Music and Well-being:
Leveraging music interventions and technology for health

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IPS-NAC Arts and Culture Research Symposium on Arts and Wellness

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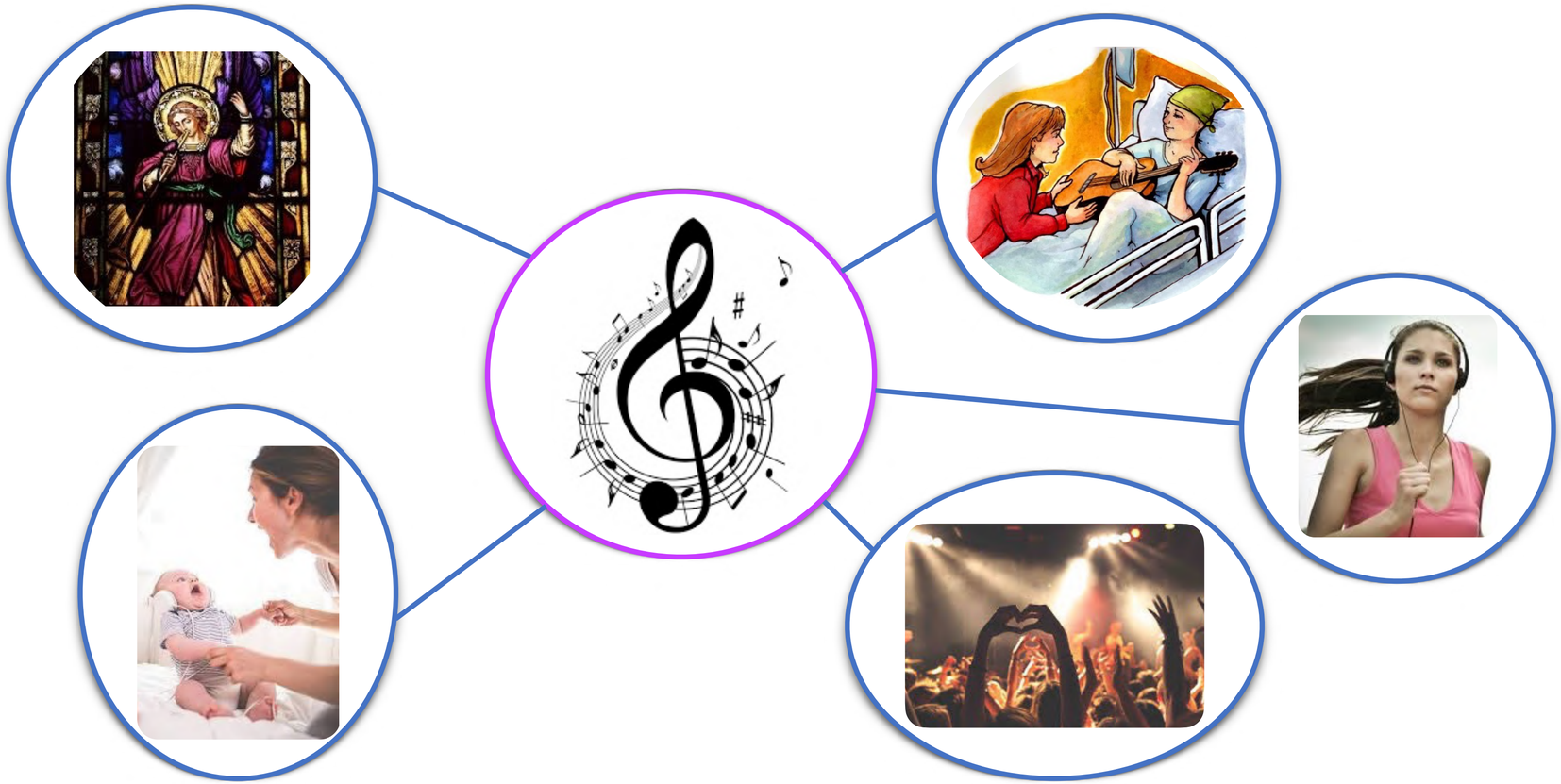
My background and research interests

- Examine **Music Cognition** using interdisciplinary methods (experimental psychology, computational modeling, neuroscience, etc)
- Investigate **how musical structure impacts listeners' perception, cognition, and emotional responses**
- I also have a background in **cello performance**
- Develop **music-based interventions for health and well-being**

The roles of music in society



Music supports Mental Health

Music supports our:

- **Mental health by decreasing anxiety and depression** (Irish, et al., 2006; Khalfa, Bella, Roy, Peretz, & Lupein, 2003; Thaut et al, 2009), for example, relaxing music interventions have been shown to reduce HR, respiratory rate, and state anxiety scores (White, 1992)

- **Emotional Resilience**: Participatory music programs can help foster social and emotional competencies as well as emotional resilience (Daykin, De Viggiani, Moriarty, & Pilkington, 2017), and can even foster resilience in those with serious illness, e.g., undergoing cancer treatment (Docherty et al., 2013)

- **Confidence**: Music-making activities can improve self-esteem and self-confidence in youth/students, victims of abuse, and in adults with mental health conditions (Clendenon-Wallen, 1991; Williams, Dingle, & Clift, 2018)

- **Social well-being**: Participating in musical activities (e.g., choral singing) can improve social bonding and help participants feel a sense of belonging (Williams, Dingle, & Clift, 2018)

Music supports Cognition

- **Improving executive functions**: Neurologic Music Therapy helps cognitive function (Thaut et al, 2009)
- **Pain reduction:** Greater pain reduction (Perlini and Viita, 1996) and greater pain tolerance (Mitchell, et al., 2006) during preferred music listening
- **Transfer effects**: Musical training improves novel word learning (Dittinger, et al, 2016) and verbal recall (Gfeller, 1983; Wallace, 1994; Wolfe & Hom, 1993)
- **Recovery from aphasia (language disorder)**: Melodic intonation therapy helps many patients with aphasia recover speech abilities (Altenmüller & Schlaug, 2013)
- **Memory performance**: Music can act as a memory enhancer in Alzheimer patients (Prickett & Moore, 1991; Simmons-Stern, Budson, & Ally, 2010), and can even help patients access non-musical autobiographical memories (Foster & Valentine, 2001; Irish, et al. 2006)

Music supports Motor Function

- **Improvement in movement, motor control, and gait**
  - Musical interventions improve gait in stroke rehabilitation patients (Thaut, McIntosh, & Rice, 1997; Hurt, Rice McIntish, & Thaut, 1998) and Parkinson's patients (see review by Dreu, van der Wilk, Poppe, Kwakkel, & van Wegen, 2012).
  - Musical training can also improve gross and fine motor skills (speed, accuracy, and smoothness of movement) in stroke patients (Schneider, et al, 2010) and hemiparetic arm rehabilitation patients (Yoo, 2009), and musical training has been shown to be more effective than conventional physiotherapy (Schneider, et al, 2010).

- **Motivating adherence**: Music shows promise in helping elderly persons adhere to prescribed PT exercise (Johnson, Otto, & Clair, 2001)

- **Mental practice**: Music and VR has been used to support mental practice of motor movements in stroke patients, leading to improved motor function (Trobia, Gaggioli, & Antonietti, 2011)

Music, Social Cohesion, and Quality of Life

Community music activities

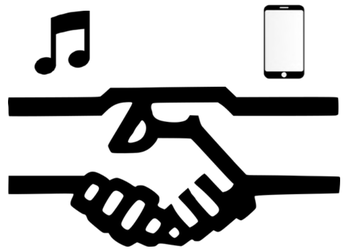
- **Group singing** has been used as an effective social intervention to support mental health. Group singing interventions can **improve emotional states** (increase positive emotions, reduce anxiety, elicit enjoyment), **enhance social bonding, increase self-confidence**, and help participants develop a **sense of belonging** (Williams, Dingle,& Clift, 2018)

- **Drumming interventions** have been shown to **increase social resilience**, **decrease depression/ anxiety**, and significantly **improve overall mental wellbeing**. Group drumming also **facilitates feelings of belonging, acceptance, safety and care**, and **stimulates new social interactions** (Fancourt, Perkins, Ascenso, Carvalho, Steptoe, & Williamon, 2016)

Where does technology come in?

Music technology for healthcare

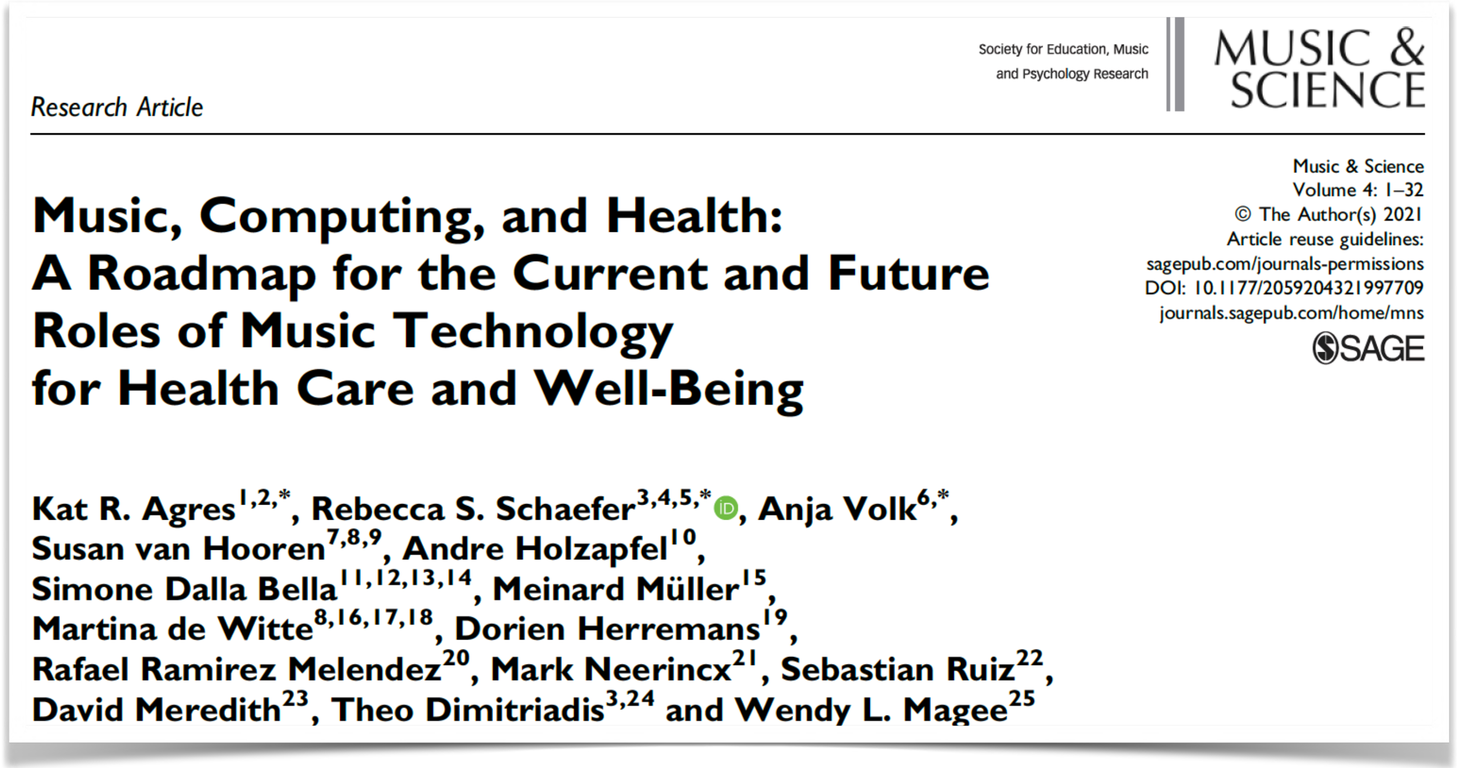
Music and technology go hand-in-hand…



Music can be integrated into real-time, interactive MedTech for an engaging, multi-modal, holistic approach to treatment of motor impairment, mental health illnesses, and neurological disorders.

- **Music interventions & technologies**: Engage participants cognitively and physically for a **faster recovery time**; can be **holistic** and **patient-centric**; are **non-invasive** and **non-pharmaceutical**; and can **reduce costs** of medicine, hospitals, and therapists/RNs

Music Technology for Health



Society for Education, Music and Psychology Research

MUSIC & SCIENCE

Research Article

Music, Computing, and Health: A Roadmap for the Current and Future Roles of Music Technology for Health Care and Well-Being

Music & Science
Volume 4: 1–32
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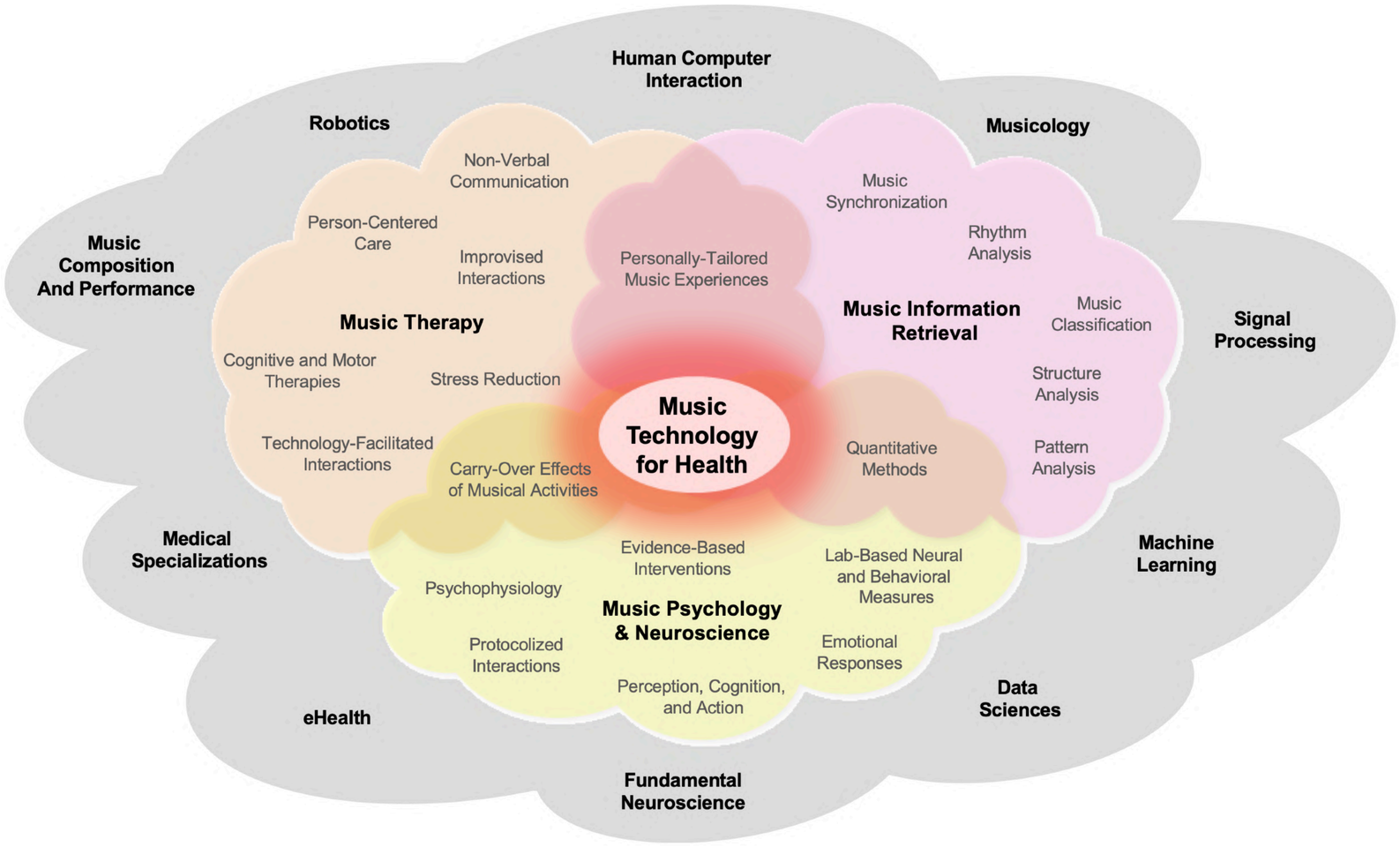
Kat R. Agres[1,2,*], Rebecca S. Schaefer[3,4,5,*], Anja Volk[6,*], Susan van Hooren[7,8,9], Andre Holzapfel[10], Simone Dalla Bella[11,12,13,14], Meinard Müller[15], Martina de Witte[8,16,17,18], Dorien Herremans[19], Rafael Ramirez Melendez[20], Mark Neerincx[21], Sebastian Ruiz[22], David Meredith[23], Theo Dimitriadis[3,24] and Wendy L. Magee[25]

QR code for the paper:

- Collaboration between researchers from music psychology & neuroscience, music therapy, music information retrieval (MIR), medical technology (MedTech), music technology, and robotics

Music Technology for Health



- The article discusses how these fields may interact to develop exciting new music technologies for health and well-being, capable of supporting person-centered care and evidence-based treatments
- Summarizes the state of the art in music technology for healthcare applications
- Provides a “roadmap” laying out possible future directions of this interdisciplinary intersection

Music technology for healthcare

Research Article

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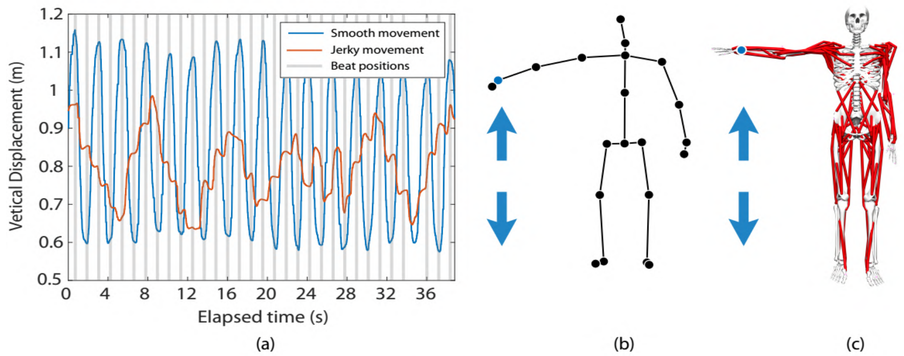
- We use the term **music technology** as “the umbrella term for software and hardware devices supporting digital means to analyze, process, generate, perform, edit, and interact with music”
- This encompasses:
  - supporting the creation, playing, and recording of music
  - providing feedback through the use of sound and music
  - employing musical interfaces for musical expression and creation
  - analyzing musical data produced within music therapy sessions

Use cases of Music Tech in Health



Kinematic analyses (moving to music). Satkunarajah & Agres (2021)

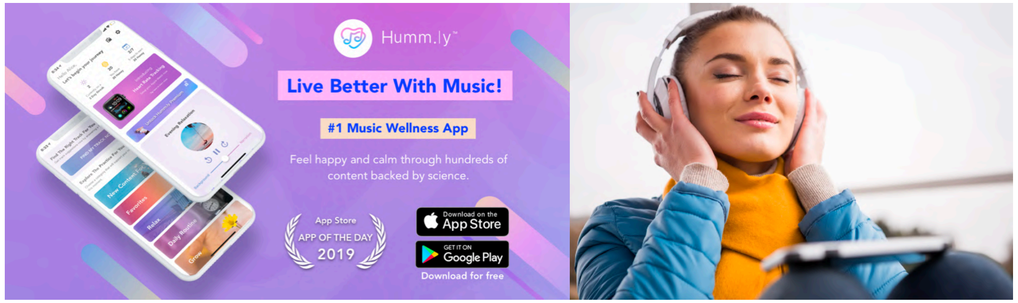
Data analysis

Vamvakousis, Z., & Ramirez, R. (2016)

Providing support for conducting music therapy sessions

Music games to increase engagement, support motor control and memory (Agres, Lui, & Herremans, 2019)

Tech for at-home training between MT sessions



Supporting health and well-being outside of MT contexts

Music therapy & technology study

ORIGINAL RESEARCH article

Front. Psychol., 21 May 2021 | https://doi.org/10.3389/fpsyg.2021.647790

frontiers in Psychology

Music Therapy During COVID-19: Changes to the Practice, Use of Technology, and What to Carry Forward in the Future

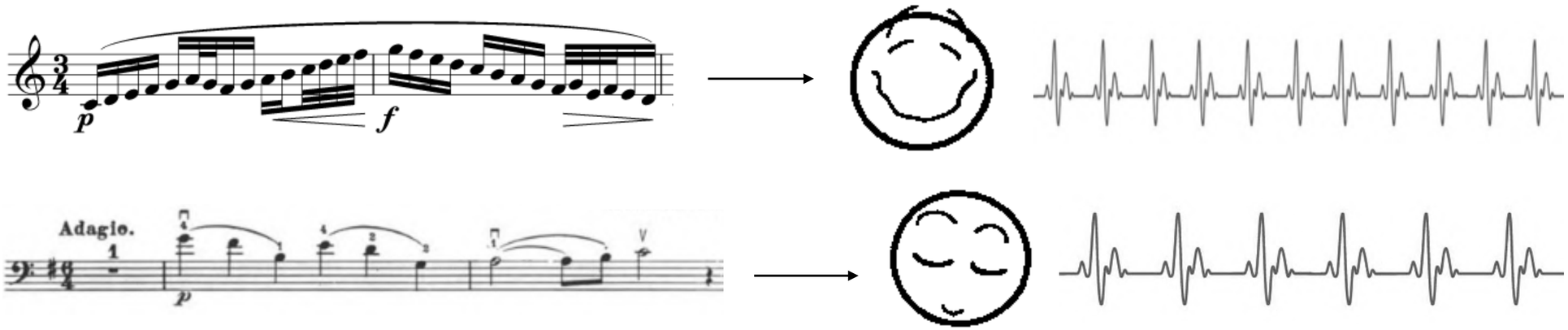
Kat R. Agres[1*], Katrien Foubert[2,3,4] and Siddarth Sridhar[5]

[1]Yong Siew Toh Conservatory of Music, National University of Singapore, Singapore, Singapore

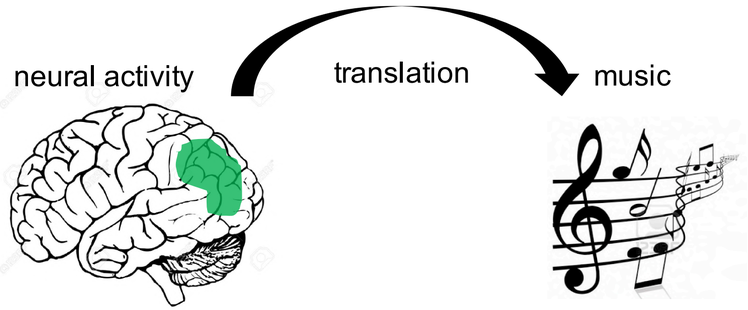
QR code for the paper:

- 87% of music therapists interviewed said they believe there is a **greater need for music therapy**, now due to Covid-19, but 80% had to **see fewer patients** (e.g., due to restrictions, social distancing measures)
- "Music is always about making a connection… and connection is precisely what we tend to lose during this time of isolation and quarantine."

Music-based BCIs

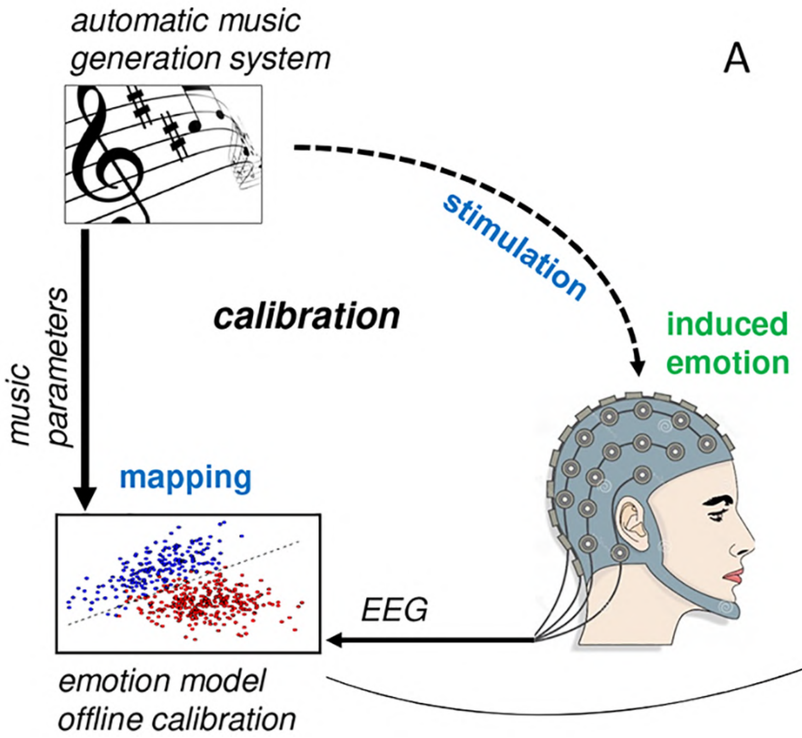


- Different **musical attributes** can lead to differing **physiological and neural responses**
- Real-time automatic music generation can leverage combinations of musical features to **enliven** or **relax listeners** in real time…
  - …and can be embedded into a BCI system to flexibly generate music in real time to listeners, based on their brain state



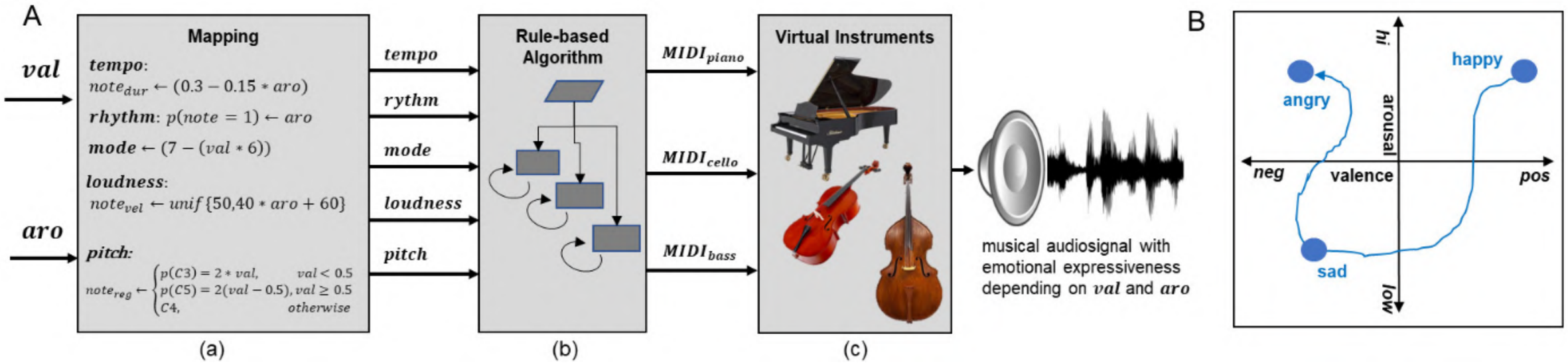
Music-based BCI study

- BCI system that uses algorithmic music generation to capture and influence a person's affective state in real time => **Closed-loop interaction between participant's brain responses and music**



Ehrlich, Kat Agres, Cuntai Guan, & Gordon Cheng (*PLOS One*, 2019)

Automatic music generation system



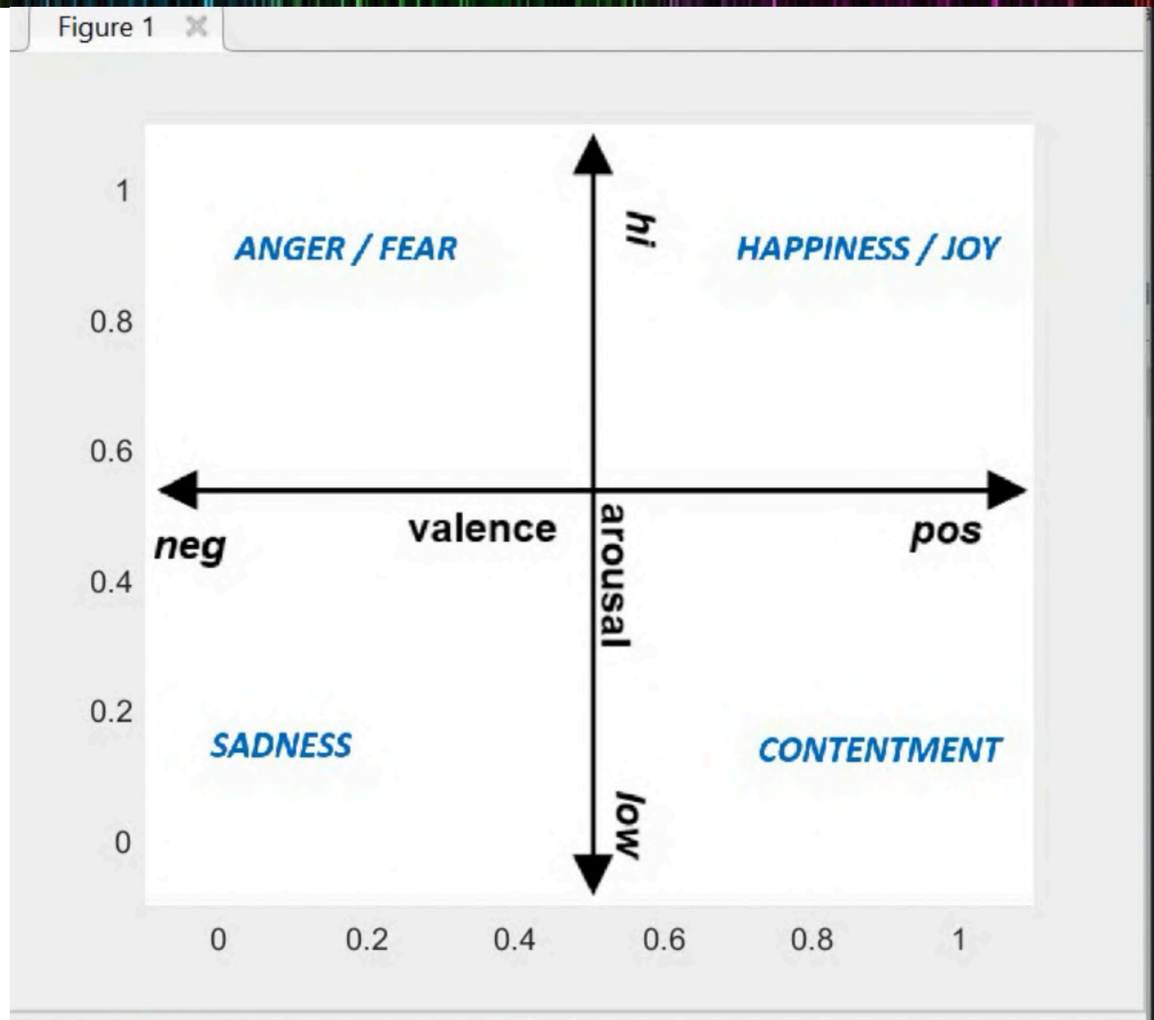
Music generation algorithm:

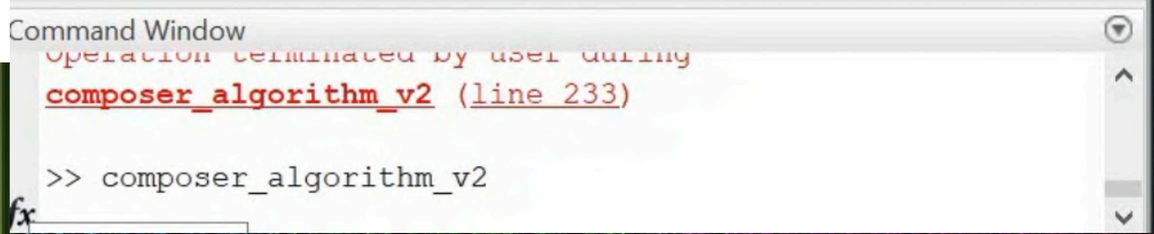
A. Mapping emotion states (valence and arousal) onto musical parameters, and ultimately translating those MIDI patterns into high quality *affective* music.

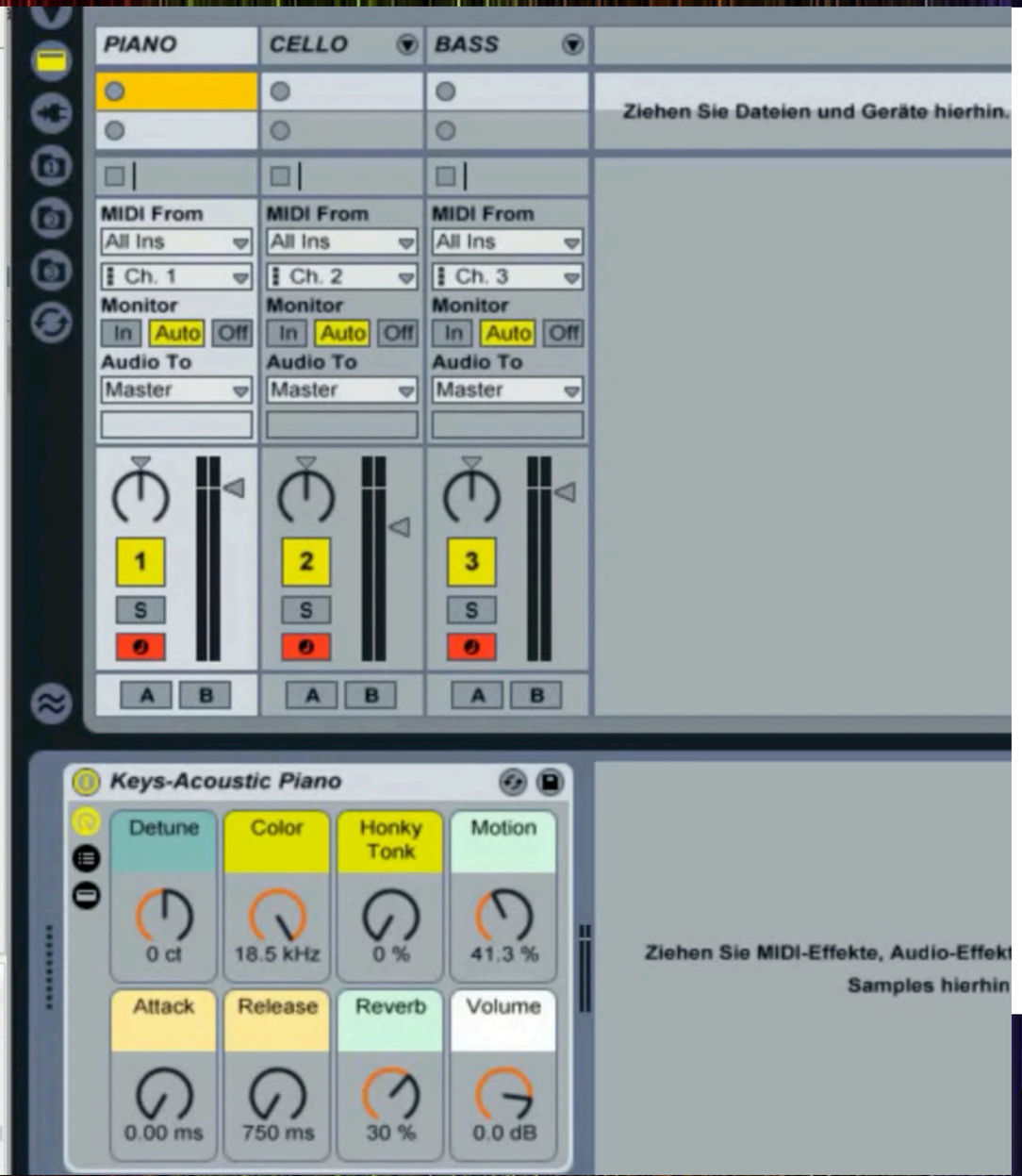
B. Example of musical trajectory through affective space (valence-arousal-model; see Russell, 1980)

Ehrlich, Kat Agres, Cuntai Guan, & Gordon Cheng (*PLOS One*, 2019)

Automatic music generation system

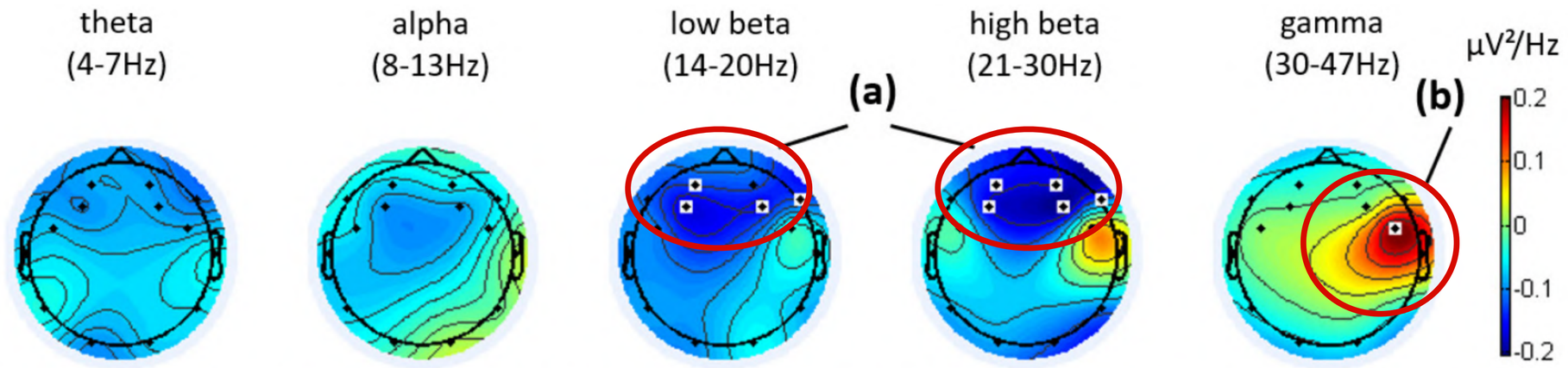






Music-based BCI study

Brain activity during ‘modulate to happy’ task



Significant power decrease in beta band over frontal areas (a), and an increase in gamma power over the right hemisphere (b)

Stefan Ehrlich, Kat Agres, Cuntai Guan & Gordon Cheng (*PLOS One*, 2019)

Music-based BCI study

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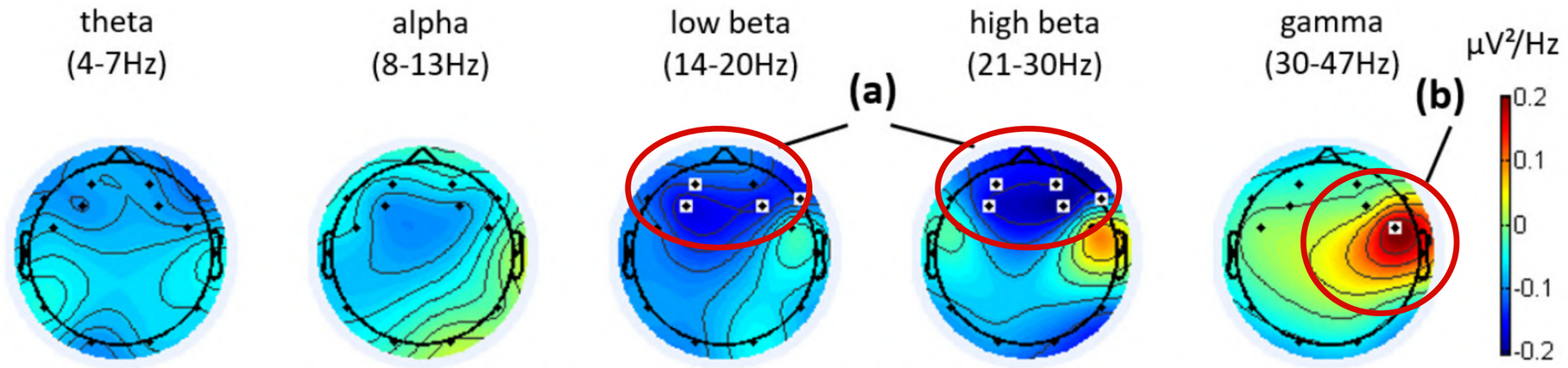


Takeaway messages:

- Participants were able to change their brain state and modulate the musical feedback by self-inducing emotions!
- **This system <u>enables self-regulation of affective states in listeners</u>**: The system sonifies listener’s affective state in real-time, but also gave listeners a tool to mediate their own emotions by interacting with the music

Stefan Ehrlich, Kat Agres, Cuntai Guan & Gordon Cheng (*PLOS One*, 2019)

Music-based BCI study

If you'd like to know more details, please check out our paper, which is freely accessible via PLOS ONE:

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

A closed-loop, music-based brain-computer interface for emotion mediation

Stefan K. Ehrlich, Kat R. Agres, Cuntai Guan, Gordon Cheng

Published: March 18, 2019 • https://doi.org/10.1371/journal.pone.0213516

Article | Authors | Metrics | Comments | Media Coverage

Abstract
1 Introduction
2 Materials and methods
3 Results
4 Discussion
Acknowledgments
References

Abstract

Emotions play a critical role in rational and intelligent behavior; a better fundamental knowledge of them is indispensable for understanding higher order brain function. We propose a non-invasive brain-computer interface (BCI) system to feedback a person's affective state such that a closed-loop interaction between the participant's brain responses and the musical stimuli is established. We realized this concept technically in a functional prototype of an algorithm that generates continuous and controllable patterns of synthesized affective music in real-time, which is embedded within a BCI architecture. We evaluated our concept in two separate studies. In the first study, we tested the efficacy of our music algorithm by measuring subjective

Closing thoughts and take-home messages

Music & technology for well-being and healthcare

- **Music has many affordances for therapeutic use**, and can help people improve their memory, attention, motor coordination, language abilities, well-being (including mental health), social wellness, and more
- Music can effectively be **embedded within technology to promote health and wellness** in a variety of clinical/therapeutic & non-clinical contexts.
- Increasing use of music technology by music therapists has allowed **greater support of patients** who could not be seen in person **during COVID-19**.

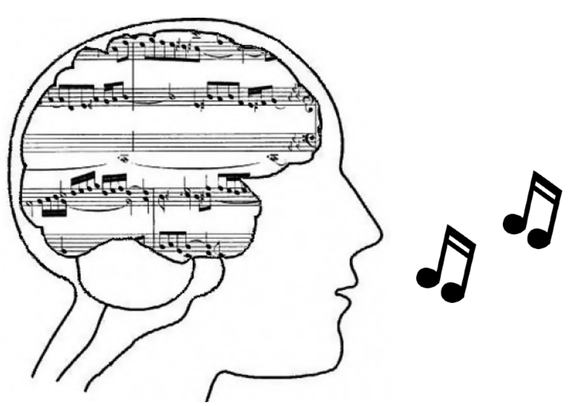
- **Actionable takeaway messages regarding the impact of music (and music technology) on society:**
  - Musicians/arts practitioners: Music is excellent at bringing people together, bridging communities and creating cohesion, and (even if you don't intend for it) supporting mental health. Make music in and with your communities to form a tighter-knit, healthier society.
  - Academics: More interdisciplinary research (between academics, musicians/arts practitioners, the tech/AI community, and clinicians) will be helpful to develop bespoke technologies for healthcare.
  - Policy-makers: Be an advocate for more/diverse funding, resources, and spaces for long-term arts health programs. Sustainable programs are needed for the biggest impact (this is a challenge).

Thanks for listening!

NUS National University of Singapore

Yong Siew Toh Conservatory of Music

Any questions?



Contact me at: katagres@nus.edu.sg

For research updates, see my website at: www.katagres.com

YST NUS web page: www.ystmusic.nus.edu.sg/faculty-kat-agres/

References

QR code for ‘Music, Computing, & Health’ paper:

QR code for ‘Music Therapy & Technology Use during COVID-19’:

QR code for ‘Music BCI for Emotion Mediation’ paper:

Just scan QR code with your phone - will take you directly to the paper!