Institution: University of Sussex		
Unit of Assessment: 33 – Music, Drama, Dance, Performing Arts, Film and Screen Studies		
Title of case study: Innovating and Opening Up Live Coding for Artists and Non-Specialist Users		
Period when the underpinning research was undertaken: 2013 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Thor Magnusson	Professor of Future Music; Head of Department of Music	2013 – present
Period when the claimed impact occurred: 2013 – 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

Live Coding is an improvisational way of making and performing electronic music with a computer where the computer code is made visible to the audience. Magnusson's research and the resulting software (*ixi lang* in particular) have transformed the way that live coding can be produced, broadening the landscape of creative practice, opening up the field to non-specialist users and expanding the diversity of those involved. *ixi lang* has been taken up extensively by live coding artists. Beneficiaries of the software releases, code libraries, workshops, tutorials and performances range from creative practitioners to those new to coding or live coding music, many of whom are women – traditionally considered a minority group in the male-dominated fields of coding (in general) and live coding music (in particular).

2. Underpinning research

Magnusson designed and directed an AHRC-funded Live Coding Research Network (2014) which has yielded a series of workshops, software releases and tutorials, and the yearly International Conference on Live Coding (https://iclc.toplap.org/). As part of his two-year AHRC Leadership Fellowship, Magnusson ran open symposia on new music, for example, the Musical Organics symposium at STEIM (http://www.sonicwriting.org/steim.html) and the New Notations symposium at IRCAM (http://www.sonicwriting.org/ircam.html). These public events were both part of the research and also contributed to further practice-based and theoretical research.

As part of this AHRC-funded research [G1] Magnusson has developed and distributed three live coding systems: *ixi lang Qt* [R1], and more recently *Threnoscope* [R2] and *Sema* [R3]. A simple way to encode music, *ixi lang* is a notational live coding language that focuses on speedy input, redesign, re-evaluation, manipulation of coders' scores and the routing of coders' output through effects. *Threnoscope* is a live coding system focused on three key areas of music: spatial sound, timbre and texture, and tunings and scales [R2]. *Sema,* developed by Magnusson and his team in Sussex's Experimental Music Technologies Lab (www.emutelab.org), as part of the MIMIC (Musically Intelligent Machines Interacting Creatively) project allows non-programmers to create their own live coding languages for machine learning [R3] [G3]. Since *Sema*'s launch in May 2020, Magnusson has been active in fostering a user community around the *Sema* system for language design for machine learning (http://www.sema.codes). Through public facing workshops, including 200 international participants in an online workshop in summer 2020, the system is gaining popular usage across the globe. Together the *ixi lang, Threnoscope* and *Sema* live coding systems represent a paradigm shift in live coding practice, opening it up for the use of Artificial Intelligence (AI) as part of realtime performance, and enabling people to design their own languages for personal expression, rather than being restricted by the structures of established systems.

This practice-based research on live coding systems has been informed by Magnusson's AHRC funded investigation into the role of technology in musical expression [G2]. His monograph, *Sonic Writing* (2019) [R4] theoretically underpins these new technological developments. The book describes the profound effect of new digital music technologies on musical expression, exploring how new computational technologies, including machine learning, are transforming our musical practices. Magnusson provides a conceptual framework for the creation and analysis of new musical work, grounding digital musical practices in historical instances of technological adaptation and new instrument design. *Sonic Writing* introduced the notion of 'new systematicity' as a trend in contemporary musical practice where the focus moves from the piece to a system generating infinite versions of the music. The research was disseminated through hands-on involvement with professional and amateur musicians through international workshops, symposia, and performance, for example, teaching live coding at the influential Darmstadt Summer School of New Music (2018). This theoretical contribution is extended through articles in journals such as *Tempo* [R5] and *Journal of New Music Research* [R6].

3. References to the research

Practice-based research:

R1. ***ixi lang Qt.*** An early version of this software was released in 2009 and submitted to REF 2014, but this version was launched in 2015, with significant changes as a cross-platform *ixi lang Qt*. The system is available here: http://www.ixi-audio.net/ixilang/

R2. **The Threnoscope** live coding system. Magnusson has performed publicly with this system since 2014, influencing ideas of visual design in live coding. https://thormagnusson.github.io/threnoscope/

R3. **Sema** (2019) is a system for users to create their own live coding languages for machine learning as part of the £1m AHRC funded MIMIC project [G3]. www.sema.codes

Theoretical research:

R4. Magnusson, Thor (2019), *Sonic Writing: Technologies of Material, Symbolic and Signal Inscriptions.* New York: Bloomsbury Academic. https://www.bloomsbury.com/uk/sonic-writing-9781501313868/ Submitted to REF2.

R5. Thor Magnusson (2019) 'Ergodynamics and a semiotics of instrumental composition,' *Tempo.* Issue 73 (287), 41-51. DOI: https://doi.org/10.1017/S0040298218000633

R6. Thor Magnusson (2017) 'Musical Organics: A Heterarchical Approach to Digital Organology,' *Journal of New Music Research*, 46(3), 286-303, DOI: https://doi.org/10.1080/09298215.2017.1353636

Grants:

G1. AHRC Live Coding Research Network (AH/L007266/1). Total awarded £27,806; £13,765 to Sussex (PI: Magnusson). 2014 – 2016. The network created a community of live coders across the globe and resulted in the ongoing International Conference on Live Coding (ICLC): https://iclc.toplap.org

G2. AHRC Leadership Fellow Grant (AH/N00194X/1) "Sonic Writing". Total project fund £239,735, including £190,267 from AHRC to Sussex (PI: Magnusson). 2016 – 2019. This project involved organising publicly open research events that led to the writing of the Sonic Writing monograph. Project website: www.sonicwriting.org

G3. AHRC Research Grant (AH/R002657/1) MIMIC (Musically Intelligent Machines Interacting Creatively) of which Sema is part. Total awarded £806,693; £235,050 to Sussex (Co-I: Magnusson). 2018 – 2021. https://mimicproject.com/. Run by teams at Goldsmiths College, Durham University and the University of Sussex. The project is ongoing but has resulted in a recent MOOC (massive open online course) on machine learning in the arts (~2500 people enrolled, Jan 2021). This MOOC was recommended by the UK Government in their "Skills Toolkit". *Sema* is part of the MIMIC project, integrated with it, and it has recently been awarded a £80,583 follow-on grant (2021) from the AHRC (AH/V005154/1).

4. Details of the impact

Magnusson's research has transformed the way music is produced by changing and shaping coding practices and creative practitioner communities nationally and internationally. Magnusson's live coding systems, particularly *ixi lang*, have both contributed to technical innovation in music practice, and respond to live coding's 'diversity problem', enabling access for new users including non-programmers and women who are, due to 'a significant imbalance in gender' in the wider coding community and in 'music technology' in particular, traditionally an underrepresented group (Shelly Knotts, e.g. https://youtu.be/PboSZGllzsU).

Contribution to technical innovation in musical practice

Magnusson's research has been pivotal in furthering technical innovation in the field of live coding, by providing the foundations and 'inspiration' [S1, p. 173]] for other systems. Since 2019, *ixi lang* has been integrated into the most widely used live coding system [S2], Sonic Pi (https://sonic-pi.net/). Sonic Pi was initially designed to reduce 'barriers to […] coding and is used in both educational settings and by professional performers, composers, musicians' [S3], and has been downloaded more than a million times [S4]. Even before its integration into this influential system, *ixi lang* was, as Sonic Pi's creator Sam Aaron notes, 'a large influence [on Sonic Pi] with respect to [*ixi lang's*] simple uncluttered syntax and tight relationship between visible syntax and sound' [S5 p.7].

Magnusson's research, shared in workshops such as the one held at STEIM, has been instrumental in further technological innovations. According to [text removed for publication], Magnusson's research 'had a major beneficial impact on the commercialisation of Bela, an open source platform for creating musical instruments.' [S6] The open source nature of Magnusson's software means it is impossible to trace all of the many developer iterations of *ixi lang*, but some of the most prominent include WulfCode [S7] and Atomiix from Rumblesan [S8].

Changing music practice amongst industry professionals

Magnusson's Live Coding Research Network, the resulting software, workshops, talks and training, as well as live coding conferences (https://iclc.toplap.org/) in Ireland, Spain, Mexico, Canada and the UK, have shaped networks of pioneering practitioners across the globe and been influential in the development of live coding and the culture and community of Algorave (https://algorave.com/) – a dance party in which 'DJs' live code music and the audience watches the code projected behind them. *ixi lang* is widely used internationally by a diverse range of Algorave artists including UK-based Belisha Beacon [S9] and Deerful [S10].

Jesús Jara López, cultural programmer of the Media Lab Prado (Madrid) directly accredits Magnusson with initiating profound shifts in music practice. Magnusson's workshops in Spain, he suggests, 'show[ed] musicians new ways of making music … [T]hat was a big change because people were used to thinking that only professionals could make electronic music… [it] was game-changing' [S11]

Other practitioners have described how the system opened up a new world of musical expression to them. Ash Sagar, digital sonic artist, notes, '*ixi lang* was a way for me to use the computer as a musical instrument. It provided a high-level entry into making live music with computer code' [S12]. Dorien Schampert, who performs as Algorave artist Beacon, talks about how *ixi lang* 'facilitates improvisation and has helped me get over my perfectionism […] It has kick-started a new chapter in my music career' [S13].

Opening up live coding to non coders and to underrepresented groups

Magnusson's live coding systems and tutorials have been recognized as an ideal educational tool and invaluable for getting non-programmers started on their path to mastering computer programming and those with knowledge of music on the path to live coding music. Sam Aaron, of Sonic Pi fame, notes that *ixi lang* 'allows people to take first steps in coding who wouldn't do so otherwise, which is why it works as a "first contact" experience of live coding.' [S3]

Shelly Knotts, a specialist in teaching live coding to women and children in a range of settings, including the Montreal Arts Festival and the National Media Museum in Bradford, also notes *ixi lang*'s suitability 'for people who've never done live coding.' [S14] Through Yorkshire Sound

Women Network (YSWN) (https://yorkshiresoundwomen.com/), a network for women interested in music technology, Knotts ran a workshop for 20 female participants, some of whom were 'non coders with knowledge of music' and others who had 'knowledge of computer code' in December 2015, designed to introduce them to *ixi lang* (https://youtu.be/PboSZGllzsU). One attendee – Schampert, mentioned above – has gone on to perform as Belisha Beacon, a live coding artist in the Algorave scene [S9]. In an article for *Mixmag*, the electronic music and clubbing magazine, the journalist Isabelle Bolt described a women-only live coding workshop that used *ixi lang*, praising its useability for an inexperienced coder [S15]. Similar observations were made by a female interviewee and noted in an article by Joanne Armitage in *Dancecult: The Journal of Electronic Dance and Music Culture* [S16].

As well as inspiring and shaping new live coding systems and communities amongst creative practitioner professionals in the UK and internationally, Magnusson's 'intuitive' [S13] *ixi lang* has made live coding accessible to non-programmers, democratising this skill, and thereby transforming the field.

5. Sources to corroborate the impact

S1. Sam Aaron, (2016) 'Sonic Pi - performance in education and technology and art' *International Journal of Arts and Digital Media* 12(1), 171-178 [p. 173]. https://doi.org/10.1080/14794713.2016.1227593

S2. Code showing *ixi lang* being integrated into Sonic Pi https://github.com/sonic-pi-net/sonic-pi/blob/main/app/server/ruby/lib/sonicpi/lang/ixi.rb

S3. Sam Aaron, live coder and CEO of Sonic Pi. Interview transcript. Audio recording available.

S4. Sonic Pi One Million users, Apr 2018 https://in-thread.sonic-pi.net/t/one-million-users/987

S5. 'Craft Practices of Live Coding Language Design (2015)' Sam Aaron on *ixi lang*'s influence on Sonic Pi. (Proceedings of the First International Conference on Live Coding, Leeds), p. 7.

S6. [text removed for publication], Bela – an open source platform for creating musical instruments, 13 Sep 2017.

S7. Wulfcode -MIDI livecoding environment. Credits Magnusson's 'ixilang' (mp4 file) (2014) https://www.youtube.com/watch?v=F2--JzAvPsg

S8. Atomiix – a 're-implementation of the *ixi lang* live-coding environment.' (2019) (archived webpage) https://github.com/rumblesan/atomiix

S9. Belisha Beacon – Interview in *ATT:Magazine* Jack Chuter, Apr 2017 https://www.attnmagazine.co.uk/features/11610

S10. Deerful Album (2018) – made with *ixi lang*. https://deerful.bandcamp.com/album/tell-me-i-can-fix-this-on-my-own

S11. Jesús Jara López, cultural programmer of the Media Lab Prado. Interview transcript. Audio recording available, 30 Aug 2018.

S12. Ash Sagar, digital sonic artist, personal communication, 5 May 2015.

S13. Dorien Schampert (aka Algorave artist Belisha Beacon) on *ixi lang*, email, 26 Sep 2017.

S14. Shelly Knotts, composer, performer and improvisor of live coded music. Interview transcript. Audio recording available, 30 Aug 2018.

S15. 'Meet the Female Coders' article in *Mixmag*, showing how *ixi lang* has been adopted by people in Algorave, particularly in workshops focusing on diversity and gender, Aug 2017: http://mixmag.net/feature/female-coders-algorave

S16. Joanne Armitage 'Spaces to Fail in: Negotiating Gender, Community and Technology in Algorave' *Dancecult: Journal of Electronic Dance Music Culture* 10.1, 31-45 [p. 32 and throughout] Nov 2018. http://dx.doi.org/10.12801/1947-5403.2018.10.01.02