Supplementary materials for "Enhancing museum experiences: Using immersive environments to evaluate soundscape preferences"

Milena J. Bem,[1, a)] Samuel R.V. Chabot,[2] Vic Brooks,[2] and Jonas Braasch[2]
[1] *School of Architecture, Rensselaer Polytechnic Institute, Troy, New York 12180, United States*
[2] *Curtis R. Priem Experimental Media and Performing Arts Center (EMPAC), Rensselaer Polytechnic Institute, Troy, New York 12180, United States*

©2024 Acoustical Society of America. [http://dx.doi.org(DOI number)]

[XYZ] Pages: 1–12

I. VISUAL STIMULI AND CONGRUENT SOUNDS FOR EACH MUSEUM EXHIBITIONS

This supplementary material provides further details on two essential aspects of this research: the panoramic photos used as visual stimuli for the experiments and the sounds used as congruent maskers in the "Congruent" scenario for each museum exhibition. First, the visual stimuli consisted of 360° panoramic images captured in 15 museum rooms, documented with the permission of each museum. Second, the "Congruent" scenario is a virtual soundscape created by combining sounds congruent with each exhibition layered over the original museum soundscape recorded in each room. Each sound was chosen to align with the thematic content of the exhibitions, and this supplementary material discusses the rationale behind each sound's choice.

A. Hessel Museum of Art – Fuga exhibition

Within the "Fuga" exhibition (Figure 1), bird sounds were chosen as the congruent auditory element. Specifically, a field recording titled "birds at a watering hole, Madumbalai National Park, Tamil Nadu, late afternoon with mynahs, barbets, parakeets, bulbuls, and crickets" (BBC, 1998) was selected (See Figure 2 for the spectrogram). This sound choice complements the exhibition's figurative depictions of birds. It evokes the intimacy of domestic spaces, aligning with the curatorial goal of crafting a room in a home where people come and go.

FIG. 1. Hessel Museum of Art – Fuga. The author took the photograph with permission from the museum's art curator. The image shows a key exhibition room where soundscapes were tested.

B. Hessel Museum of Art – Gorgeous, Thrilling, Spectacle exhibition

For the "Gorgeous, Thrilling, Spectacle" exhibition (Figure 3), the instrumental track "Fela Kuti and De La Soul: Trouble In The Water" (Soul, 2011) (See Figure 4 for the spectrogram) was selected as a congruent masker due to its congruence with the thematic focus and intended atmosphere. The fusion of Fela Kuti's Afrobeat and De La Soul's hip-hop influences in the instrumental track contributes to its rhythmic and energetic grooves, aligning with the essence of Afrobeat and funk genres deeply rooted in Black culture. These musical elements can enhance the exhibition's intent to highlight the significance of adornment, self-care, and self-presentation within Black communities.

[a)] jonasm@rpi.edu

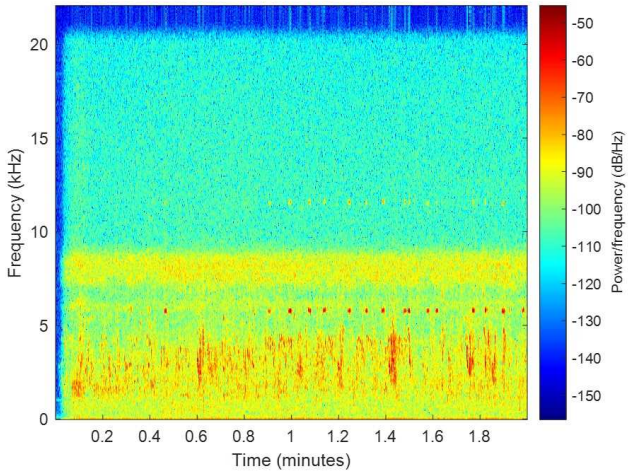

FIG. 2. Hessel Museum of Art — Fuga. Spectrogram of the "Congruent" soundscape: bird sounds from a field recording titled "Birds at a watering hole, Madumbalai National Park, Tamil Nadu" (BBC, 1998).

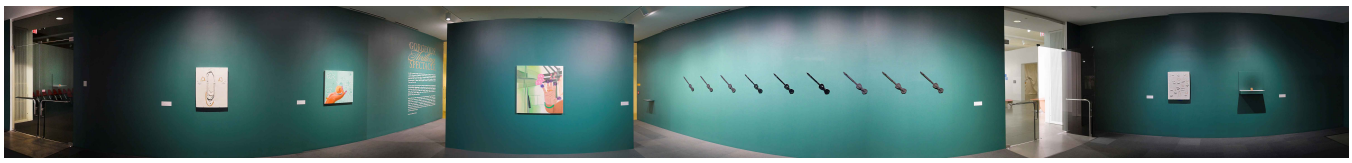

FIG. 3. Hessel Museum of Art – Gorgeous, Thrilling, Spectacle. The author took the photo with the permission of the museum's art curator.

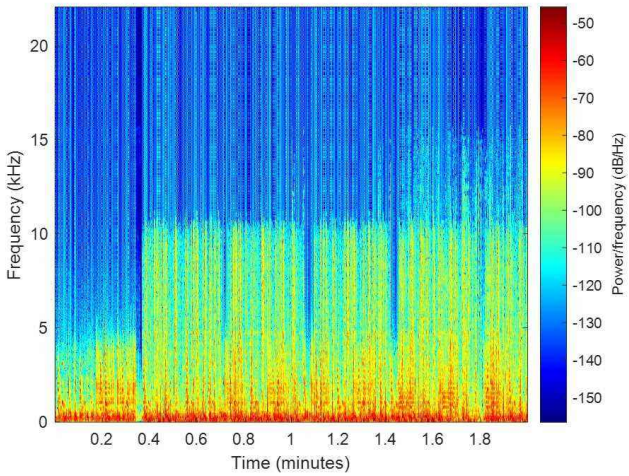

FIG. 4. The Hessel Museum of Art – Gorgeous, Thrilling, Spectacle. Spectrogram of the sound used in the "Congruent" soundscape: the instrumental track "Fela Kuti and De La Soul: Trouble In The Water" (Soul, 2011).

C. MASS MoCA – Joe Wardwell: Hello America: 40 hits from the 50 states exhibition

The Hello America exhibition (Figure 5) draws inspiration from Negativland's composition "I Still Haven't Found Snuggles" which incorporates a sample of U2's song "I Still Haven't Found What I'm Looking For." This musical reference influenced the selection of the instrumental version of U2's song (The Hit Co., 2013) as a sound in congruence

with the exhibition (See Figure 6 for the spectrogram), as this song can evoke a contemplative and introspective mood that resonates with the exhibition's conceptual framework.

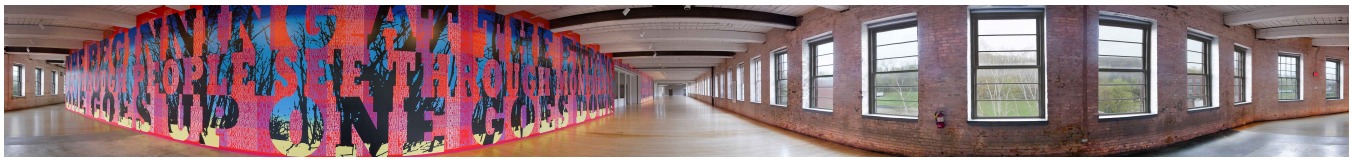

FIG. 5. MASS MoCA – Joe Wardwell: Hello America: 40 hits from the 50 states. The author took the photo with the permission of the museum's art curator.

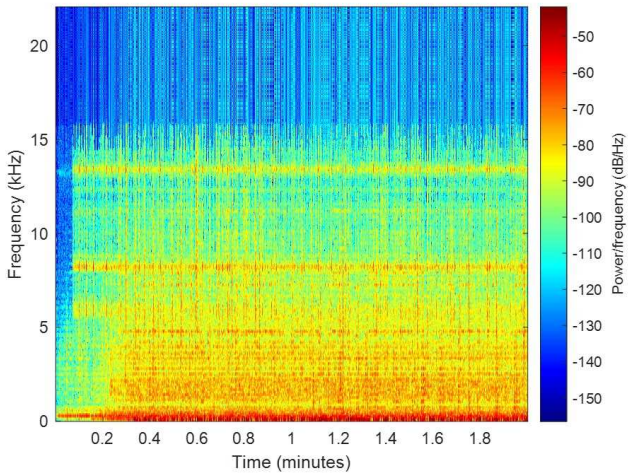

FIG. 6. MASS MoCA – Joe Wardwell: Hello America: 40 hits from the 50 states. Spectrogram of the sound used in the "Congruent" soundscape: an instrumental version of "I Still Haven't Found What I'm Looking For" (The Hit Co., 2013).

D. MASS MoCA – Sol LeWitt: A Wall Drawing Retrospective exhibition

For Sol LeWitt's exhibition (Figure 7 and 8), the Philip Glass's composition "Glassworks" (Glass, 2017) was employed as a sound congruent with this exhibition (See Figure 9 for the spectrogram). The rationale behind this choice is the exhibition's thematic emphasis on geometric forms and the intricate interplay between simplicity and complexity. The repetitive and minimalist characteristics of Glass's composition resonate with LeWitt's artwork's conceptual and geometric elements.

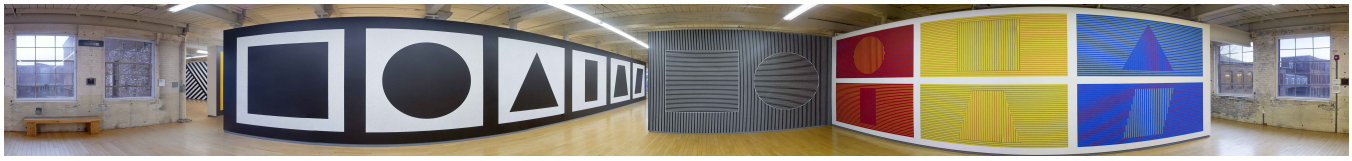

FIG. 7. MASS MoCA – Sol LeWitt: A Wall Drawing Retrospective. Wall Drawings 335, 340 and 343. The author took the photo with the permission of the museum's art curator.

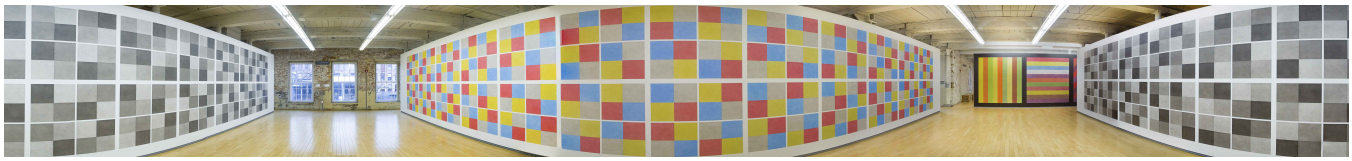

FIG. 8. MASS MoCA – Sol LeWitt: A Wall Drawing Retrospective. Wall Drawings 413 and 414. The author took the photo with the permission of the museum's art curator.

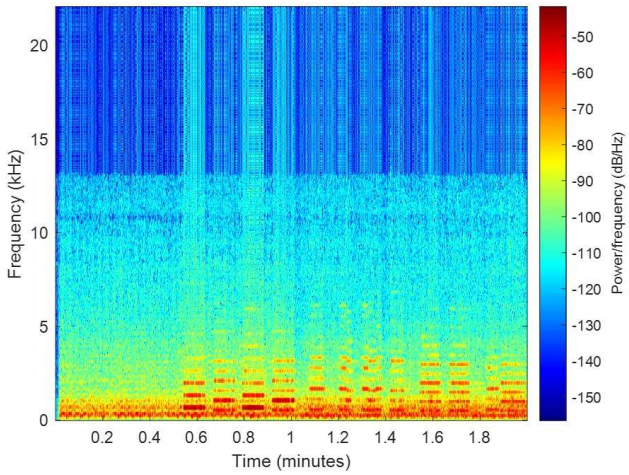

FIG. 9. MASS MoCA – Sol LeWitt: A Wall Drawing Retrospective. Spectrogram of the sound used in the "Congruent" scenario: Philip Glass's composition "Glassworks" (Glass, 2017).

E. MASS MoCA – The Prow

The Prow is a multipurpose space that can be used for work, rest, and learning (Figure 10). A "natural" sound was chosen as sound in congruence, specifically a field recording of river rapids (BBC, 1998). This recording captures the sound of water rushing, obtained near its source, without other environmental or non-anthropogenic sounds (See Figure 11 for the spectrogram). This decision is grounded in prior research that presented evidence supporting the notion that exposure to "natural" sounds can have positive and restorative effects on performance in attention-depleting tasks (Ratcliffe, 2021). Another study also revealed that listeners prefer "natural" sounds over conventional masking signals as it enhance cognitive functioning, optimizes the ability to concentrate, and increases overall satisfaction (DeLoach *et al.*, 2015).

FIG. 10. MASS MoCA – The Prow. The author took the photo with the permission of the museum's art curator.

F. MASS MoCA – Back Stars exhibition

For the Black Stars' exhibition by Jason Moran –the museum has not granted permission to share images publicly– the own artist's composition "RFK In The Land Of Apartheid" (Moran, 2014) was chosen as a congruent sound (See Figure 12 for the spectrogram). Moran's artworks connect profoundly to his performance practice and the embodied exchange between performers, instruments, and audience members. Consequently, incorporating his music into the

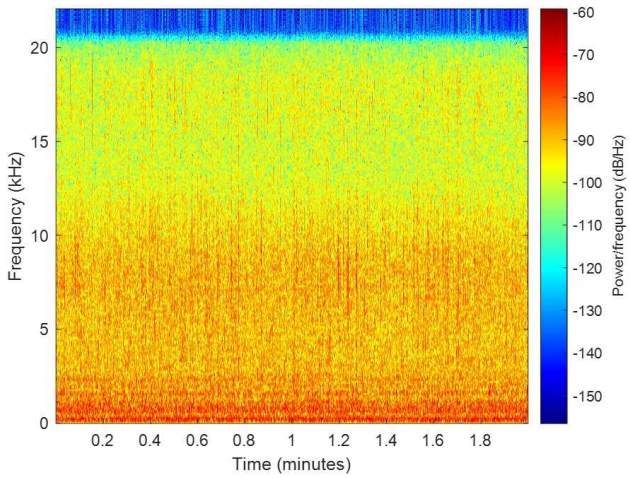

FIG. 11. MASS MoCA – The Prow. Spectrogram of the sound used in the "Congruent" scenario: a field recording of river rapids (BBC, 1998).

exhibition aligns with this perspective. Moreover, the exhibition explores the physical aspects involved in the creation and experience of live music, particularly within the context of Black jazz musicians and the transformative impact of the venues in which they performed. By featuring Moran's music firmly rooted in jazz traditions, the exhibition can acquire a historically significant sonic backdrop that resonates with the thematic content and narratives.

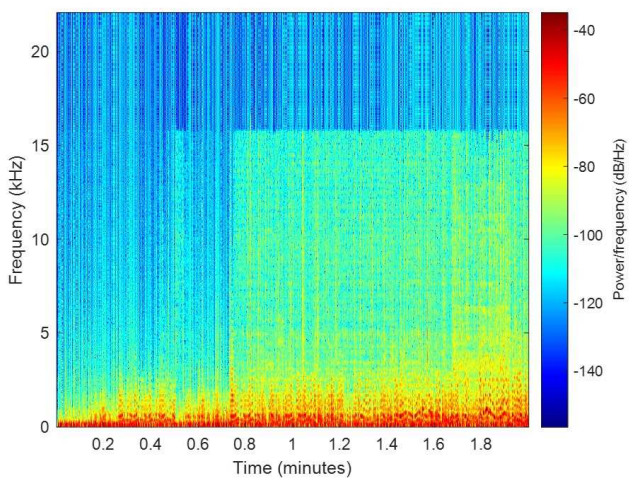

FIG. 12. MASS MoCA – Jason Moran: Black Starts: Writing in the dark. Spectrogram of the sound used in the "Congruent" scenario: The composition "Jason Moran RFK In The Land Of Apartheid" (Moran, 2014).

G. MASS MoCA – EJ Hill: Brake Run Helix exhibition

A roller coaster sound (Craigsmith, 2018) was chosen to compose the congruent soundscape with the exhibition "Brake Run Helix" –the museum has not granted permission to share images publicly– derives from its pivotal role as a primary source of inspiration for EJ Hill's installation, as the central artwork in the exhibition is a roller coaster that the visitors can run, encompassing symbolic and cultural significance within the thematic context of the exhibition (See Figure 13 for the spectrogram).

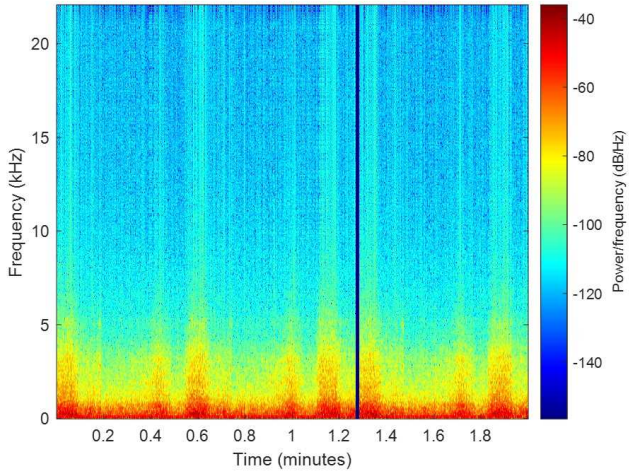

FIG. 13. MASS MoCA – EJ Hill: Brake Run Helix. Spectrogram of the sound used in the "Congruent" scenario: a roller coaster sound (Craigsmith, 2018).

H. MASS MoCA – Spencer Finch: Cosmic latte exhibition

In the context of Spencer Finch's "Cosmic Latte" exhibition (Figure 14), 'celestial soundscapes' (BaDoink, 2020) were selected as the sound in congruence with the exhibition's theme (See Figure 15 for the spectrogram) due to the cosmic inspiration that underlies the artwork. Cosmic phenomena, such as the Milky Way and the average color of the universe, inspire the installation itself, and the celestial sounds—such as ambient tones evoking stars, galaxies, or planetary movement—align with the visual representation of the universe.

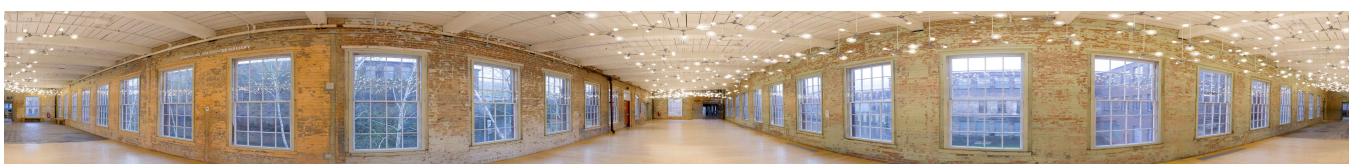

FIG. 14. MASS MoCA – Spencer Finch: Cosmic latte. The author took the photo with the permission of the museum's art curator.

I. New York State Museum – Birds of New York exhibition

This exhibition shows that New York's diverse wildlife habitats attract over 240 species of birds that breed within the state and over 450 different bird species that spend at least part of the year in New York (Figure 16). Therefore, bird sounds were employed as sounds in congruence with the exhibition as they are closely aligned with the thematic focus. Specifically, a field recording titled "birds at a watering hole, Madumbalai National Park, Tamil Nadu, late afternoon with mynahs, barbets, parakeets, bulbuls, and crickets" (BBC, 1998) was selected (See Figure 17 for the spectrogram).

J. New York State Museum – Adirondack Wilderness exhibition

A field recording of river rapids (BBC, 1998) was chosen as a sound in congruence with the Adirondack Wilderness exhibition at the New York State Museum (Figure 18). This exhibition's remarkable characteristic lies in its organic layout, unveiling distinct discoveries at every turn. Within this hall, visitors encounter diverse exhibitions, all intricately intertwined with nature, featuring elements such as stones, wood, animals, boats, and creeks. In the past, this exhibition had, in fact, a small puddle of water to refer to water from nature, but this was disabled due to technical problems. Hence, the river rapids' sound aligns with this space's thematic coherence and intention (See Figure 19 for the spectrogram).

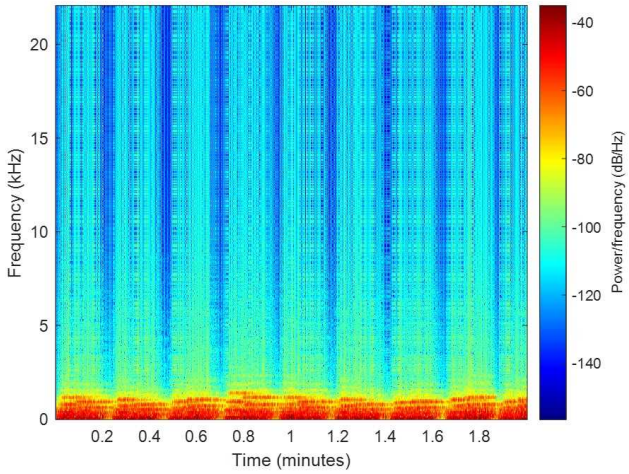

FIG. 15. MASS MoCA – Spencer Finch: Cosmic latte. Spectrogram of the sound used in the "Congruent" scenario: celestial soundscapes (BaDoink, 2020).

FIG. 16. New York State Museum – Birds of New York. The author took the photo with the permission of the museum's Director of Exhibitions.

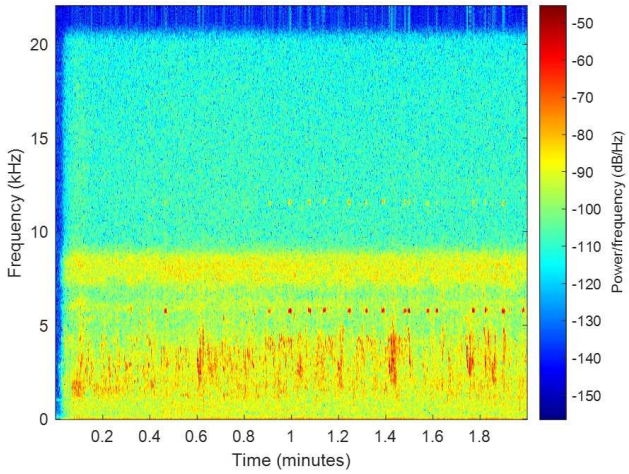

FIG. 17. New York State Museum – Birds of New York. Spectrogram of the sound used in the "Congruent" scenario: a field recording of "birds at a watering hole, Madumbalai National Park, Tamil Nadu, late afternoon with mynahs, barbets, parakeets, bulbuls, and crickets" (BBC, 1998).

K. UAlbany museum

In the UAlbany Museum (Figure 20), "Round Midnight" by Thelonious Monk (Monk, 2016) was chosen as the sound congruent with the exhibition featuring black and white photography or works with a noir aesthetic (See

FIG. 18. New York State Museum – Adirondack Wilderness. The author took the photo with the permission of the museum's Director of Exhibitions.

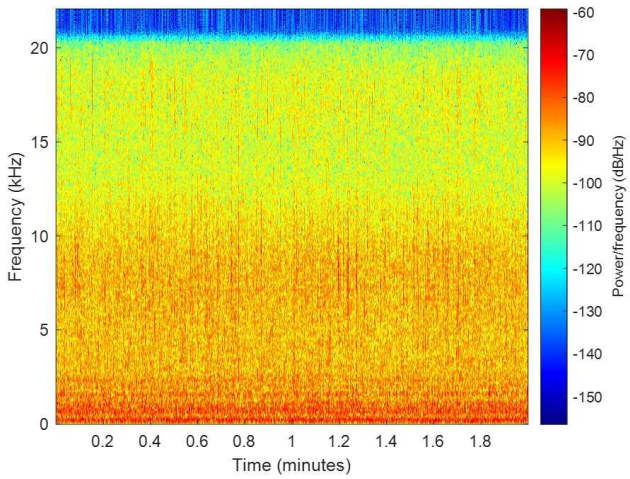

FIG. 19. New York State Museum – Adirondack Wilderness. Spectrogram of the sound used in the "Congruent" scenario: field recording of river rapids (BBC, 1998).

Figure 21 for the spectrogram). Firstly, the introspective tone of the music corresponds with the atmospheric and evocative qualities commonly associated with noir photography. Second, the melodic and rhythmic elements inherent in "Round Midnight" created an engaging ambiance, fostering a deeper connection between the viewers and the exhibited photographs.

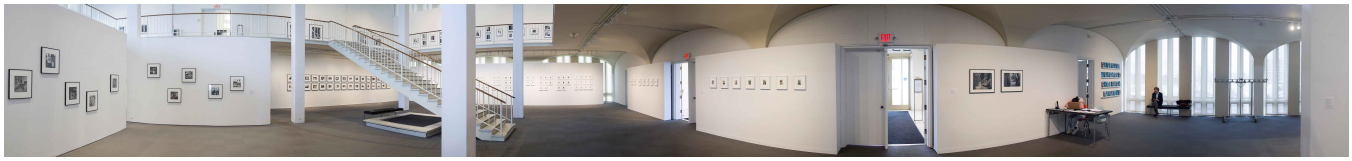

FIG. 20. UAlbany museum first floor – Photographers Tom Baril, Andreas Feininger, Larry Fink, Mary Ellen Mark, Edward Steichen, and Andy Warhol. The author took the photo with the permission of the museum's art curator.

L. WCMA – Rotunda

Similar to "The Prow" at MASSMoca, the Rotunda is a multipurpose space that can be used for work, rest, and learning (Figure 22). Therefore, the same "natural" sound was chosen as sound in congruence (BBC, 1998), for the same reasons explained above for "The Prow" (See Figure 23 for the spectrogram).

M. WMCA – "Across Shared Waters"

A Tibetan Chant (Johnson, 2015) was used as sounds congruent with the exhibition "Across Shared Waters" (Figure 24) as it aligns with the exhibition's context. This exhibition aims to highlight the diversity and richness of Tibetan artistic expression while fostering a deeper understanding of Himalayan histories and identities. Therefore,

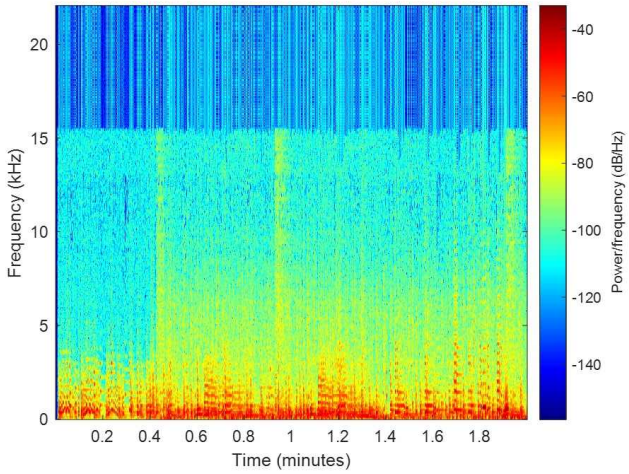

FIG. 21. UAlbany museum – Spectrogram of the sound used in the "Congruent" scenario: "Round Midnight" by Thelonious Monk (Monk, 2016).

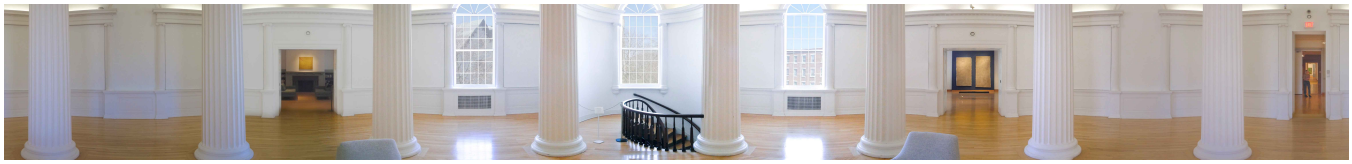

FIG. 22. WCMA – Rotunda. The author took the photo with the permission of the museum's art curator.

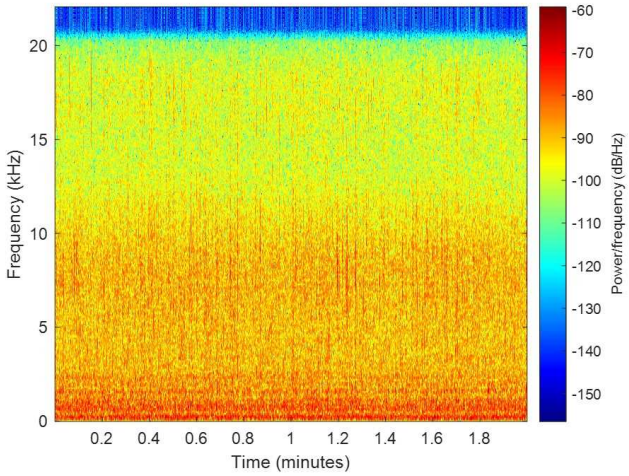

FIG. 23. WCMA Museum – Rotunda. Spectrogram of the sound used in the "Congruent" scenario: a field recording of river rapids (BBC, 1998).

the chants can evoke Tibetan art and culture's sacred and contemplative atmosphere, creating a sense of tranquility that encourages visitors to reflect upon the artworks' intricate details and symbolic meanings (See Figure 25 for the spectrogram).

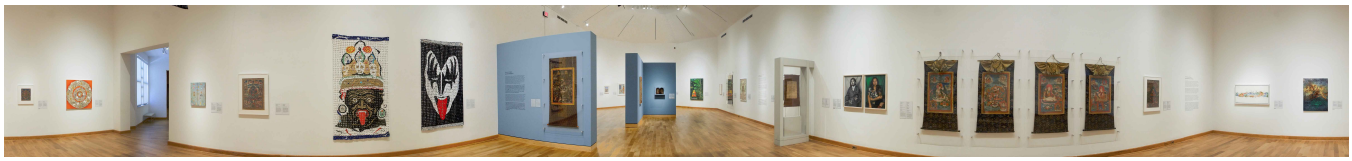

FIG. 24. WCMA – Across Shared Waters. The author took the photo with the permission of the museum's art curator.

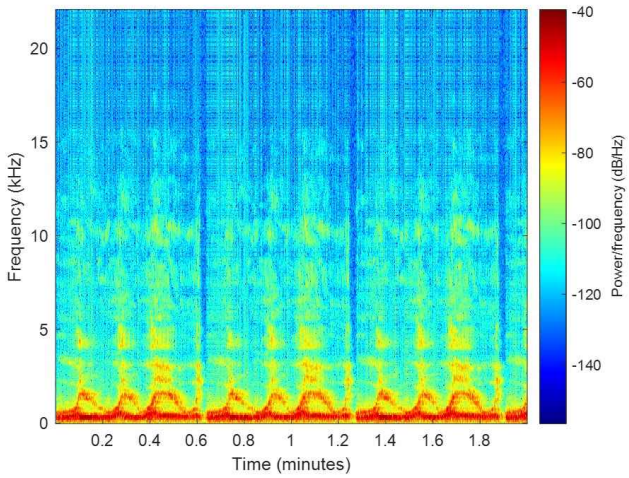

FIG. 25. WCMA Museum – Across Shared Waters. Spectrogram of the sound used in the "Congruent" scenario: A Tibetan Chant (Johnson, 2015).

N. WCMA Museum – Object Lab exhibition

Similar to "The Prow" at MASSMoca and the "Rotunda" at WCMA, the Object Lab is a multipurpose space that can be used for work, rest, and learning (Figure 26). Therefore, the same "natural" sound was chosen as sound in congruence (BBC, 1998), for the same reasons explained above for "The Prow" (See Figure 27 for the spectrogram).

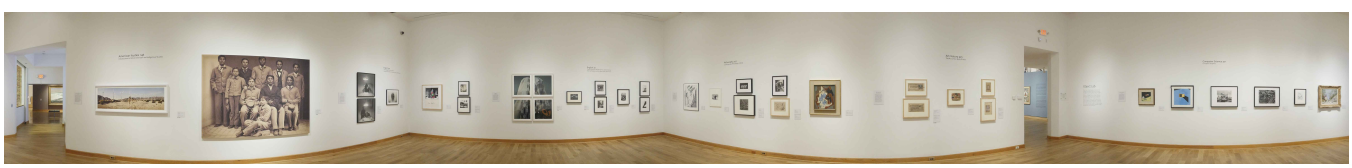

FIG. 26. WCMA Museum – Object Lab: Spring 2023. The author took the photo with the permission of the museum's art curator.

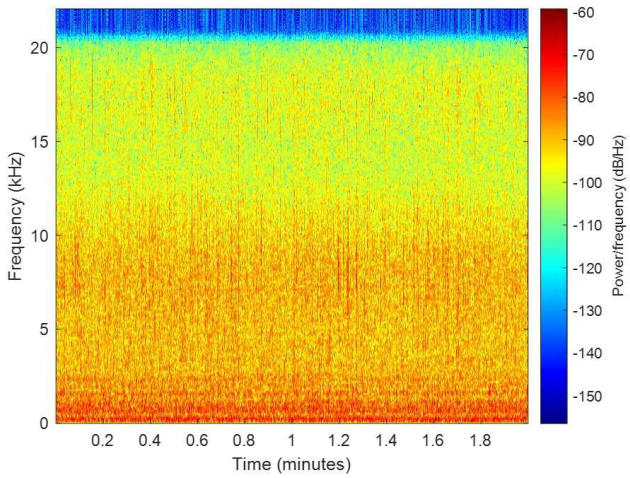

FIG. 27. WCMA Museum – Object Lab: Spring 2023. Spectrogram of the sound used in the "Congruent" scenario: a field recording of river rapids (BBC, 1998).

BaDoink (**2020**). "*Celestial Journey*" [Song]. Freesound Sound Effects Library. https://freesound.org/people/BaDoink/sounds/540057/, (Accessed Jun 6, 2023).

BBC (**1998**). "*BBC sound effects library*" https://sound-effects.bbc\rewind.co.uk/, (Accessed May 31, 2023).

Craigsmith (**2018**). "*Roller Coaster Roar Sound.*" [Song]. Freesound Sound Effects Library. https://freesound.org/people/craigsmith/sounds/438677/, (Accessed Jun 6, 2023).

DeLoach, A. G., Carter, J. P., and Braasch, J. (**2015**). "Tuning the cognitive environment: Sound masking with "natural" sounds in open-plan offices," Journal of the Acoustical Society of America **137**(4_Supplement), 2291–2291.

Glass, P. (**2017**). "*Glassworks*" [Video]. Youtube. https://www.youtube.com/watchv$=-$5b7UVWD6b0&list$=$OLAK5uy$_$lx$_$oYc2mHA8eWBle\XwYO$-$MLsJ9i3dCYtQ, (Accessed Jun 6, 2023).

Johnson, A. (**2015**). "*Praising Chakrasamvara*" [Video]. Youtube. https://www.youtube.com/watch?v=L42AnSAdzXw, (Accessed Jun 6, 2023).

Monk, T. (**2016**). "*Thelonious Monk - 'Round Midnight*" [Video]. Youtube. https://www.youtube.com/watch?v=CqTIWtjpU0Q, (Accessed Jun 6, 2023).

Moran, J. (**2014**). "*RFK In The Land Of Apartheid*" [Video]. Youtube. https://www.youtube.com/watch?v=aCQO84NF1-I, (Accessed Jun 6, 2023).

Ratcliffe, E. (**2021**). "Sound and soundscape in restorative natural environments: A narrative literature review," Frontiers in psychology **12**, 570563.

Soul, G. (**2011**). "*Gummy Soul Presents: Amerigo Gazaway - Trouble In The Water*" [Video]. Youtube. https://www.youtube.com/watch?v=s7ghnfJfRwo, (Accessed Jun 6, 2023).

The Hit Co. (**2013**). "*I Still Haven't Found What I'm Looking For (Instrumental Version)*" [Video]. Youtube. https://www.youtube.com/watch?v=mfSOO1dBn2o, (Accessed Jun 6, 2023).