jupyter Notebook environment (Kluyver et al., 2016), with the following libraries: Pandas (McKinney, 2010), NumPy (Harris et al., 2020), Matplotlib (Hunter, 2007), Seaborn (Waskom, 2021) and Scikit-learn (Pedregosa et al., 2011).

Participants who completed only demographic information or answered less than 50% of the survey were dropped from the dataset. For the remaining participants with few missing values, an Iterative Imputer with RandomForestRegressor from Scikit-learn was adopted (Pedregosa et al., 2011). This later predicts each missing value based on previously given information. Subsequently, this operation contributed to valuable, partially completed responses.

Table 4. Data Cleaning Process

Step	Initial Count	Final Count	Action Description
Total responses	148	148	Raw data
Completion filter	148	83	Removed responses with less than 50% completed
Missing value imputation	83	94	Imputed occasional missing

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			values using Iterative Imputer

Variable Transformation and Scoring

-Some variables were harmonised for consistency. Nationalities were standardised to their two-letter ISO codes.

-Native language data showed high collinearity with nationality and was therefore excluded from the dataset to avoid redundancy.

-A music expertise score was calculated from three ordinal measures as described below in Table 5.

Table 5. Music Expertise Score

Component	Response Options	Numerical Coding
Formal Training	Yes/No	1/0
Years of Practice	1-2/3-5/6-10/None	1/2/3/4/0
Theory Knowledge	Beginner/Intermediate/Advanced/None	1/2/3/0

The score was then calculated using the formula:

Music score = 0.4 × (training) + 0.3 × (years) + 0.3 × (theory)

The weighting here emphasises formal training while also considering the duration of practice and theoretical knowledge (Wöllner et al., 2011). The result was min–max scaled to 0-5 range for data analysis.

-For personality traits, scores were calculated according to BF-10 scoring protocols. For each trait, the results of each question were averaged to create scores ranging from 1-5.

-Due to the limited sample size within specific neurodivergence conditions, responses from the neurodivergence categorisation were aggregated into three larger classifications, as shown in Table 6:

Table 6. Neurodivergence Categorisation

Aggregated Category	Original Response Options	Numerical Coding
Confirmed or self-identified neurodivergence	ADHD, Autism Spectrum Disorder, Anxiety, etc.	1
No neurodivergence reported	No diagnosis	0
Unsure	I don’t know	-1

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-Countries were aggregated into three cultural groups to maintain statistical power and allow clearer comparisons between Algerian and non-Algerian participants, as follows:

Table 7. Cultural Group Aggregation

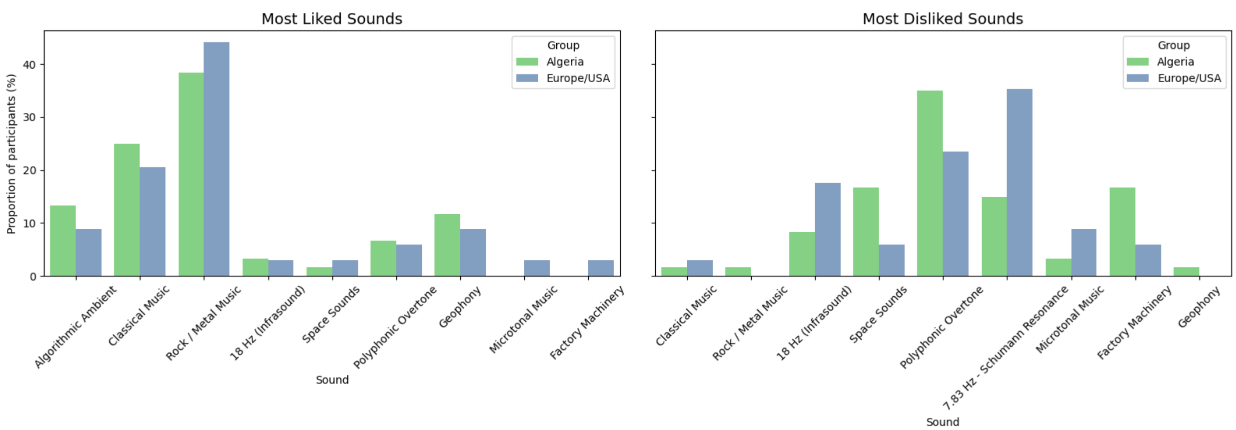
Region	Count	Percentage (%)
Algeria	60	63.83
EU/USA	30	31.91
Asia	2	2.13
Oceania	1	1.06
Latin America	1	1.06

Ethics

This survey was conducted in accordance with basic ethical principles. All participants provided digital consent prior to participation. The data collection ensured full anonymity, with no personal information such as IP addresses or geographic locations being collected or stored.

Results

Figure 1. Comparison of Most Liked and Disliked Sounds by Cultural Group



Both Algerian and European/US participants showed a strong preference for Rock/Metal music (Algeria: 38.3%; Europe/USA: 44.1%) and Classical music (25.0% and 20.6%, respectively). Notably, these two categories accounted for nearly two-thirds of all "most liked" selections in both cultural groups (Algeria: 63.3%; Europe/USA: 64.7%). However, the sounds most frequently cited as disliked diverged: Algerian participants most disliked polyphonic overtone singing (35.0%), followed by space sounds and factory machinery (16.7% each). In contrast, European/US participants most disliked the 7.83 Hz Schumann resonance tone (35.3%) and the 18 Hz infrasound (17.6%), indicating a stronger aversion to low-frequency stimuli. Algerian participants showed greater tolerance for these low-frequency tones.

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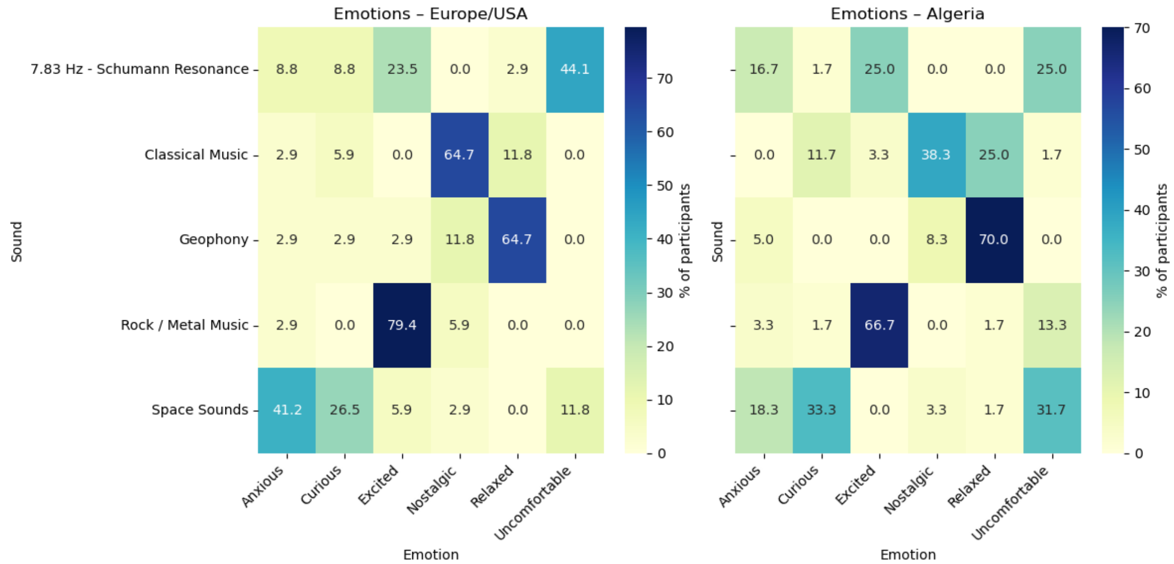
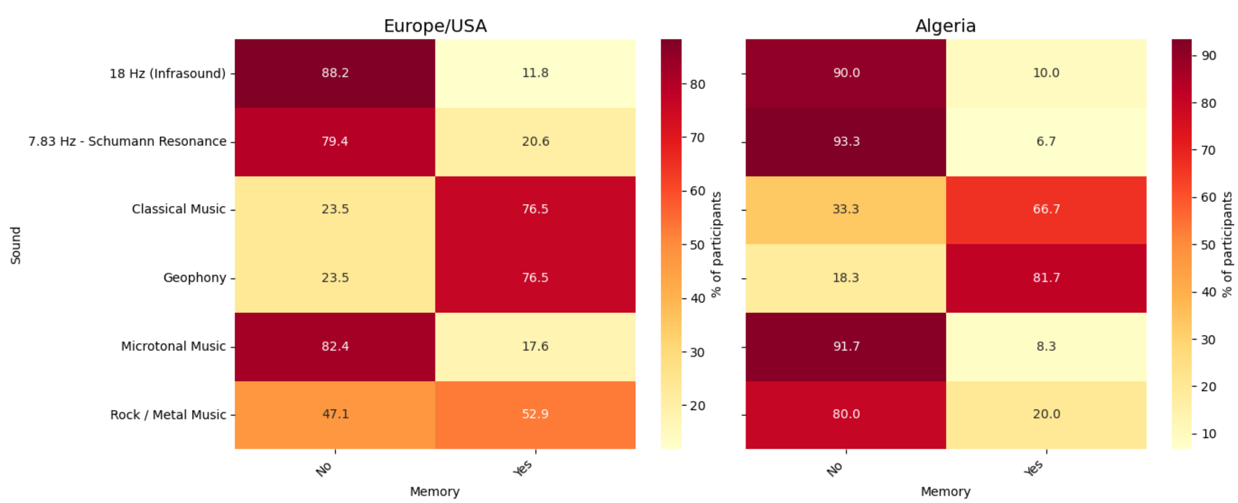
Figure 2. Emotions for Selected Sounds by Cultural Group



Both groups predominantly felt “excited” by rock/metal music (Europe/USA: 79.4%; Algeria: 66.7%) and “relaxed” by geophony (64.7% and 70.0%, respectively). Classical music evoked stronger “nostalgia” in the Europe/USA group than in the Algerian groups (64.7% vs. 38.3%). Notable differences emerged for unconventional sounds: space sounds provoked “anxiety” in the Europe/USA group (41.2%) but “curiosity” in the Algerian group (33.3%). Furthermore, the 7.83 Hz Schumann resonance was primarily “uncomfortable” for both, but this feeling was more pronounced in the Europe/USA group (44.1% vs. 25.0%).

Figure 3. Memory Recall for Selected Sounds by Cultural Group



Geophony and classical music were the most potent triggers for memory in both cultural groups (Europe/USA: 76.5% for both sound categories; Algeria: 81.7% and 66.7%,

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respectively). Conversely, the low-frequency tones (18 Hz, 7.83 Hz) and microtonal music rarely triggered memories (<20% recall for both groups). A notable cultural difference emerged for rock/metal music, which triggered memories in over half of the Europe/USA participants (52.9%), but only in one-fifth of Algerian participants (20.0%).

Table 8. Colour Associations for Selected Sounds by Cultural Group

Sound Stimulus	Top Colour (EU/USA	% (EU/USA)	Top Colour (Algeria)	% (Algeria)
Geophony	Blue	41.2	Blue	28.3
Space Sounds	Black	38.2	Black	51.7
Rock/Metal Music	Black	41.2	Black	35.0
18 Hz Infrasound	Grey	20.6	None	33.3

Both groups strongly associated geophony with the colour blue (Europe/USA: 41.2%; Algeria: 28.3%), space sounds with black (38.2% and 51.7%, respectively), and rock/metal music with black (41.2% and 35.0%). For more abstract sounds, associations were less consistent.

Table 9. Physical Sensations for Selected Sounds by Cultural Group

Sound	Reported Sensations	Range/Group Difference
Low-frequency tones, (7.83 Hz, 18 Hz)	Headache (up to 18.3%), Muscle tension (up to 25.0%)	Consistent across groups → linked to discomfort
Geophony	Floating (20.626.7%), Sleepiness (16.723.5%), Chest heaviness	Stronger chest heaviness in Algerian group (30.0%) vs Western group (17.6%) → cultural nuance
Rock/Music	Increased heart rate (25.0–26.5%)	Similar intensity across groups → associated with arousal

Low-frequency tones consistently cause discomfort (headaches and muscle tension), while geophony provokes floating, sleepiness, and chest heaviness, more widely reported by Algerians than Westerners.

Figure 4. Neurodivergence by Cultural Group

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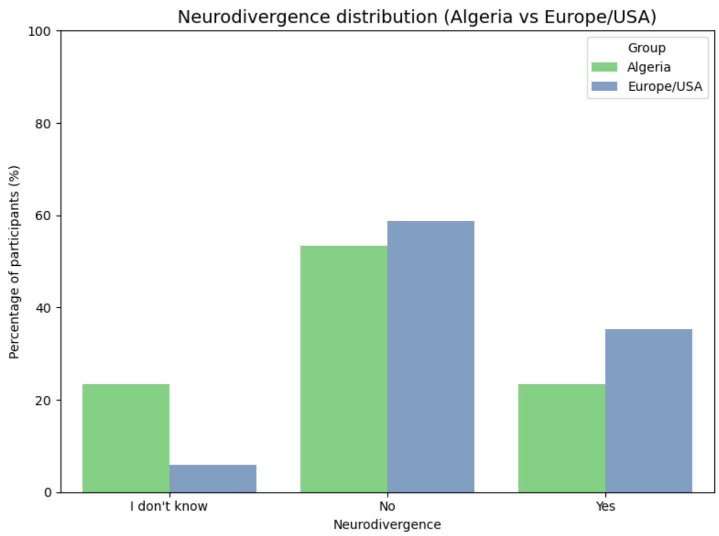
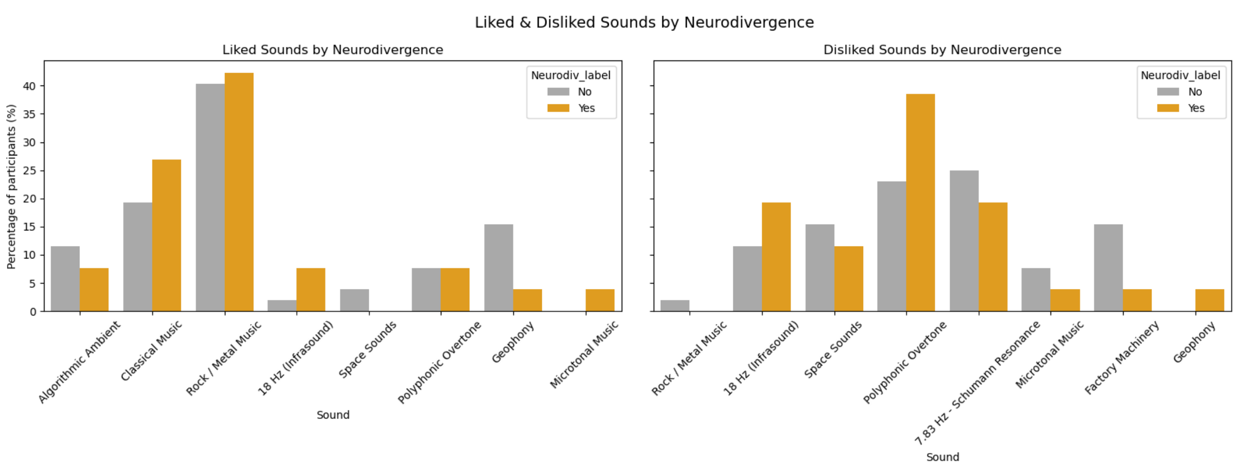


Significant differences emerged in neurodivergence awareness between cultural groups. Algerian participants were more likely to report uncertainty about their neurodivergence status ("I don't know": 23.3%) compared to Europe/USA participants (5.9%). Correspondingly, the proportion of participants identified as neurodivergent was higher in the Europe/USA group (35.3%) than in the Algerian group (23.3%). This pattern supports observations of lower awareness and diagnostic availability for neurodivergence in the Algerian context.

Figure 5. Liked and Disliked Sounds by Neurodivergence



The analysis of sound preferences by neurodivergence status revealed distinct patterns, particularly for low-frequency stimuli. While both groups shared a preference for rock/metal and classical music, neurodivergent participants demonstrated greater tolerance for low-frequency sounds. The 18 Hz infrasound was listed as a favoured sound by 7.69% of neurodivergent participants compared to only 1.92% of neurotypical respondents. The 7.83 Hz Schumann resonance was the primary dislike for neurotypical participants (25.00%), but ranked lower for neurodivergent participants (19.23%).

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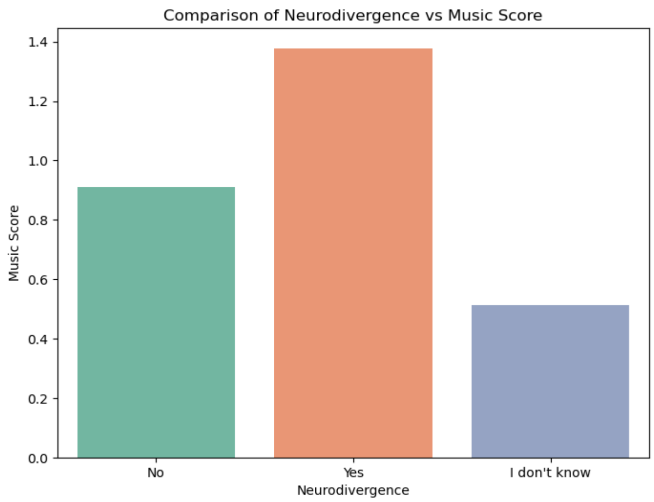
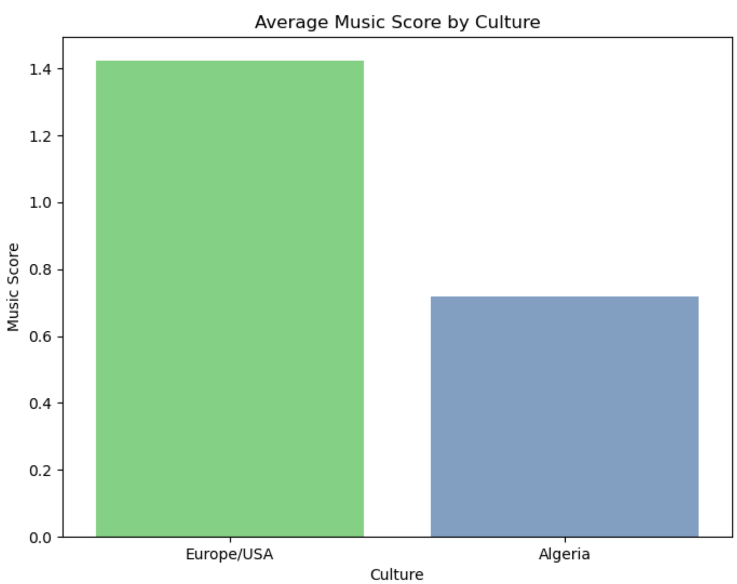
Neurodivergent volunteers indicated a stronger aversion to polyphonic overtone singing (38.46% vs 23.08%).

Figure 6. Music Score by Neurodivergence



Participants who were identified as neurodivergent also reported higher levels of musical training compared to neurotypical participants and those unsure of their status.

Figure 7. Music Score by Cultural Group



The Europe/USA group demonstrated higher levels of musical training, with a mean music expertise score nearly double that of the Algerian group (1.42 vs 0.72).

Figure 8. Music Score by BFI-10

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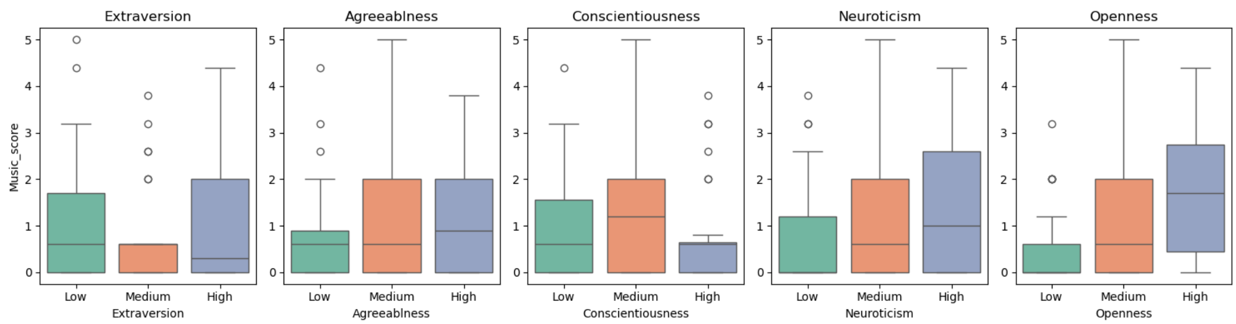

Respondents scoring higher in openness and neuroticism reported greater musical training. The category of volunteers with higher conscientiousness reported the lowest musical training.

Additional observations: Neurodivergent participants were more likely to form specific colour associations (e.g., silver for 18 Hz infrasound) for abstract stimuli that neurotypical participants often left unassociated.

Discussion

This exploratory study set out to map the complex terrain of sound perception beyond traditional methods, with a specific focus on the under-researched Algerian society. Investigating a diverse set of sounds allows us to reveal that auditory experience is not universal but is deeply shaped by an interplay of cultural background, neurodivergence, musical expertise and many other traits.

The initial research question investigated cultural differences between Algerian and international participants. The shared remarkable preference for rock/metal and classical music across groups suggests that certain musical structures, chiefly popular ones, may consistently evoke high-arousal, positive valence responses regardless of cultural background. Similarly, the strong association of geophony with relaxation and the colour blue point to a potential cross-cultural, biologically rooted response to naturalistic sounds (Buxton et al., 2021). However, differences in reactions to unconventional sounds are distinctly revealing. Furthermore, the greater tolerance and curiosity towards low-frequency infrasound and space sounds among Algerian participants contrasted with a stronger aversion and anxiety reported by the Europe/USA group. Additionally, it shows that exposure to scientific narratives plays a significant role in shaping the perception of unfamiliar sounds. This aligns with the concept of “semantic mediation,” in which the meaning assigned to a sound influences its emotional impact (Gao et al., 2023). In the same line of thought, the fact that rock/metal music triggered memories in far more European/US participants also reinforces that the link between memory and sound is culturally conditioned.

Memory recall was the strongest for geophony and classical music in both groups, which demonstrates the role of familiar environmental sounds in memory recall (Schulkind et

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al., 1999). However, rock/metal music evoked more memories among Western participants, likely due to differences in everyday listening practices and cultural integration of this genre.

The analysis of neurodivergence adds another dimension to the study's findings. For instance, neurodivergent participants demonstrated greater openness to unconventional sounds, including low-frequency tones, and were more likely to form specific colour associations with abstract auditory stimuli. Such cross-modal tendencies are consistent with findings on sensory processing differences and synesthetic experiences in autism and ADHD (Ward et al., 2017). In addition, the higher levels of musical training among neurodivergent respondents also indicate that music provides a structured and expressive outlet for individuals with heightened auditory sensitivity.

Additionally, differences in awareness of neurodivergence itself highlight a broader social issue. Algerian participants were more likely to be unsure of their neurodivergence status. This fact clearly indicates diagnostic inaccessibility and limited cultural discourse around neurodiversity in North Africa. This disparity aligns with global reports of uneven diagnostic recognition, specifically in non-Western contexts (Mosbah, 2022).

Taken together, these observations suggest that sound perception is not merely biological but is filtered through culture, memory, training, neurodivergence and many other traits. Applications in therapy, education, and AI-driven sound design should take these factors into account, moving away from universalist models of auditory preference and toward more personalised and culturally inclusive approaches.

Potential applications that could be extracted from this study include:

-Personalised music therapy: Instead of only using "calm" music, therapists can adapt soundscapes to individual profiles (e.g., neurodivergent people may respond better to algorithmic or repetitive patterns).

-Learning & memory enhancement: Pairing sounds with shapes/colours (cross-modal associations) may improve memory retention in education.

-Cross-cultural counselling: Therapists working with multicultural populations can adapt sound-based interventions according to cultural sound preferences.
Example: In Algeria, incorporating traditional instruments or desert soundscapes might resonate more deeply than Western piano music.

Illustrative comments from our participants:

"The test was well-structured, but I think it would be interesting to explore how blind individuals perceive sound and colour more accurately than sighted people. Their enhanced auditory processing could provide valuable insights." (Participant, Algeria).

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“Schöne Rhythmen und komponierte Lieder, bleiben länger im Gedächtnis und man hat dann auch im Alltag mehr die Lust dazu etwas aus dem Bauch heraus zu singen, da man sich an solche Lieder deutlich besser erinnert und man viel mehr körperliche Emotionen wahr nimmt.” [translated from German: “Beautiful rhythms and composed songs stay longer in memory, and in everyday life one feels more like singing spontaneously, because such songs are remembered more clearly and evoke stronger bodily emotions.”] (Participant, Germany).

“I usually associate images or scenes instead of just shapes that are abstract with the sounds that were presented.” (Participant, USA).

“Niektóre dźwięki były denerwujące, ale takiej odpowiedzi nie było do wyboru.” [translated from Polish: “Some sounds were annoying, but that option was not available to choose.”] (Participant, Poland).

“Cette expérience m’a donné l’impression qu’elle pouvait révéler certains traits de personnalité et les émotions liées aux difficultés de la vie quotidienne.”
[translated from French: “This experiment gave me the impression that it could reveal certain personality traits and the emotions linked to everyday challenges.”] (Participant, France).

Limitations

Like any exploratory study, this work has several limitations that should be kept in mind. The number of participants was relatively small. As recruitment was done through personal networks and social media, the sample cannot be considered fully representative. The survey was distributed in multiple languages, which may have introduced slight differences in how questions were understood, and the fixed answer options did not always capture the full range of reactions. For instance, some participants noted their open-ended feedback. Another important point is that the study relied entirely on self-report data, without laboratory materials or controlled listening conditions, which limited the precision of the findings. In addition, while the collected dataset is eminently multidimensional, the focus was solely on the information most relevant to the presented research questions. Other dimensions remain unexplored, but the full dataset could be made available for further analysis or educational use. Finally, although the results highlight meaningful findings, these observations remain preliminary and should be followed up with larger and more balanced samples.

Conclusion

This study demonstrates that sound perception is a richly layered experience that extends far beyond the traditional arousal–valence model. By focusing on an understudied population and incorporating a diverse set of sounds and response dimensions, the outcomes have uncovered a complex interplay of cultural, cognitive, and individual factors.

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The findings clearly indicate that cultural background significantly shapes how sounds are interpreted, with Algerian participants showing distinct patterns of tolerance and association compared to Western participants. Furthermore, individual neurotype emerged as a powerful influence. The limited awareness of neurodivergence within the Algerian sample itself highlights a critical area for future research and public health consideration.

Ultimately, these results argue against a one-size-fits-all approach to sound in applied settings. Instead, they advocate for more personalised and culturally attuned practices in fields such as sound therapy, education, and urban design. By applying this, they can move toward creating soundscapes that are not only more effective but also more inclusive and meaningful for all.

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