Respiratory Musical Interfaces (RMIs) in NIME

ZIYUE PIAO, IDMIL, MPBL, CIRMMT, McGill University, Canada
KANYU CHEN, Keio University, Japan

Breathing is a fundamental physiological process that occupies a unique space in human-computer interaction, sitting at the intersection of autonomic reflex and conscious control. In the context of New Interfaces for Musical Expression (NIME), Respiratory Musical Interfaces (RMIs) have emerged as a powerful modality for high-fidelity, embodied musical control. This workshop aims to cultivate a dedicated research community to explore the technical, aesthetic, and physiological dimensions of RMIs. The session transitions from foundational respiratory biomechanics and real-time signal processing to implementation insights from leading practitioners across academia and industry. Through a combination of technical tutorials, hands-on engagement with custom RMI wearables, and a moderated panel discussion, participants will address critical topics facing the field. By synthesizing diverse perspectives on embodied interaction and bio-sensing, this workshop seeks to define a future roadmap for the next generation of expressive respiratory interfaces.

Additional Key Words and Phrases: Respiratory musical interfaces, embodied interaction, NIME, respiratory physiology, gesture mapping

1 Motivation

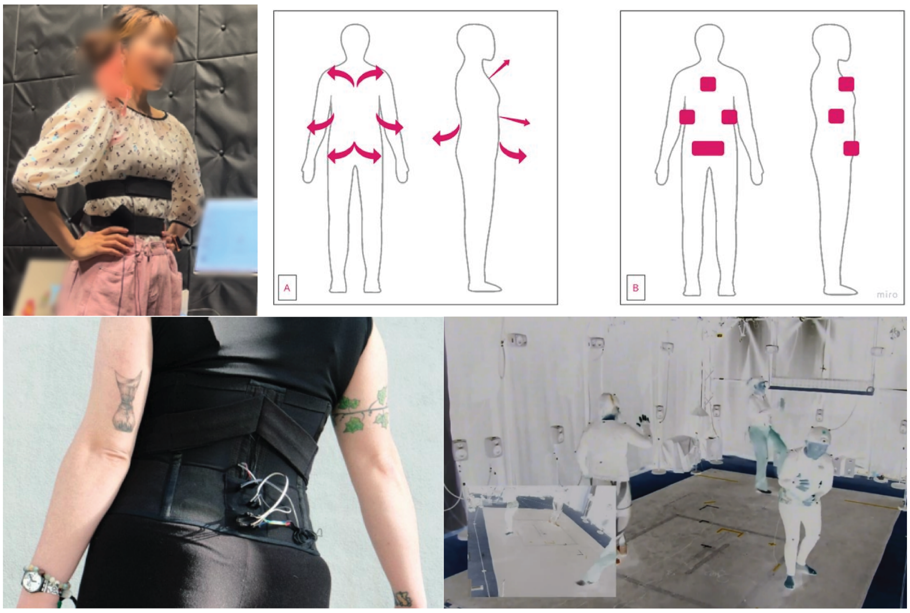

Fig. 1. Previous research on breathing interfaces in music HCI [3, 5–7]

Breathing represents one of the most fundamental human physiological processes, making it a compelling modality for musical expression and human-computer interaction [2, 8]. Unlike discrete button presses or gestural movements, breath offers continuous, nuanced control that naturally connects the performer's internal state with external sonic output. Besides, breathing serves as a unique interface because it is partially conscious and partially automatic, allowing for both deliberate and organic musical control [14]. The exploration of breathing as an input channel in New Interfaces for Musical Expression (NIME) research has advanced significantly over the past two decades, leading to the emergence of what we define as Respiratory Musical Interfaces (RMIs): systems that leverage respiratory data as a primary, high-fidelity controller for musical performance.

Authors' Contact Information: Ziyue Piao, IDMIL, MPBL, CIRMMT, McGill University, Montreal, QC, Canada, ziyue.piao@mail.mcgill.ca; Kanyu Chen, Keio University, Tokyo, Japan.

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For RMI research, the NIME conference contributes foundational technical approaches, design methodologies, and performance applications. Scavone's PIPE established early technical foundations for breath pressure sensing with flexible mapping schemes [12], and Nagashima's bio-sensing systems demonstrated professional performance viability and introduced bidirectional breath sensing [10]. Later, Siwiak et al.'s CatchYourBreath bridged therapeutic and artistic applications [13]. Lee et al.'s dancer respiration system expanded RMI interaction into dance contexts with rigorous evaluation through professional choreographer feedback [9]. Bhandari et al.'s work investigated music-based respiratory biofeedback in visually demanding tasks [1]. Cotton et al.'s Body Electric introduced soma design methodology to NIME, reframing the body as a controller and the RMI as a co-performer [5]. Piao et al.'s multimodal singing tutoring interface addressed the under-researched area of breath guidance in vocal training [11]. Feldt et al.'s Peripipe explored discrete breath gestures, while Diaz et al.'s INTIMAL extended RMI interaction into location-based contexts [6]. These contributions collectively demonstrate NIME's role in advancing the technical, artistic, and theoretical dimensions of respiratory-based musical interaction.

In this workshop, we aim to cultivate a research community dedicated to the advancement of RMIs. By grounding designers in the physiological mechanics of breathing, we can facilitate the creation of high-fidelity, embodied systems that transcend biological necessity to become more flexible musical controllers. Central to this effort is a discussion of the limitations inherent in legacy systems, such as mechanical latency, motion artifacts from torso movement, and the constraints of binary breath triggers, which have historically limited expressive potential. By exploring emergent sensing modalities and refined mapping strategies, this workshop seeks to overcome these technical barriers with practitioners in RMIs and unlock the full expressive capabilities of the breath as a primary musical interface.

2 Workshop Structure

The workshop is designed as a four-hour session, transitioning from foundational physiological theory, practical insights from RMI designers and researchers, to the discussion about future RMIs. The schedule is divided into three core modules with two 15-minute networking breaks in between.

2.1 Part 1: Breathing Foundations (1 Hour)

The opening hour establishes a common language between biological mechanics and digital data. We begin with an introduction to respiratory biomechanics, focusing on the distinction between diaphragmatic and thoracic movement and their respective roles in musical phrasing.

We then demonstrate common real-time signal processing techniques for RMIs, including normalization, low-pass filtering for motion artifact suppression, and high-level feature extraction such as BPM and apnea detection. On-site participants will have the opportunity for hands-on engagement with our custom RMI wearables, allowing for real-time interaction and experiential evaluation of the systems.

2.2 Part 2: Wearable Realities and Practitioner Insights (1.5 Hour)

This segment focuses on the implementation of Respiratory Musical Interfaces (RMIs) within professional performance contexts. The session features three distinguished experts (two confirmed, one pending) who will provide 30-minute concentrated insights in a hybrid format. To ensure a diverse exchange, speakers are encouraged to utilize a flexible format—such as a combination of lectures, interactive demonstrations, and prototyping showcases—followed by a moderated Q&A. If the pending invitation is declined, the position will be filled by Kanyu Chen.

2.3 Part 3: Synthesis and Future Roadmap (1 Hour)

The final hour transitions from existing technologies to the definition of the next generation of Respiratory Musical Interfaces. This session features a moderated panel discussion and an open forum involving all invited researchers from Part 2, alongside both on-site and remote participants. Four senior researchers and professors will join the session (three confirmed, one pending). If the pending invitation is declined, the position will be filled by Ziyue Piao or Kanyu Chen.

The discussion is structured around four core thematic provocations for the future of RMIs:

- **The Autonomy Paradox: Conscious Intent vs. Non-conscious Reaction.** Unique among musical inputs, breathing exists at the intersection of conscious control and non-conscious reaction. We examine the design challenges of this dual agency: how can mapping strategies distinguish between a performer's deliberate musical phrasing and the body's organic physiological demands? How can we design a future wearable device to capture this pre-reflective interplay without imposing a cognitive tax that disrupts the performer's primary artistic flow?

- **Beyond the Discrete: From Triggering to Instrumental Control.** This topic addresses the transition from treating breath as a series of discrete triggers, such as binary states or pre-defined pattern classifications, to high-dimensional, continuous mapping strategies. We discuss the technical requirements for future wearables in capturing fluid nuances in volume, rate, and pressure to achieve a truly instrumental level of expressivity.
- **The Invisible Burden: Scientific Rigor vs. Artistic Freedom.** A debate on the wearability gap, focusing on how medical-grade sensors (e.g., restrictive straps or masks) fundamentally alter a musician's natural respiratory flow and aesthetic presence. How do we balance the need for high-precision data with the psychological and physical freedom required for high-stakes performance?
- **Agency and the AI Gap.** As RMIs increasingly integrate with AI and cloud-based bio-sensing, the performer's biological signature is transformed into persistent, potentially accessible digital assets. We discuss the ethical implications of externalizing internal physiological states during performance and whether AI-mediated interaction bridges or widens the embodied gap between a performer's intent and the machine's response.

3 Organisers

Ziyue (Monica) Piao is a Ph.D. candidate in Music Technology at McGill University's Schulich School of Music, supervised by Prof. Marcelo M. Wanderley and Prof. Isabelle Cossette. Her research sits at the intersection of wearable design and embodied interaction, with a specialized interest in how wearable systems can capture respiratory physiology and be applied to embodied musical practices. She has collaborated with companies Sony Computer Science Laboratories and Yamaha Corporation to pioneer the use of wearables for capturing physiological data in both professional performance and music education contexts. She is currently engaged in an ongoing collaboration with Yamaha centered on using sensing wearables to capture and analyze breathing patterns during piano performance. This research aims to bridge the gap between internal physiological states and external musical dynamics, providing new tools for performance and pedagogical feedback. Ziyue's work has been recognized with the FRQSC Doctoral Scholarship and has been published in top conferences, including ACM CHI, NIME, and TEI. She is also an active contributor in communities such as the IEEE Technical Committee on Haptics, CIRMMT, NIME, ISMIR, and TEI.

Kanyu (Cady) Chen is a Ph.D. researcher in Wearable Computing at the Graduate School of Media Design, Keio University, Tokyo, Japan, supervised by Prof. Kai Kunze and Prof. Kato Akira. Her research centers on the application of physiological sensing technologies to embodied skill acquisition. She investigates how multimodal sensing technologies—including electromyography, ultrasonography, respiration sensing, and audio signal analysis—can support vocal training and music cognition. Her work aims to make internal physiological processes perceptible and actionable, bridging the gap between somatic awareness and expressive musical performance [3, 4]. She is particularly interested in designing biofeedback interfaces for embodied learning and creative practice, and in advancing the digital transformation of musical skills through physiology-driven interaction design. Her research has been published in top venues such as ACM CHI, UbiComp, SIGGRAPH Asia, IEEE ISMAR, etc. She actively serves the research community as a program committee member for conferences, including CHI and UbiComp.

Mastering an instrument or the voice requires precise coordination and deep internal awareness. This "internal feel" of the body is known as kinesthetic awareness. For singers, this demands the nuanced interplay of breathing muscles and chest expansion. However, singing learners often struggle with a kinesthetic mismatch: a disconnect between how they think they are engaging their body and how their body is actually doing. Despite its importance, this internal coordination is often ignored in research, which tends to focus on visible posture via motion capture technology rather than the hidden physiological movements that drive a performance. When these disconnects go undetected, singers reinforce bad habits and increase the risk of injury.

This manuscript investigates how singing teachers and students communicate hidden respiratory dynamics through multimodal metaphors, while exploring how kinesthetic mismatches emerge and are resolved during singing training. I conducted three focus groups with eleven participants using body mapping, a soma design method where learners drew representations of bodily sensations that are difficult to verbalize. Analysis of these discussions and drawings revealed that traditional metaphors often fail to correct deep-seated muscle tension. Consequently, I evaluate existing pedagogical methods and propose how new technologies, such as wearable haptics, can provide the objective data needed to resolve kinesthetic mismatches. While rooted in singing, these findings extend to all instrumental practices. By making "invisible" breathing visible, this work fosters healthy, injury-free mastery in music and paves the way for advanced physical training in wider motor-learning contexts.

4 Description of technical and space requirements

Space and Furniture

- **Room Layout:** A flexible space with 20–30 chairs to seat is required to facilitate the transition from lightning talks.
- **Presentation Area:** A designated demo table (approx. 2m x 1m) at the front is needed to display wearable prototypes and the workstation for live signal processing.

Audio-Visual and Network

- **Visuals:** A high-resolution projector (HDMI input) for lightning talk.
- **Audio:** Standard speaker setup with a common audio output and two microphones for the hybrid panel.
- **Network:** Wi-Fi is essential for the hybrid connection with online participants.

Provided by Organizers

- Prototype wearable breathing devices.

5 Ethical Standards

Please note that Ziyue Piao's PhD study is sponsored by an FRQSC Doctoral Scholarship (No. 0000342567) from Fonds de recherche du Québec and supported by Yamaha Corporation's Global Internship Program. Kanyu Chen's work is funded by the JST SPRING Doctoral Scholarship (Grant No. H09GQ24152).

We will take photos to document the workshop events. Additionally, with the permission of all panel speakers, we will audio-record the discussion to help us record the main ideas and future directions for the field from these panel speakers. The audio recordings will serve as a basis for a summarized position article outlining future directions for the field.

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