Liminal Space: A Performance with RaveNET

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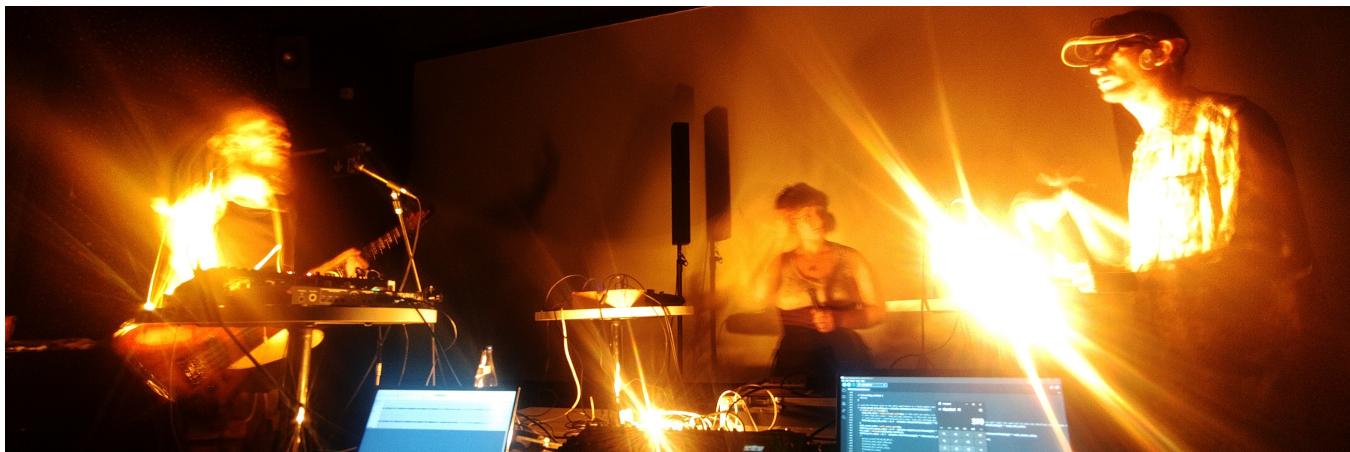
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Figure 1: Our group's RaveNET in performance: Strohmeier (left) incorporates the Tendons node into his bass playing, Reed (middle) the Bones node to her singing, and Martinez-Missir (right) the Veins node to operating his drum machine.

ABSTRACT

We present our musical performance exploration of liminal spaces, which focuses on the interconnected physicality of bodies in music, using biosignals and gestural, movement-based interaction to shape live performances in novel ways. Physical movement is important in structuring performance, providing cues across musical ensembles, and non-verbally informing other musicians of intention. This is especially true for improvised work. Our performance involves the use of our musicking bodies to modulate audio signals. Three bespoke wearable nodes modulate the performance through control voltages (CV) and interface with specific technical aspects of our instruments and techniques: 1) an "anti-corset" that measures the expansion and resistance of Reed's abdomen while singing, 2) an augmented glove that assists Strohmeier's bass/guitar signal routing across his pedal board and modular setup, and 3) a cap-like device that captures Martinez-Missir's subtle facial expressions as he manipulates his modular synthesizer and drum machine setup. Through these performances we explore the notion of control in musical improvised performance, the interconnectedness and communications between our ensemble as we learn to collaborate and interpret each others' bodies in this novel interaction.

CCS CONCEPTS

• **Applied computing** → *Performing arts*; *Sound and music computing*; *Performing arts*; **Sound and music computing**; • **Human-centered computing** → **Interaction design**; *Gestural input*; **Interaction design process and methods**; *Interaction techniques*; **Interactive systems and tools**.

KEYWORDS

interaction networks, musical performance, wearable sensing, body-based control, biosignals

1 INTRODUCTION

We make sense of ourselves and the world through narration in which we create edges and borders: Me versus not-me, here versus there, past versus future [11]. Our work explores how such edges are transcended in the liminal space created in the network between musicians, instruments, and technology in performance. Liminal space are states of change, wherein we retain our sense of self but are open to and receive influences around us [11]. In musical performance, our own creation is manipulated by the presence of others — even in solo performance, non-musicians and spaces around the performance are part of the networked interaction. We here focus on the rave as a technologically mediated ritual [4]. These rituals involve networks of analog and digital technology and facilitate connections, dialogue, and language between people; what Durkheim might have termed "collective representation." We in the TEI community might describe and research these networks as shared, embodied experiences. Such embodied experiences drive musical interaction and the expressive, technical behaviour used in performance [13, 17]; in collaborative performance, embodied connections and understanding are formed jointly, between human and non-human agents in the network.

Our rave network — RaveNET — is a design-space exploration which began as a conversation about the structure of musical collaboration and the ways in which we can share and extend the experience of collaborative music making using technology. We designed three wearable research-artifacts to investigate the networking and modulation of bodies and data, inspired by human traditions which predate the contemporary ubiquity of mediated technological products and interfaces. Our aim is to further connect artifacts in modern music rituals to our shared experiences as a group by incorporating human activity as a source of modulation to the network.

We designed three prototypes, or nodes, for our group, which constitute the initial version of RaveNET: 1) *Bones*, which measures the expansion of Reed's diaphragm while she sings, 2) *Tendons*, which are half-gloves designed to capture Strohmeier's movement and biometric data while he plays bass, and 3) *Veins*, which measures Missir's facial expressions to modulate the output of his drum machine via his modular synthesizer. All aspects of these prototypes, from their inception to the current implementation are embedded within our musical practice.
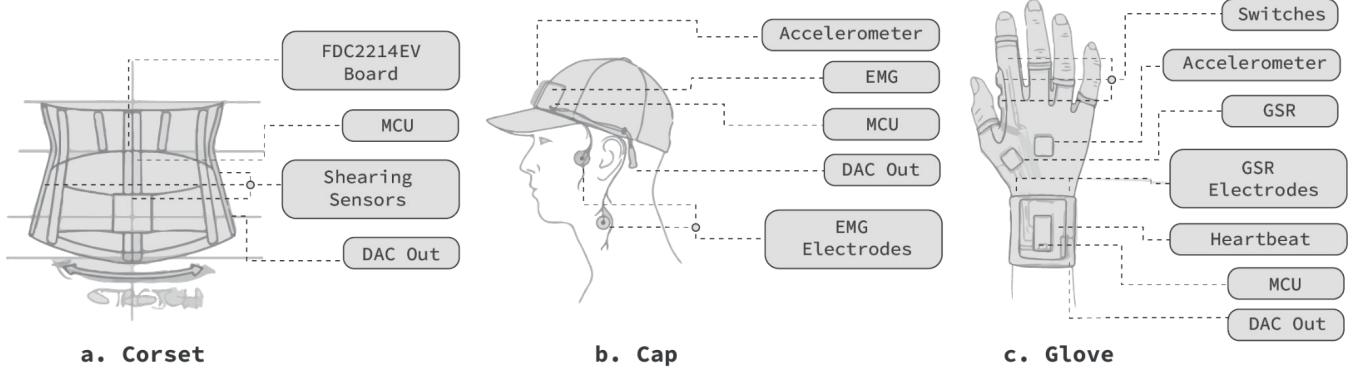
2 RELATED WORK

RaveNET draws on the distinction and blurring between experiences to examine the networks between people and other agents in musical performance. We draw on the discussion of Takahashi and Olaveson about raving as an embodied experience and claim that ravers have an "overpowering sense of social connectedness," characteristic of ritual and liminal events [16]. We treat our musical practice as a liminal space, wherein our individual responses become part of the group experience; we react to one another and our action becomes a product of the setting and environment, rather than only of the self. Our design of and performance of RaveNET was aimed to explore such connections to each other, particularly our physical bodies and the non-verbal cues we use to communicate in performance. We draw on other research in connecting humans, instruments, and bodies through sound and music and create a liminal space through our own mapped movement. Specifically, we draw on related biosignal sonification [3, 7, 14] to map our movements to sound and incorporate ourselves in novel ways into this interaction network. In addition to the technical contributions our bodies make to performing, we also digitally manipulate sound through this biosignal-mapped modulation.

The physical implementation of the RaveNET nodes builds on our prior work on sensorized garments [14] and reflections on how wearability of technology must be considered in all stages of the design process [9] . We also build upon a strong tradition of experimentation with the use of sensors and digital technology to build new forms of instruments. We trace our ideas back to the seminal *Hands* by Michael Waisfisz [10], which were followed by instruments built by Bert Bongers, such as *Midi Conductor* as played by Edwin van der Heide in Sensorband [1] and *Lady's Glove* as played by Laetitia Sonami. Using an interactive glove as music controller received mainstream attention through the *MiMU* gloves used by Imogen Heap [12]. Our *Tendons* prototype directly builds on this work, based on an eaerly open source MiMU glove pattern designed by Rachel Freire and Hannah Perner-Wilson [6]. Similarly, *Bones* builds on previous work to capture vocalists' body movements in performance, notably the Body Electric [2], Corsetto [8], and the Singing Knit [14]. The way we intend to *use* the RaveNET nodes, however, differs from much of the previous work. RaveNET is not primarily designed to give musicians control over music, but rather to provide modulation sources for music created with traditional instruments.

3 DESIGN & PERFORMANCE SETUP

To investigate these areas of embodied interaction and communication between bodies in musical performance, we adopted a Research Through Design (RtD) approach involving the iterative design of wearable musical controllers — what we call *nodes* in the embodied network — for each of our needs and performance applications. The nodes are wearable sensing elements, each with a digital and analog signal processing component, integrated into a wearable device created by Freire. Our performances with these nodes are a critical part of their design and not only provide necessary debugging and

Figure 2: The three RaveNET nodes designed by Freire: Reed's corset, *Bones*, Missir's cap, *Veins*, and Strohmeier's glove, *Tendons*.

evaluation-in-action but also discourse among our group about our roles in our musical collaboration and how our bodies factor into performance.

3.1 Nodes

The RaveNET nodes and their integrated hardware and software facilitate translation of biosignal and movement data to CV (Figure 2). We treat the controllers as part of a larger network across our ensemble; they are named after other connective structures and systems within a human body. Each wearable is constructed with the wearer's body, practice, and functions in our ensemble in mind.

Bones is an *anti*-corset; that is, rather than providing structure around the abdomen of the wearer, the wearable allows for freedom of movement across the belly and back (Figure 2a). The wearable uses capacitive sensing to measure shearing across Reed's body, particularly the abdomen and sides of the back, as it expands during her breathing.

Veins is a wearable cap with integrated electromyography sensing (Figure 2b). A classic baseball cap with added customized electrodes extending through the brim measures Martinez-Missir's facial expressions while he controls his drum machine.

Tendons is a sensorized glove which measures Strohmeier's pulse, galvanic skin response (GSR), and movement with an IMU across his fingers, palm, wrist, and back of his hand (Figure 2c). These capture incidental movements as Strohmeier plays bass and guitar. Three buttons are also incorporated to provide a switchable functionality, similar to the effects pedals he already uses.

3.2 Performance

Through musical performance, our group presents our research in the interaction between musical bodies and the collaborative networks that structure improvisation. Prior to this project, we had spent the last two years performing as a musical ensemble, incorporating music technology such as modular synthesis and audio signal processing into our trio performance. Our performance style trended towards improvisation and serendipitous creation in lightly structured performances. Through our music creation, we formed questions about this creative process and performance

which informed several research questions. Namely, we have begun to investigate how body movements can be used to manipulate performance and how non-verbal, gestural interaction in performance structure improvisation. These results and this on-going work will be presented alongside this performance in the TEI Work in Progress track [5].

Using these wearable nodes of RaveNET in our performance context led to reflections on our creative process and how we are able to facilitate shared musical experiences and understand our own and each others' bodies in our practice. In particular, the intersection of embodied existence and control became apparent: while the nodes were designed for relinquishing control, we subconsciously wished to maintain it. This is not completely possible, as the nodes are intrinsically linked to our activities. For example, breathing is an activity which occurs in support of Reed's singing - here Reed needs to negotiate control between these actions of breathing and singing. We were aware of this from our previous explorations [15]. The collaborative nature of these performances added a new dimension to the the experience of control, highlighting that it is also dependent on point of view. For example, Martinez-Missir felt in control of his drum-machine rythm modulation through their facial EMG; however, this control was not perceivable to those who did not share his embodied experience. As we were exploring the creation of liminal spaces, we found ourselves at another edge between control and chaos. Going forward, this will be in the focus on our exploration. We have found that toeing the edge between control and chaos raises new questions about interconnectedness between humans and technology and will prove to be an extremely creative space, in which we are facilitated us to explore new music ideas.

We propose an exhibition of these controllers and our body-based musical performance. From discourse among our small ensemble and also others observing the performance setting, we aim to address important aspects of creating together and how the physical forms musical collaboration.

ACKNOWLEDGMENTS

REFERENCES

[1] Bert Bongers and Sensorband. 1998. An Interview with Sensorband. *Computer Music Journal* 22, 1 (1998), 13–24.

[2] Kelsey Cotton, Pedro Sanches, Vasiliki Tsaknaki, and Pavel Karpashevich. 2021. The Body Electric: A NIME designed through and with the somatic experience of singing. In *Proceedings of the International Conference on New Interfaces for Musical Expression*. Shanghai, China, Article 27. https://doi.org/10.21428/92fbeb44.ec9f8fdd

[3] Richie Cyngler. 2017. Music for Various Groups of Performers (After Lucier): An Improvised Electroencephalographic Group Performance. In *Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition* (Singapore, Singapore) *(C&C '17)*. ACM, New York, NY, USA, 462–465.

[4] Lorenzo D'Orsi and Fabio Dei. 2018. What is a rite? Émile Durkheim, a hundred years later. *Open Information Science* 2, 1 (2018), 115–126.

[5] Rachel Freire, Valentin Martinez-Missir, Courtney N. Reed, and Paul Strohmeier. 2024. RaveNET: Connecting People and Exploring Liminal Space through Wearable Networks in Music Performance. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction* (Cork, Ireland) *(TEI '24)*. ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3623509.3635270

[6] Hannah Perner-Wilson. Accessed: 2023-11-23. The Gloves Project. https://theglovesproject.com/.

[7] Noura Howell, Greg Niemeyer, and Kimiko Ryokai. 2019. Life-Affirming Biosensing in Public: Sounding Heartbeats on a Red Bench. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland, UK) *(CHI '19)*. ACM, New York, NY, USA, 1–16.

[8] Ozgun Kilic Afsar, Yoav Luft, Kelsey Cotton, Ekaterina R. Stepanova, Claudia Núñez Pacheco, Rebecca Kleinberger, Fehmi Ben Abdesslem, Hiroshi Ishii, and Kristina Höök. 2023. Corsetto: A Kinesthetic Garment for Designing, Composing for, and Experiencing an Intersubjective Haptic Voice. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. ACM, New York, NY, USA, Article 181, 23 pages. https://doi.org/10.1145/3544548.3581294

[9] Jarrod Knibbe, Rachel Freire, Marion Koelle, and Paul Strohmeier. 2021. Skill-Sleeves: Designing Electrode Garments for Wearability. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction* (Salzburg, Austria) *(TEI '21)*. ACM, New York, NY, USA.

[10] Volker Krefeld and Michel Waisvisz. 1990. The Hand in the Web: An Interview with Michel Waisvisz. *Computer Music Journal* 14, 2 (1990), 28–33.

[11] Johan Liedgren, Pieter Desmet, and Andrea Gaggioli. 2023. Liminal design: A conceptual framework and three-step approach for developing technology that delivers transcendence and deeper experiences. *Frontiers in Psychology* 14 (02 2023), 1043170.

[12] Thomas J Mitchell, Sebastian Madgwick, and Imogen Heap. 2012. Musical interaction with hand posture and orientation: A toolbox of gestural control mechanisms. (2012).

[13] Luc Nijs, Micheline Lesaffre, and Marc Leman. 2009. The musical instrument as a natural extension of the musician. In *the 5th Conference of Interdisciplinary Musicology*. LAM-Institut jean Le Rond d'Alembert, 132–133.

[14] Courtney Reed, Sophie Skach, Paul Strohmeier, and MacPherson Andrew. 2022. Singing Knit: Soft Knit Biosensing for Augmenting Vocal Performances. In *Augmented Humans '22*. ACM, New York, NY, USA.

[15] Courtney N. Reed and Andrew P. McPherson. 2021. Surface Electromyography for Sensing Performance Intention and Musical Imagery in Vocalists. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction* (Salzburg, Austria) *(TEI '21)*. ACM, New York, NY, USA, Article 22, 11 pages.

[16] Melanie Takahashi and Tim Olaveson. 2003. MUSIC, DANCE AND RAVING BODIES: RAVING AS SPIRITUALITY IN THE CENTRAL CANADIAN RAVE SCENE. *Journal of Ritual Studies* 17, 2 (2003), 72–96.

[17] Kai Tuuri, Jaana Parviainen, and Antti Pirhonen. 2017. Who Controls Who? Embodied Control Within Human–Technology Choreographies. *Interacting with Computers* (Jan. 2017). https://doi.org/10.1093/iwc/iww040

A PERFORMANCE VIDEOS

A full-length performance video can be found in the Supplemental Material for this paper. A short demo and outline of the RaveNET nodes can be found here:
https://youtu.be/dzIxJwzZMiw?si=QbPrg5FEpYT18o9p.

B BIOGRAPHIES

Rachel Freire

Rachel Freire is an artist, designer and researcher working in clothing, costume and garment technology. They are a researcher at the Sensorimotor Interaction Group at the Max Planck Institute for Informatics and the Intangible Realities Laboratory, with a BA in Design for Performance from Central Saint Martins. Their work inhabits the liminal spaces where disciplines meet, with emphasis on intricate, evocative detailing, narrative garments and exploring the relationship between futuristic applications and traditional techniques. Their work is designed to tell stories, or to inspire them.

Valentin Martinez-Missir

Valentin is a French designer and researcher. He holds a Mastere degree from the DaVinci Insitute in Paris. He has published research on tactile interaction and haptics and works on tactile interfaces with the Sensorimotor Interaction Group. In his free time he practices DJ-ing and live improvisation with various electronic instruments. Valentin will perform on his Elektron Machinedrum and his Eurorack synthesizer for the proposed performance.

Courtney N. Reed

Courtney is a researcher at the Sensorimotor Interaction Group at the Max Planck Institute for Informatics. Her research investigates collaborations and dynamic roles between human bodies and machines in creative applications. She is interested in applying body sensing in augmenting and disrupting habitual practices to research vocal performance. Courtney is a semi-professional vocalist with work ranging from classical ensembles such as the London Philharmonic Choir to solo electronic improvisations and installations. Courtney will provide vocals for the proposed performance.

Paul Strohmeier

Paul leads the Sensorimotor Interaction Group at the Max Planck Institute for Informatics. His work sits at the intersection of technology design and human experiences, and includes explorations of novel sensing methods, wearable technology, and the relationship between actions and our experience of materials. Musically, Paul has been involved with several bands and projects across various genres, including folk, metal, and electronic music. His most prolific project, Logathore, originated in Belarus and has performed in both Belarus and across Austria. For the proposed performance, Paul will play bass and provides additional vocals.