Built to Perform

Designing Digital Musical Instruments for Professional Use

Ph.D. thesis by
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Digital Musical Instruments

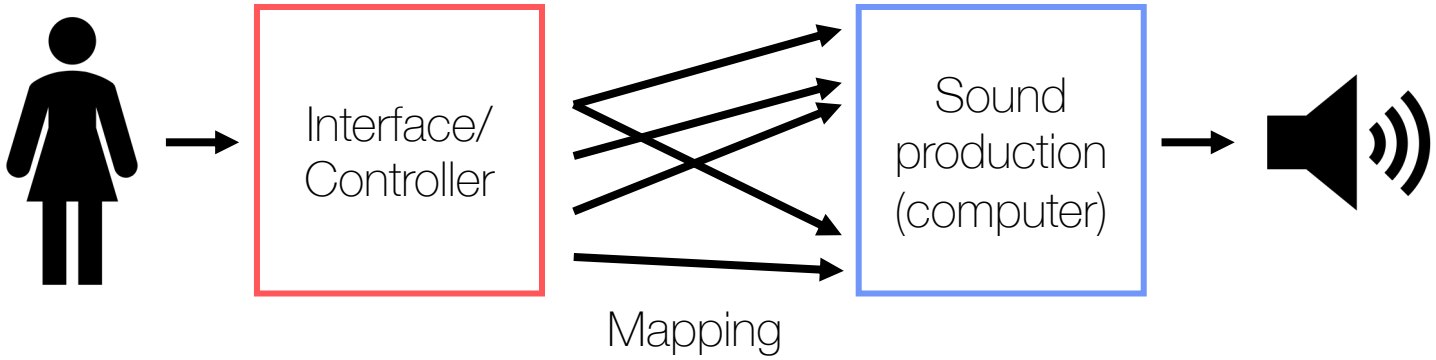


Figure adapted from Rovan, Wanderley, Dubnov & Depalle (1997)

Video: blablaTrains (Ana Dall'Ara-Majek and Takuto Fukuda). CIRMMT, Montreal, 2020.
Performance with two T-Sticks (instrument by J. Malloch)
Watch: https://youtu.be/e10h27TBzRk?t=63

DMI design research...

The Hands – M. Waisvisz (STEIM)

www.digitalbrainstorming.ch

Halldorophone – H. Úlfarsson

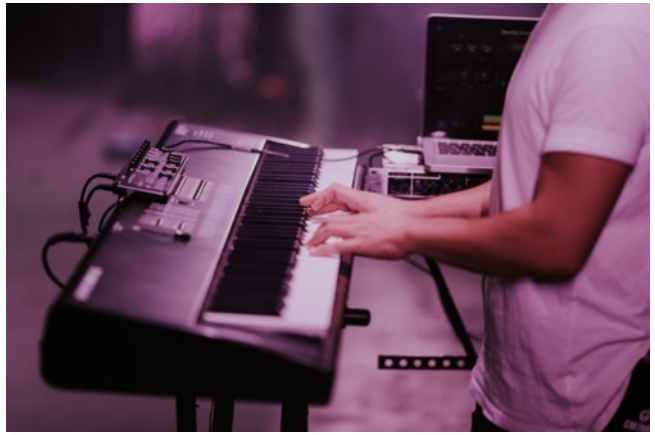
www.halldorophone.info

Prosthetic Instruments – J. Malloch, I. Hattwick (IDMIL)

www.idmil.org

...vs professional performance

piano-style keyboards



📸 Kevin Britos on Unsplash

MIDI controllers connected to computer software

📸 www.mmmmaven.com

DJ tools, digital turntables and mixers

📸 Kofi Nuamah Barden on Unsplash

What's missing:

- DMI use constrained to narrow contexts of contemporary experimental styles
- "The Problem of the Second Performer" (McPherson & Kim 2012)
- Addressing the specific demands of active/professional performance in design (Sullivan & Wanderley, 2018)

Motivation and background

- performance background
- prioritizing musicians' involvement
- Human-Computer Interaction (HCI) / Human-Centered Design (HCD)
- exploratory, practice-based approach

Post Provost, Portland, ME, US (2011)

personal archive

Research Questions	Projects	Thesis Chapter
How do active and professional musicians in diverse performance communities engage with new instruments?	The Electronic Musical Instrument Survey	Chapter 2
Can designers effectively leverage the embodied knowledge and experience of performers through applied design activities?	Design for Performance workshop and DMI design	Chapters 3 & 4
How can ongoing collaboration with active musicians support the development of new DMIs that are optimized for long-term professional use?	Collaborative design of augmented harp interfaces	Chapter 5

The Electronic Musical Instrument Survey

Background

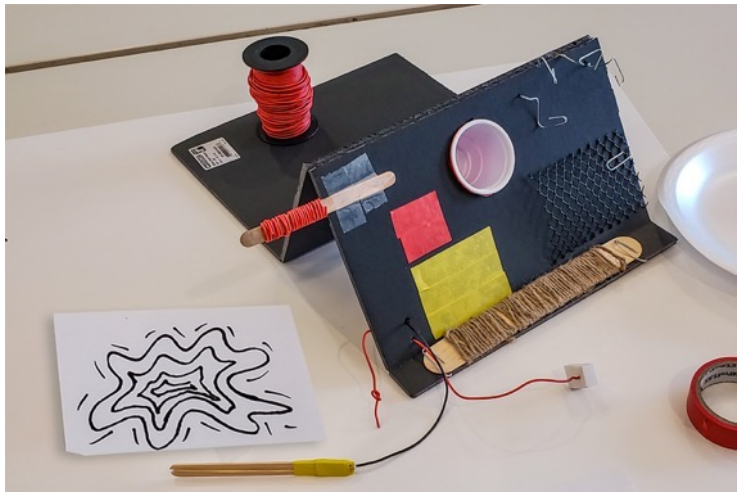
- Previous surveys have investigated performance in DMI research communities like NIME (New Interfaces for Musical Expression)
- Lack of research on more widespread and popular performance
- Designer/performers in NIME, less in professional practice

“electronic musical instruments”

Results

Analysis	Theme	List of considerations
thematic (**inductive**)	Desirable qualities of DMIs	• handling complexity • accommodate unique performer requirements • suitable for appropriation
	Up-take and retirement of instruments	• desire new features, controls, sounds • reliability concerns • instrument loyalty
thematic (**deductive**)	Factors for user engagement (O'Brien & Toms 2008, Wallis, et al. 2013)	• ownership and novelty • complexity and challenge • immediacy, incrementality, and reliability

Design for Performance workshop



Motivation

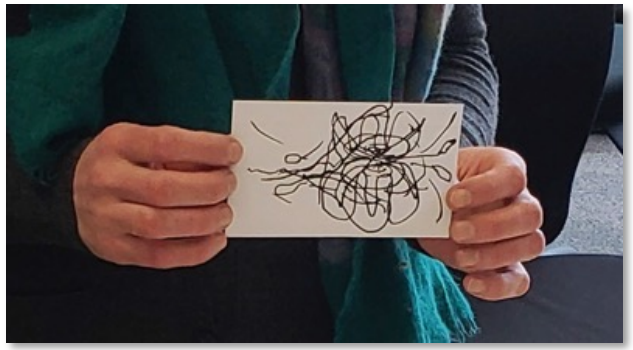
- Investigating novel methods for creative design of new DMIs
- Using human-centered and participatory design methods
- Co-design with expert performers

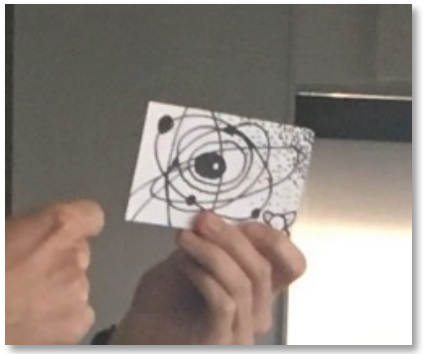
Background

- Design fiction: concepts and problems can be examined through creation of imaginary scenarios and “fantasy prototypes” (Sterling 2009)
- Magic Machine Workshops: building design knowledge “about technology, rather than of technology” (Andersen and Wakkary 2019)

Workshop activities

- **Design prompt**: “Draw the music”
- **Non-functional prototyping**: crafting imaginary instruments
- **Presentations**: describe and demonstrate
- Key element identification → dot voting → closing discussion

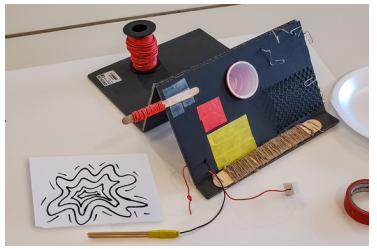




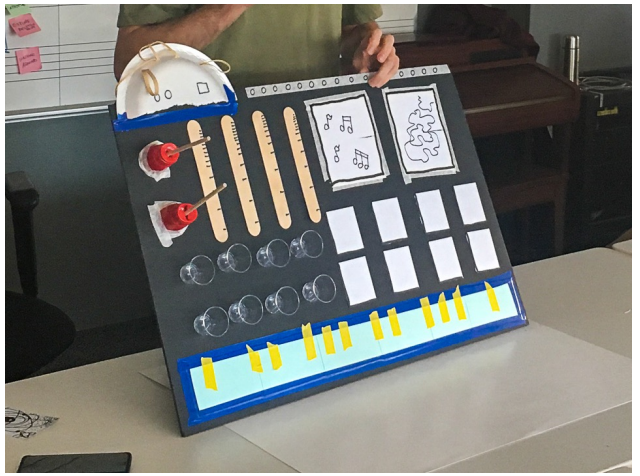
Design specifications

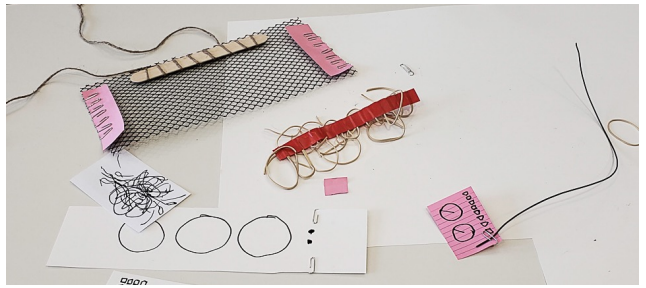
1. Prioritize **embodied, physical, and material-oriented interactions**.
2. Feature **flexible signal routing and mappings**.
3. Feature **multiple modes or modules of operation**.
4. Integrate **external audio input and resonant acoustic features; sample, synthesize, mix and modulate** audio signals.
5. **Mix familiar and novel** interactions and sound production.

resonant electroacoustic sculpture



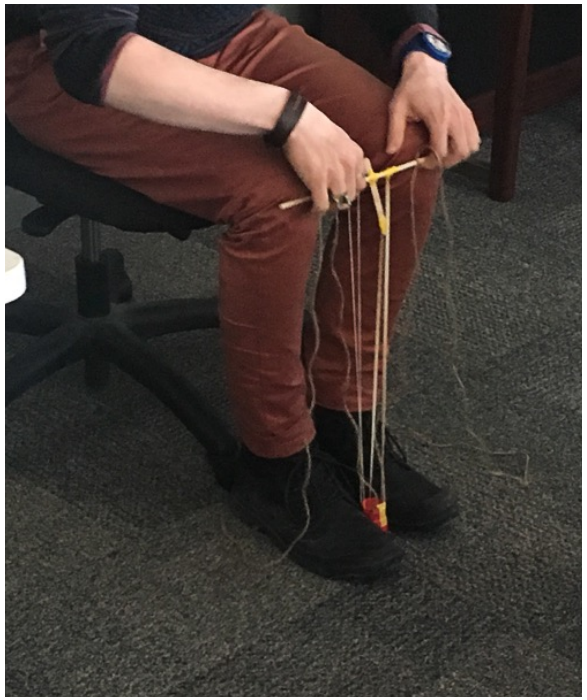
multi-fuction digital performance workstation





modular signal matrix synth and FM radio receiver

guitar x vocal scrambler



hand- and foot-controlled string instrument

From fiction to function

v1. (Sullivan 2015)

v2.

Keybox

- polyphonic subtractive synth with filter, sampler/looper, FX
- OLED display
- multifunction rotary encoders and buttons
- 20-note capacitive touch keyboard

Stringbox

- Exploring tangible, physical interaction
- 4 strings with custom piezo pickups
- dual synthesis modes:
  - guitar-like
  - sequencer/groove box

Tapbox

- digital percussion instrument
- isolated panels with piezo elements
- dual motion-controlled synthesis modes:
  - 808 drum synth
  - physical modeling

Design specification:

3. Feature multiple modes or modules of operation

Application:

- Functions as keyboard synth, effects processor, sampler/looper

Design specification:

5. Mix familiar and novel interactions and sound production

Application:

- Combines guitar form and strings with grid and motion control

Design specification:

1. Prioritize embodied, physical, and material-oriented interactions

Application:

- Instrument walls are highly sensitive percussion triggers

Design for Professionals: Case Study of Concert Harp

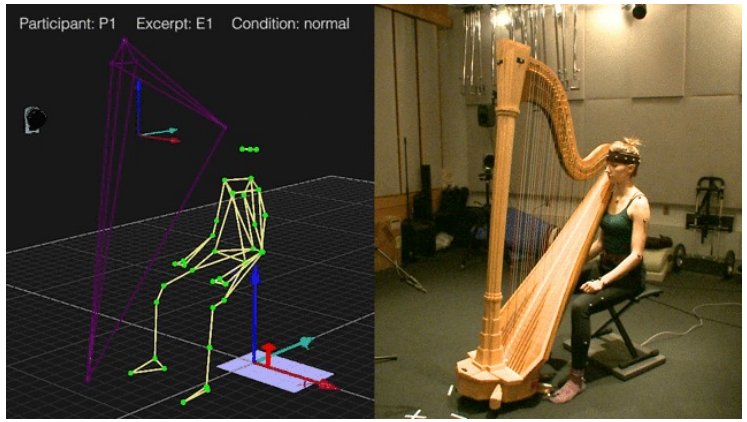
Collaborative DMI design

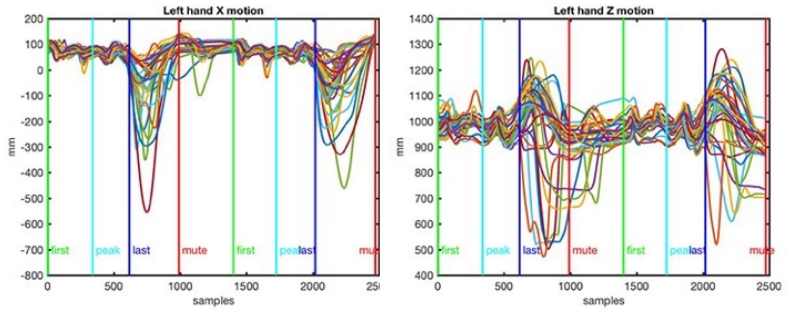
- Practice-based research and design carried out with professional performer
- Bespoke designs tailored to the unique needs of their practice
- Direct integration into collaborator's real-world professional live performance setup

1. Gestural Control of Augmented Instrumental Performance

with Alexandra Tibbitts (harpist/motion capture), Ólafur Bogason (hardware development), Brice Gatinet (composition)

A) Motion capture study





B) Hardware/software design

C) Rehearsal & performance

2. The Bionic Harpist

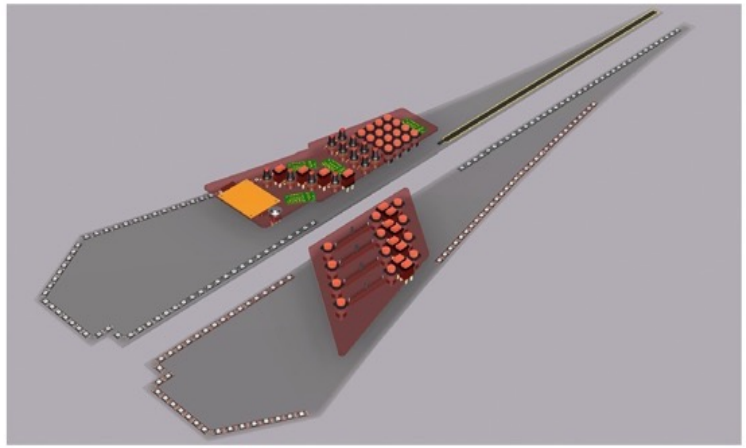
Specifications

1. Physically augment the harp
2. Simple configuration into performance workflow
3. Non-permanent, removeable
4. Ergonomic and non-invasive

Participatory design

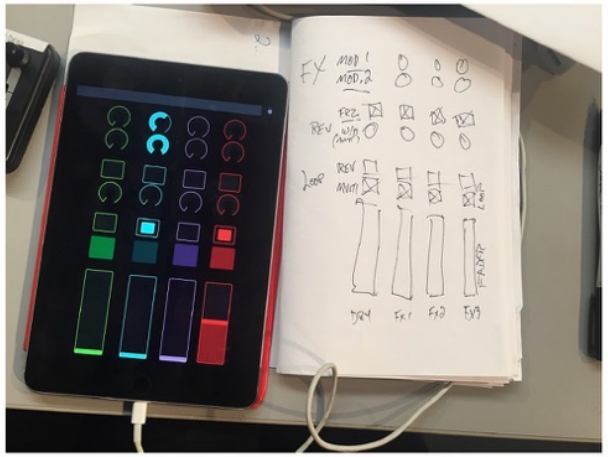
- Ideation, sketches
- Non-functional and functional prototyping
- Fabrication
- Testing
- Customization
- Performance

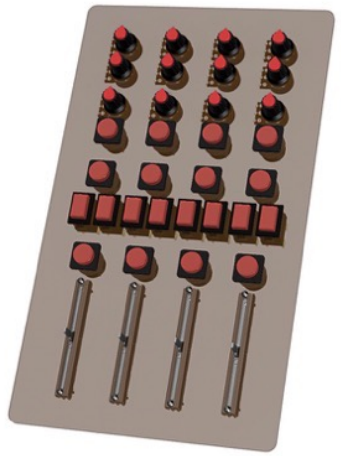
Prototyping



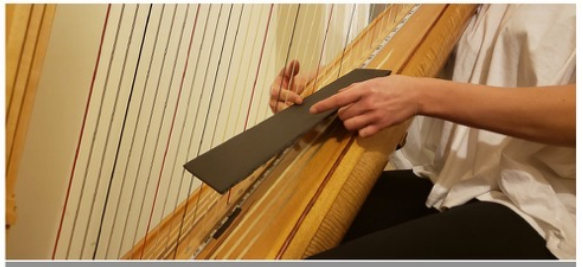
non-functional prototypes to CAD models

from sketches to CAD and functional digital interfaces

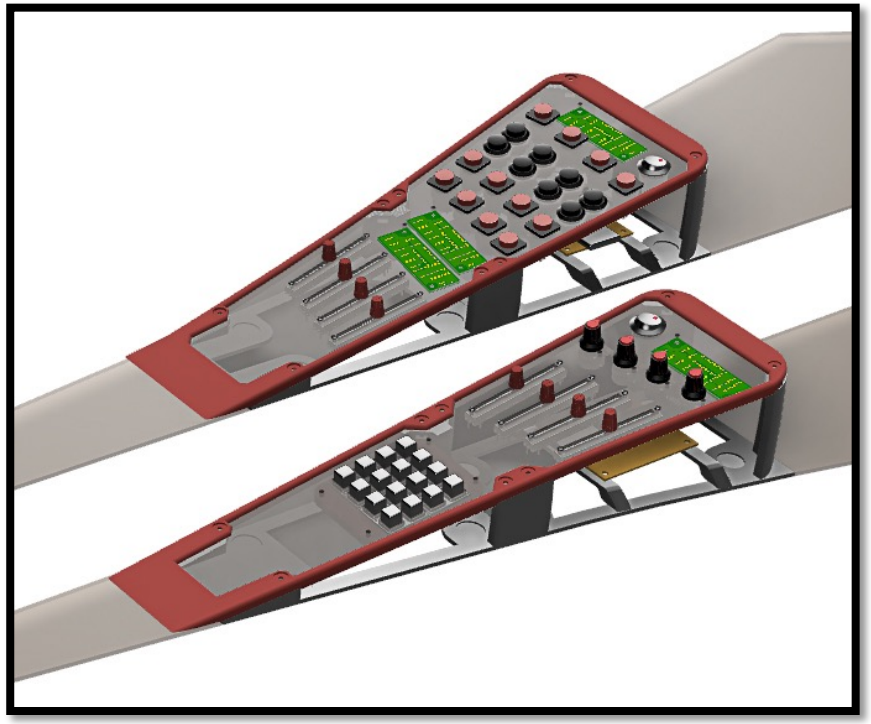




testing ergonomics with cardboard prototypes



The Bionic Harpist controllers



Performance

- MUTEK Montreal, September 2020 (video)
- MUTEK JP/MX (w/ Porto Porto!) December 2020
- “Music Rooms” Big Bang Festival February 2021
- ...now part of performance setup and used regularly

Composition and performance by Alexandra Tibbitts. Video courtesy of MUTEK.org

Contributions

The Electronic Musical Instrument Survey	Design for Performance	Design for Professionals: Case Study of Concert Harp

Research Questions

How do active and professional performers across diverse communities of practice engage with new instruments?	• Survey and workshop provided information to better understand the needs and priorities of active performers
Can designers effectively leverage the embodied knowledge and experience of performers through applied design activities?	• Methodology: Employing design fiction to generate novel instrument ideas and engaging performers deeply in the design process
How can ongoing collaboration with active musicians support the development of new DMIs that are optimized for long-term professional use?	• A model for Integrating design directly with professional performance practice, demonstrating iterative long-term projects leading to long-term DMI use

Limitations and Future Work

Understanding performance communities:

- **Limitation**: More data is needed to fully explore diversity across different performance attributes.
- **Future work:** Interview studies and workshops with specific performance groups (e.g, experimental vs popular performers, designers vs. non-designers)

Co-design workshops and evaluation:

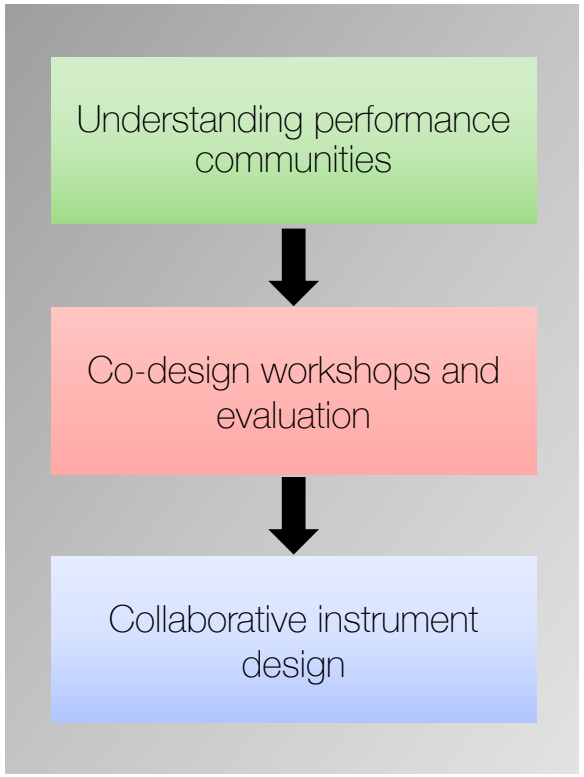
- **Limitation**: Follow-up workshop sessions were cancelled due to COVID-19 restrictions but should be included in future workshops
- **Future work**: Longitudinal studies to evaluate workshop-driven designs based on the survey results

Collaborative instrument design:

- **Future work**: Controller designs can be adapted into a flexible framework for augmented acoustic instruments.
- **Future work:** Developing workshop model into long-term design collaborations


Understanding performance communities
Co-design workshops and evaluation
Collaborative instrument design

Thank you!



References

Rovan, J. B., Wanderley, M., Dubnov, S., & Depalle, P. (1997). Instrumental Gestural Mapping Strategies as Expressivity Determinants in Computer Music Performance. In Proceedings of Kansei- The Technology of Emotion Workshop. Genova. IT.

McPherson, A. P., & Kim, Y. (2012). The Problem of the Second Performer: Building a Community Around an Augmented Piano. Computer Music Journal, 36(4), 10–27.

Sullivan, J., & Wanderley, M. M. (2018). Stability, Reliability, Compatibility: Reviewing 40 Years of DMI Design. In SMC (pp. 319--326). Limassol, Cyprus.

O'Brien, H. L., & Toms, E. G. (2008). What is User Engagement? A Conceptual Framework for Defining User Engagement with Technology. Journal of the American Society for Information Science and Technology, 59(6), 938–955.

Wallis, I., Ingalls, T., Campana, E., & Vuong, C. (2013). Amateur Musicians, Long-Term Engagement, and HCI. In S. Holland, K. Wilkie, P. Mulholland, & A. Seago (Eds.), Music and Human-Computer Interaction (pp. 49--66). Springer

Sterling, B. (2009). Design Fiction. Interactions, 16(3), 20–24.

Andersen, K., & Wakkary, R. (2019). The Magic Machine Workshops: Making Personal Design Knowledge. In CHI (pp. 1–13). Glasgow, Scotland.

Sullivan, J. (2015). Noisebox: Design and Prototype of a New Digital Musical Instrument. In ICMC (pp. 266–269). Denton, US.