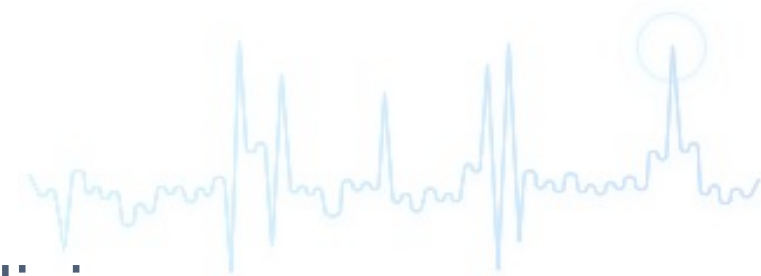Aaron Labbé (he/him)
CTO, Co-Founder

LUCID

Music That Listens

How deep reinforcement learning can bring
anecdotal healing practices into precision medicine

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PASSIVE MUSIC LISTENING : EFFECTS

PARKINSON'S — increase motor coordination [Angelucci et al., 2007]

MS — helps improve cognition, motor function, or emotional wellbeing [Sihvonen et al., 2017]

EPILEPSY — helps improve cognition, motor function, or emotional wellbeing [Sihvonen et al., 2017]

STROKE RECOVERY — [GCBH, 2020]

ameliorate cognitive deficits [Angelucci et al., 2007], improve emotional well-being + QOL, reduce anxiety, reduce depressive symptoms [Onofa et al., 2014], reduce behavioral problems [van der Steen et al., 2018]

DEMENTIA — people with dementia retain the ability to engage with music late into the disease process [Harvard Health, 2015]

increase in HGH [Koelsch, 2010] [in healthy and critically ill people - Chanda et al 2013]

CANCER
- reduce anxiety [Bradt et al., 2016]
- reduce pain [Bradt et al., 2016] [Tsimmann et al., 2017]
- reduce fatigue [Bradt et al., 2016]
- improve QOL [Bradt et al., 2016]
- may reduce the need for anesthetics and analgesics; may reduce recovery time and duration of hospitalization [Bradt et al., 2016]
- lower cancer-treatment biomarker + inflammatory cytokine IL-6 [Metcalf et al., 2019] [the anti-inflammatory effects of music] [Koelsch 2010] [in critically ill and healthy people — Chanda et al., 2013]

INFLAMMATION
- mediates the link between music and immune response [Koelsch et al., 2010]
- natural killer cell levels decreased [Koelsch 2010]
- CD4+ T cell levels rose in the presence of live music [Koelsch, 2010]
- increased s-IgA [immunoglobin] levels [Chanda et al., 2013]

NEUROGENESIS
- non-significant decrease in plasma morphine levels, increase in morphine 6 glucuronide levels
- enhance learning performance [in mice] [Angelucci et al., 2007]
- increase BDNF expression, thus modulating hippocampal activity [in mice] [Angelucci et al., 2007]
- increase connectivity of different parts of the brain [GCBH 2020]

STRESS
- reduce stress and nervousness pre-endoscopy [Jangsinkul et al., 2017]
- deactivations in the hippocampus, parahippocampal gyrus, temporal poles to pleasant music [... 2013]
- modify heart rate, respiration rate, perspiration, BP, body temperature, skin conductance, muscle tension
- reduce stress in subjects, passive music invasive medical surgery, for patients procedures undergoing and patients disease [C...
- reduced post-operative hysterectomy patients
- Although glucocorticoids act as an immunosuppressant under conditions of acute stress, they may promote a state of chronic low-grade inflammation in the long term [Chanda et al 2013]
- Prolonged, elevated circulating levels of glucocorticoids (e.g., cortisol) act as neurotoxins, weakening the ability of neurons and other cells to resist injury and making them more vulnerable to the effects of toxins and the normal attrition process [Chanda et al 2013]

ENGAGES REWARD CIRCUITRY
- reduces endogenous dopamine release in the striatum at peak emotional arousal [Salimpoor et al., 2011]
- dopamine release in the caudate pre-chills, in the NAc during chills [Chanda et al 2013]
- activation of the insula [connected to the NAc and its role in the appetitive phase of reward, particularly in addictive behaviors] [Chanda et al 2013]
- self-reported thrills / chills can be blocked by naloxone [opioid antagonist] —> link between musical reward and the central release of endogenous opioids [Chanda et al 2013]
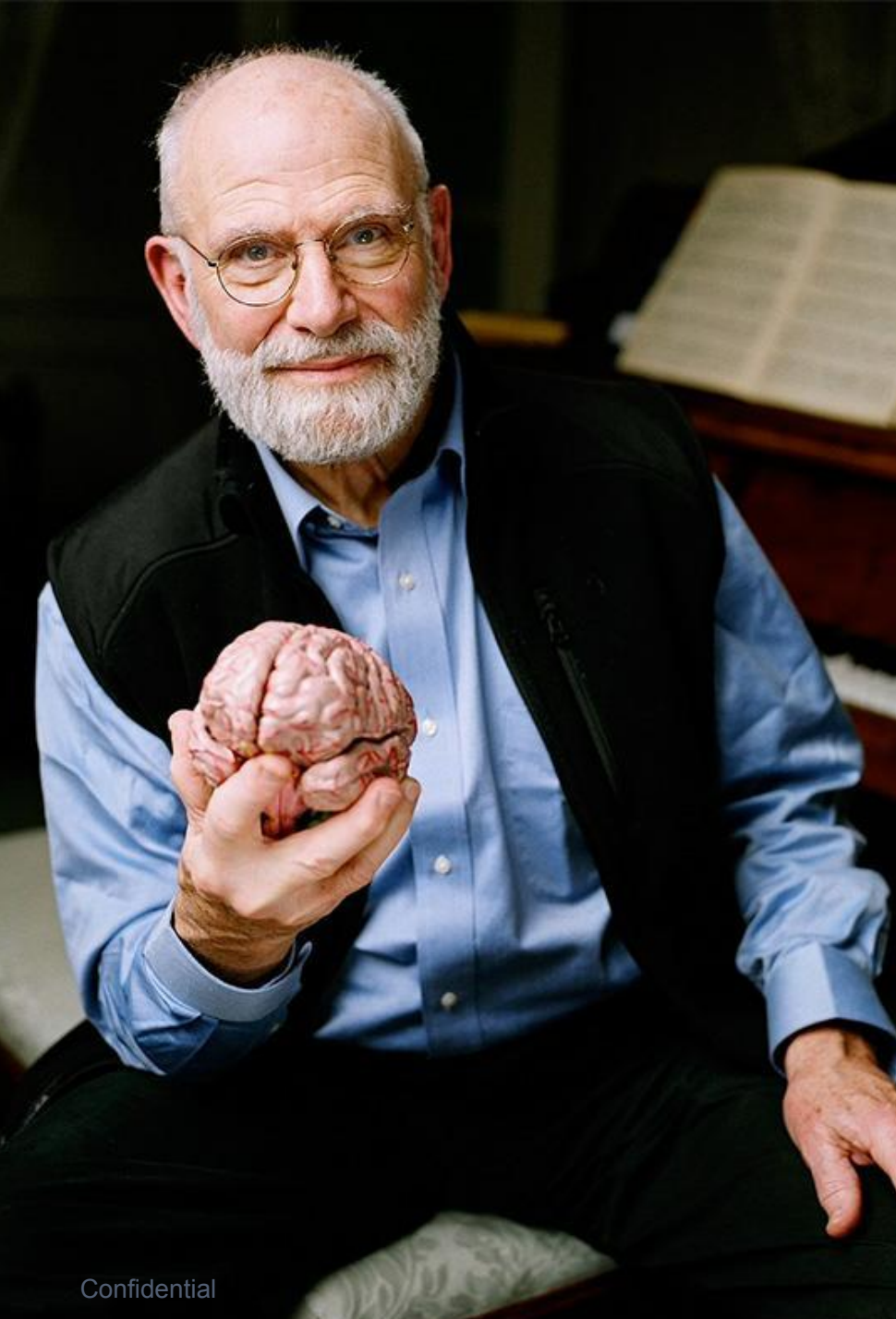- Music, an abstract stimulus, can arouse feelings of euphoria and craving, similar to tangible rewards that involve the striatal dopaminergic system. [Salimpoor et al 2011]
- musical pleasure follows a similar pattern of dopaminergic activity in response to drugs of abuse [Chanda et al 2013]

ANXIETY
- calming music found to be as effective as diazepam in reducing vital signs of anxiety [Koelsch, 2010]
- reduced levels of anxiety and plasma cortisol [Koelsch, 2010]
- lower state anxiety pre-op in bone marrow biopsy than control [Shabanloei et al., 2010]
- trend toward faster decline in anxiety post-procedure [Chanda et al 2011]
- improve coping during stressful situation [Wu et al., 2012], like post-operative [Wu et al., 2012]
- calming music can reduce plasma levels of cortisol and norepinephrine [Koelsch et al., 2010]
- listening to music post-operatively resulted in reduced plasma cortisol for cardiac and hernia surgery patients [Chanda et al., 2013]
- reduces preoperative anxiety [Bradt et al., 2013]
- significantly lower anxiety immediately following cesarean procedure, and significantly lower cortisol increase from admission to skin suture [Hepp et al., 2018]
- reduces anxiety in mechanically ventilated patients [Bradt et al., 2013]
- reduction in sedative and analgesic intake [Bradt et al., 2013]

MOOD
- antidepressants and psychotherapies have low remission rates [30-46%] [Metcalf et al., 2019]
- digital depression-related modalities may help ameliorate symptoms [Metcalf et al., 2019]
- It has been shown that music might be able to improve mood state in people affected by psychiatric disorders [Angelucci et al., 2007]
- increase in oxytocin while listening to calming music [Koelsch, 2010]
- digital health interventions for people facing mental health challenges have been shown to be more likely to commence treatment than traditional in-person therapy [80% vs 58%], and remain fully engaged for 6 weeks [84% vs...

SLEEP
- may improve sleep [in the ICU [Hong-Fang et al., 2015]] [in adults with insomnia [Jespersen et al., 2015]]

reduced distress during the first hour of the latent phase of labor [Phumdoung et al., 2003]

music more effective than a banjo at reducing pre-operative anxiety [Chanda et al 2013]

"Music can lift us out of depression or move us to tears – it is a remedy, a tonic, orange juice for the ear.

But for many of my neurological patients, music is even more – it can provide access, even when no medication can, to movement, to speech, to life.

For them, music is not a luxury, but a necessity."

Oliver Sacks, best-selling author and professor of neurology at NYU School Of Medicine

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How do we transform music into scalable medicine?

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Affective Music Recommendation System ('AMRS')

Deliver

Stream music optimized for the users desired outcome

Measure

Establish current and target mood state

Optimize

Learn and optimize using machine learning techniques

Traditional Music Recommendation Systems

COLLABORATIVE FILTERING

Listened to by both users

Similar users

Listened to by her,
recommended to him

CONTENT-BASED FILTERING

Listened to by user

Similar songs

Recommended
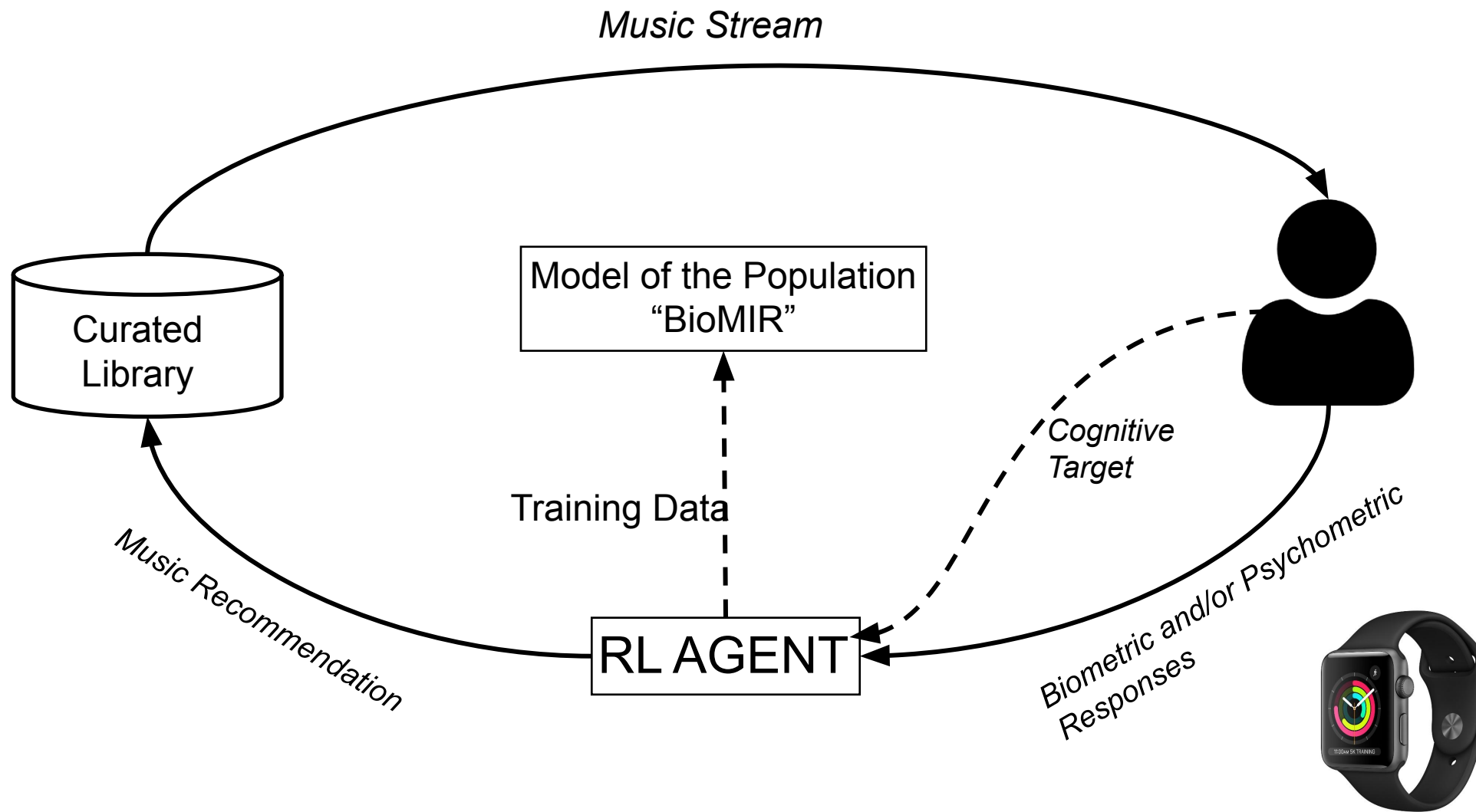to user

1

Real-time feedback

2
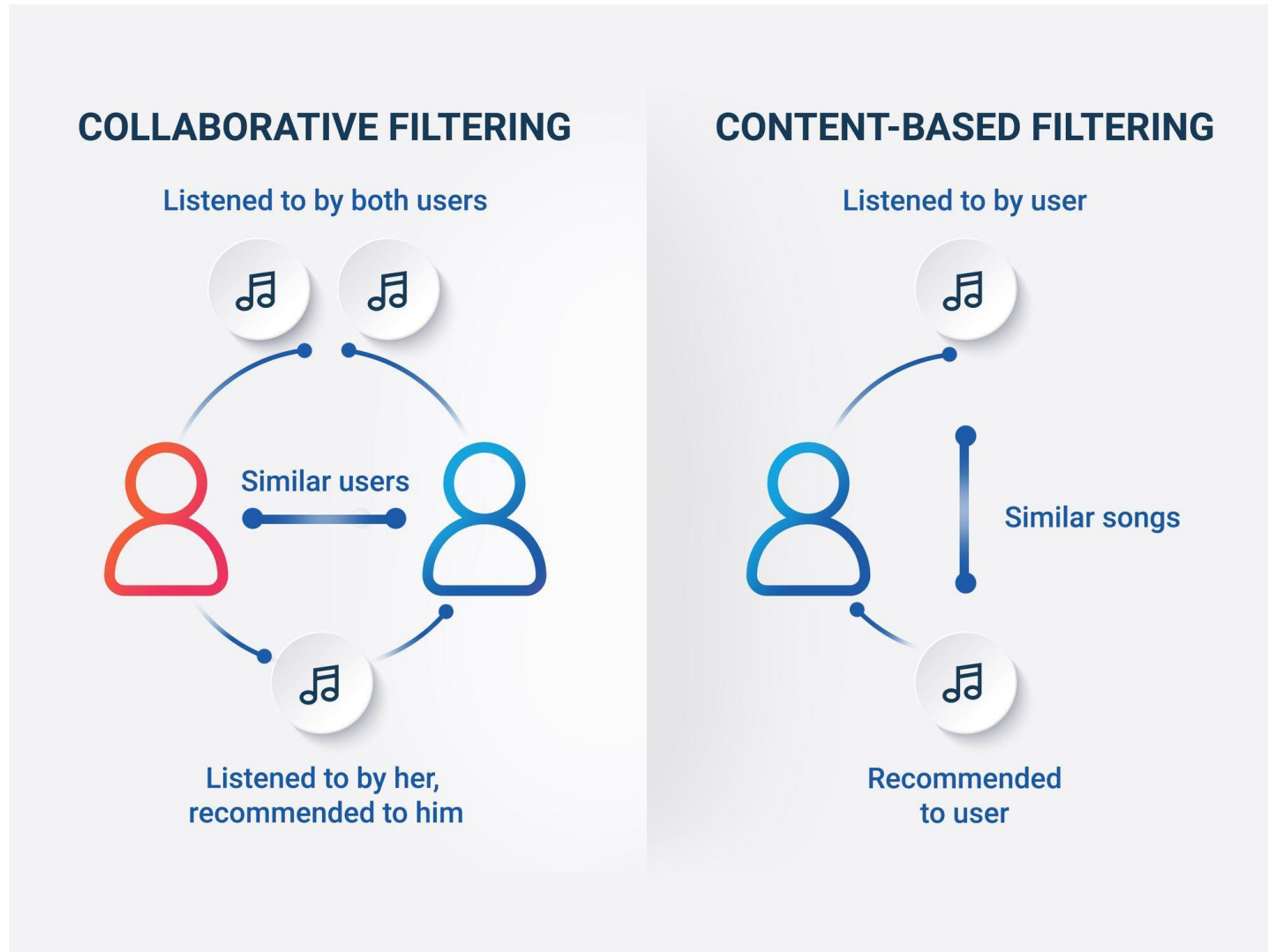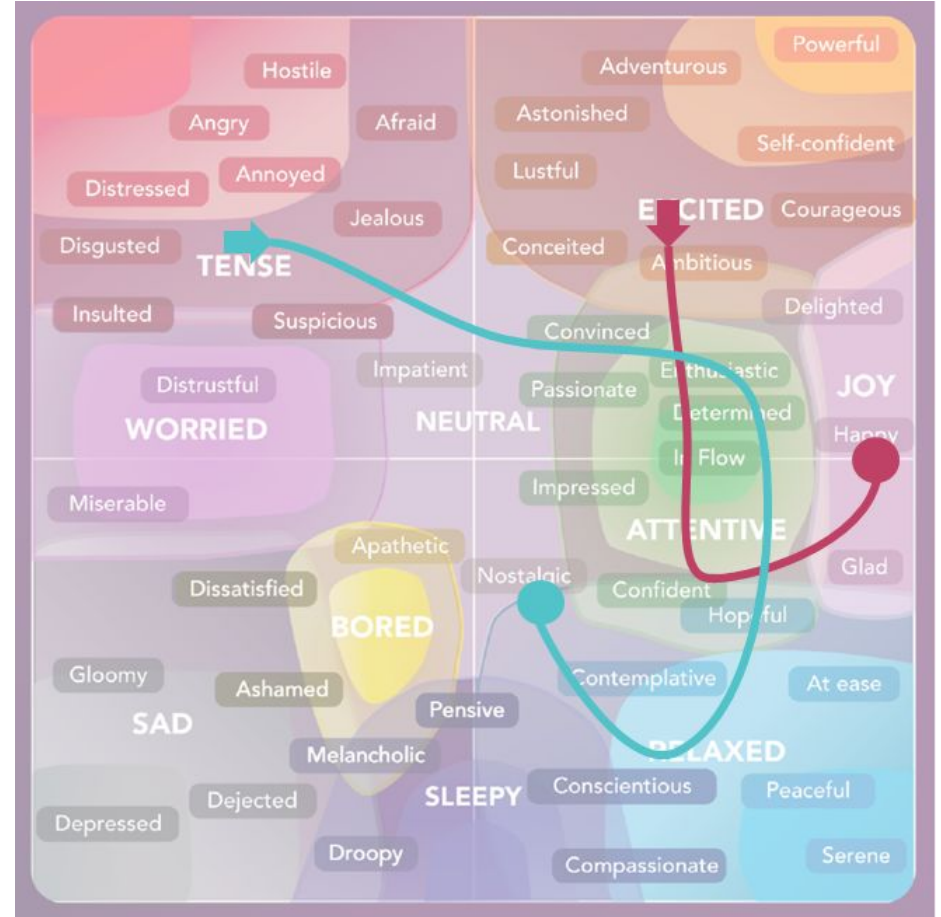
Russell's Circumplex Model of Affective States

Reinforcement Learning ('RL')

Environment

Policy Evaluation

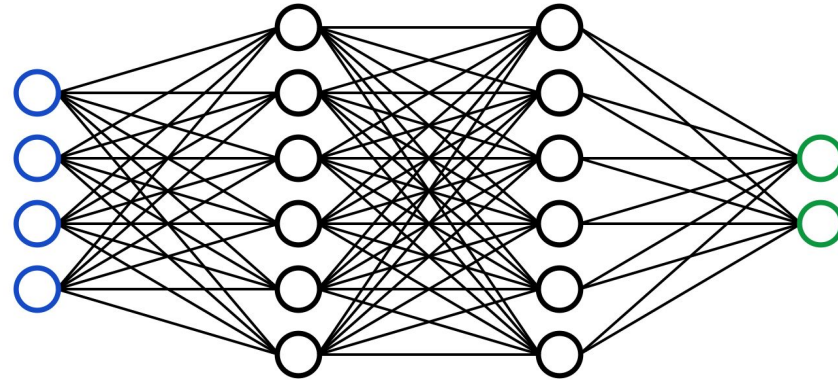Reward (t=0)
Reward (t=1)
Reward (t=2)

Average Reward

Reward

State

Policy

Action

Agent

L U C I D

2

Russell's Circumplex Model of Affective States

Music Stream

Curated
Library

Model of the Population
"BioMIR"

Cognitive
Target

Training Data

Music Recommendation

RL AGENT
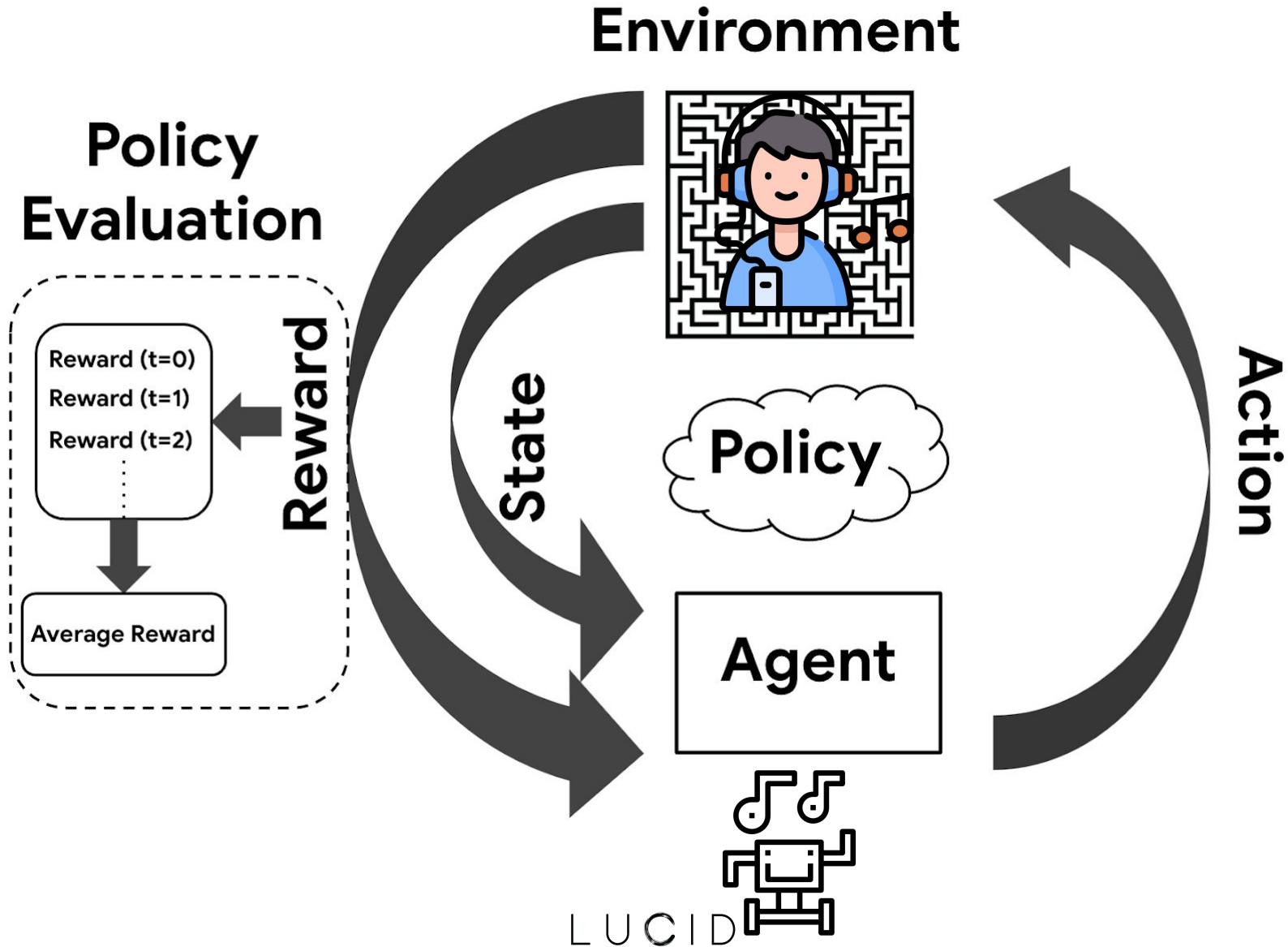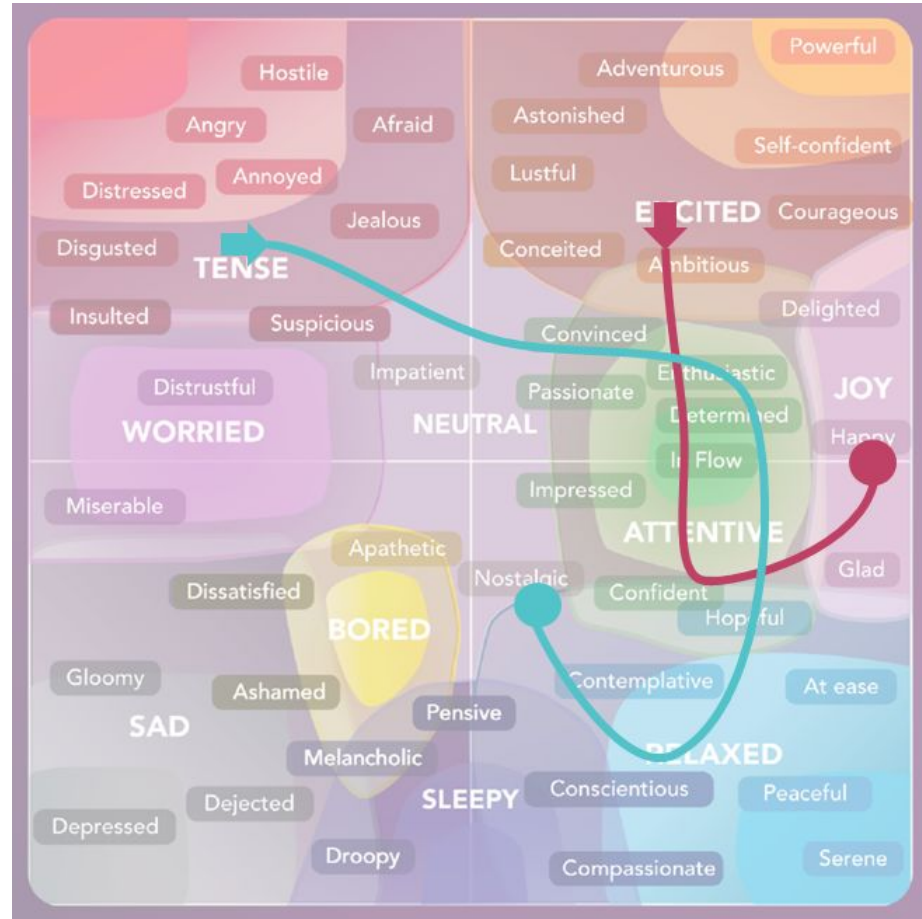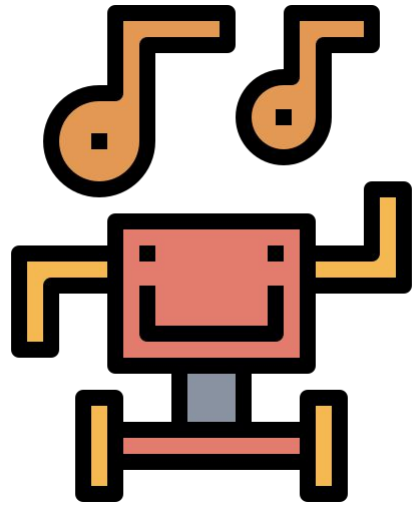
Biometric and/or Psychometric
Responses

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Model of the Population "BioMIR"
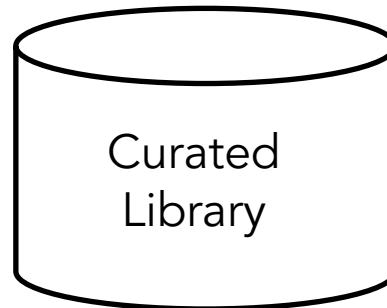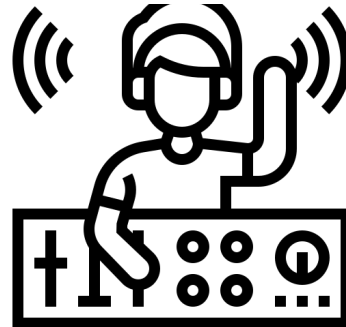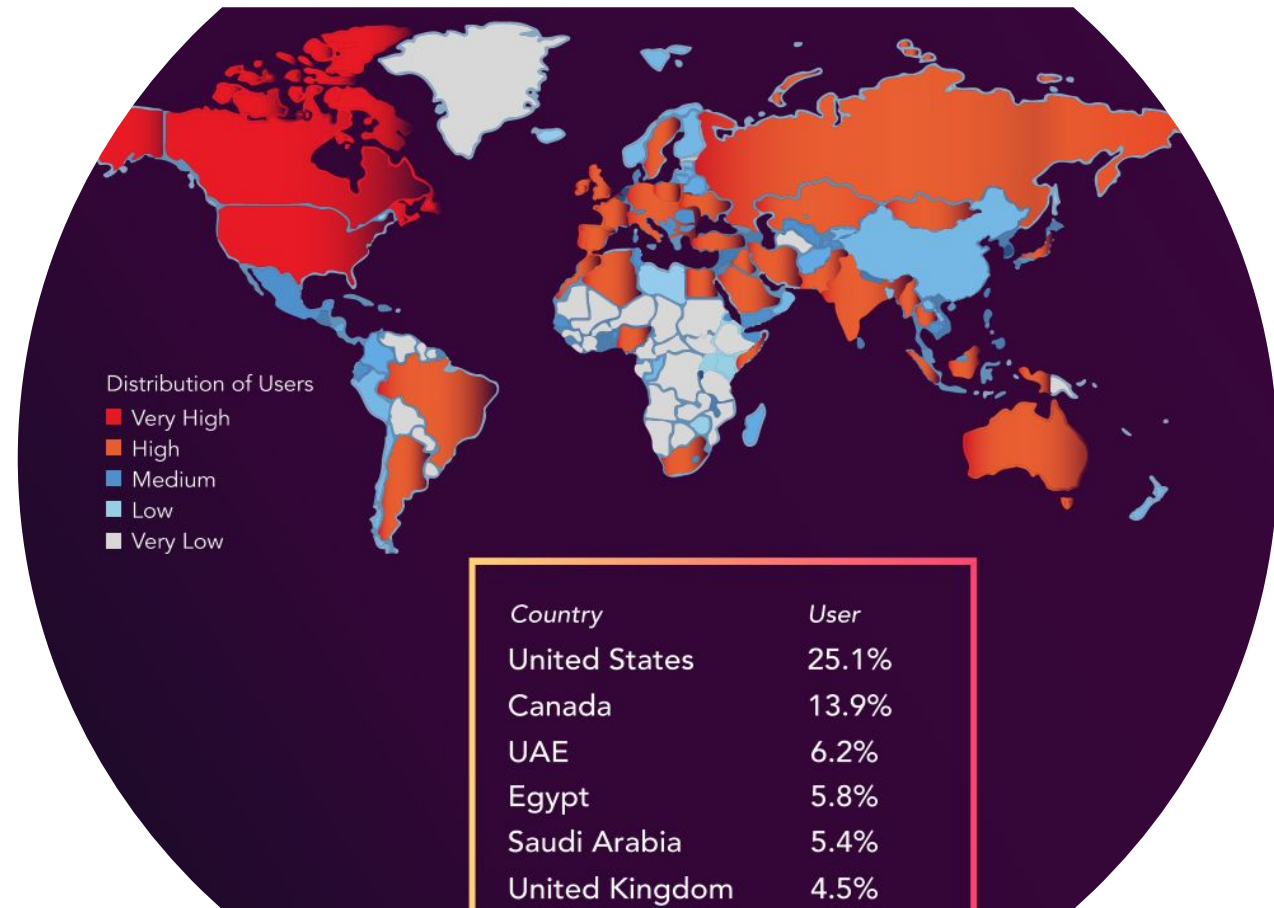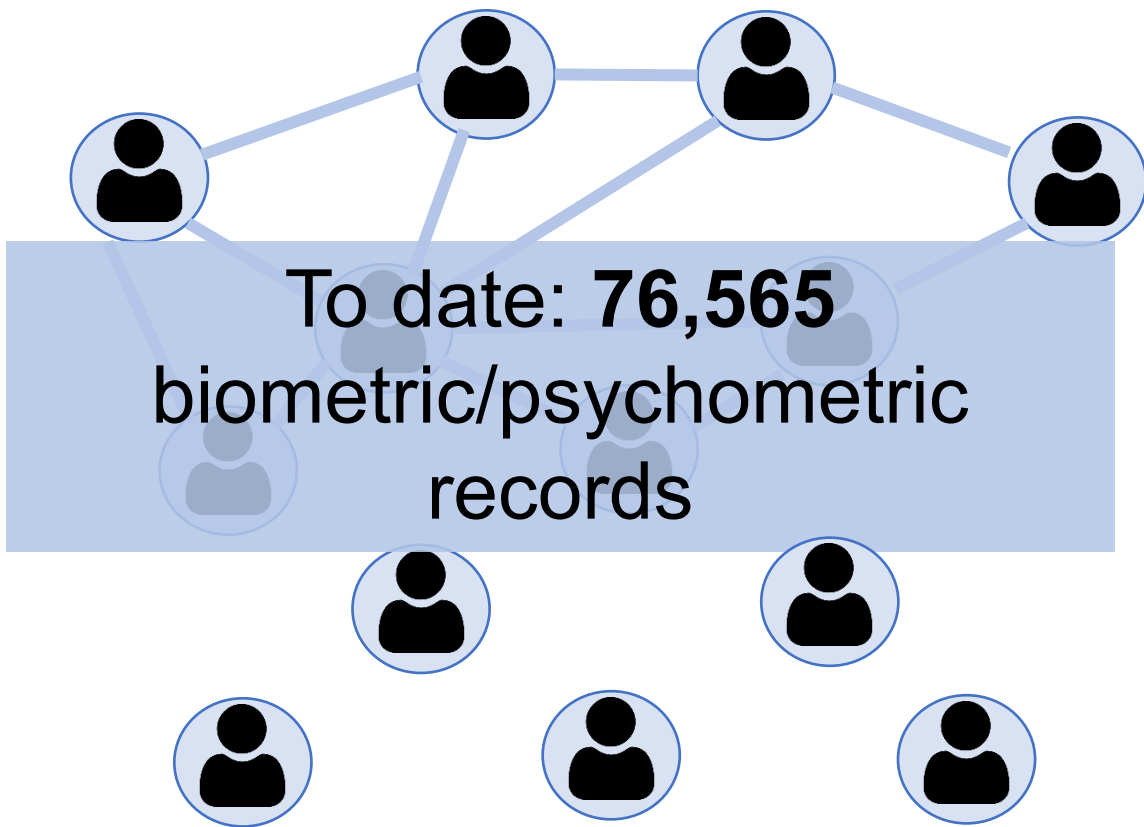
Curated Library

To date: **76,565** biometric/psychometric records

Distribution of Users
- Very High
- High
- Medium
- Low
- Very Low

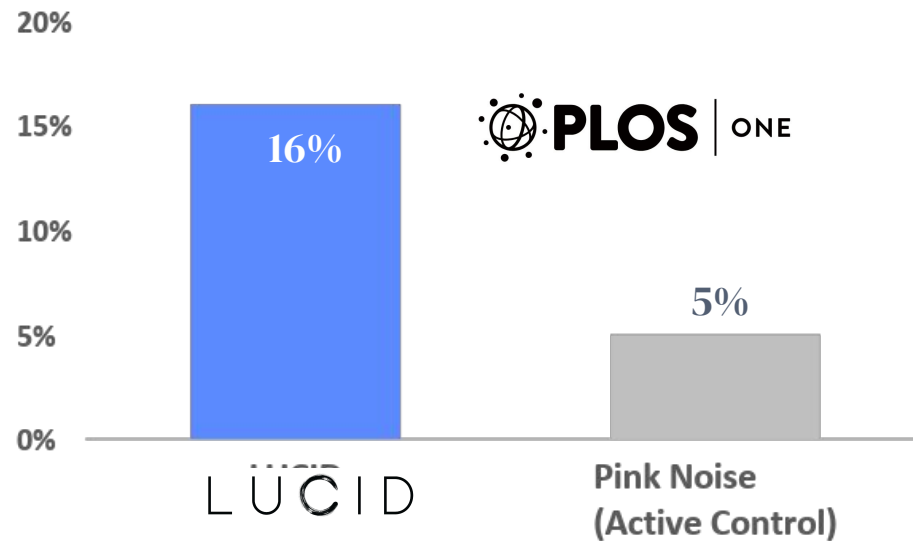| Country	User
United States	25.1%
Canada	13.9%
UAE	6.2%
Egypt	5.8%
Saudi Arabia	5.4%
United Kingdom	4.5%

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The Impact : Putting AMRS to the Test

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Randomized Control Trials & Clinical Research

Decrease in Somatic Anxiety
within Moderate Anxiety Adults
(24-minute session; n=318; p = .03)

16%

5%

LUCID

Pink Noise
(Active Control)

Randomized Controlled Trial with 318 participants (adults 18-64 with moderate to severe anxiety) led by **Ryerson University Neuroscience** Lab (SMARTLab)

Somatic Anxiety measured by the STICSA (increased blood pressure, muscle tension, **nausea**, sleeplessness) contributes to ~50% of overall anxiety level

Decrease in Acute Stress
within Moderate Anxiety Adults
(24-minute session; n=39; p = .04)
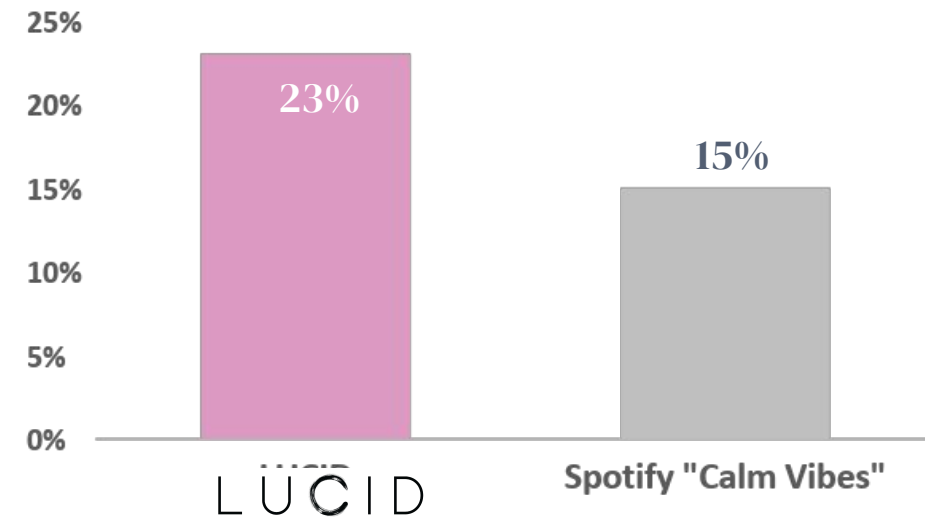
23%

15%

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Spotify "Calm Vibes"

Randomized Controlled Trial with 39 participants (adults 18-64 with moderate to severe anxiety) led by **Ryerson University Neuroscience** Lab (SMARTLab)

Acute Stress was measured by a simple self-assessment, participants are adults 18 – 60 and filtered for **moderate to high anxiety**

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LUCID's AMRS vs. The Alternatives

Acute intervention effectiveness – pre vs. post % reduction

iCBT (1 week)	LUCID (24 mins)	Breathing Excercises (30 mins)	Mindfulness (15 mins)	Anti-Anxiety (Benzodiazepines; 8 weeks)	Music Therapy (Traditional)
0.2	0.17	0.08	0.05	0.22	0.15

Digital Delivery   *Physical Delivery*

Anti-depressant & Placebo: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.629.6292&rep=rep1&type=pdf
Traditional Music Therapy: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5072238/
iCBT - acute: https://www.sciencedirect.com/science/article/pii/S2214782920300075
iCBT – chronic: https://sci-hub.mksa.top/10.1016/j.janxdis.2015.10.006
Mindfulness: https://psycnet.apa.org/record/2016-08146-001
Breathing Exercises: https://www.frontiersin.org/articles/10.3389/fpsyt.2020.00467/full?fbclid=IwAR2allcj2VGdPACVLzaCZF-TaOas9YOpTH_jz6pr9DFbYothK7wwkWUjYc0

Real-world usage data indicates that anxiety reduction, mood increase, and arousal decrease improve with repeated use

On average, users reported **pre-post anxiety reduction of ~20-35%** and **mood improvement of ~10-15%**

All metrics of success indicated **better outcomes with repeated use**
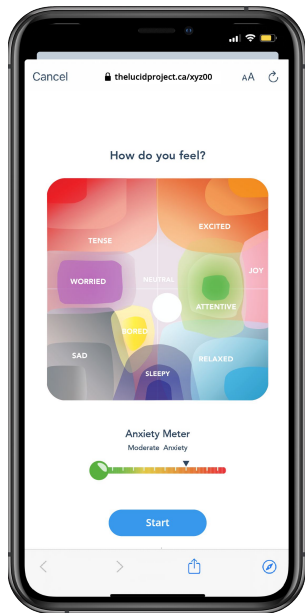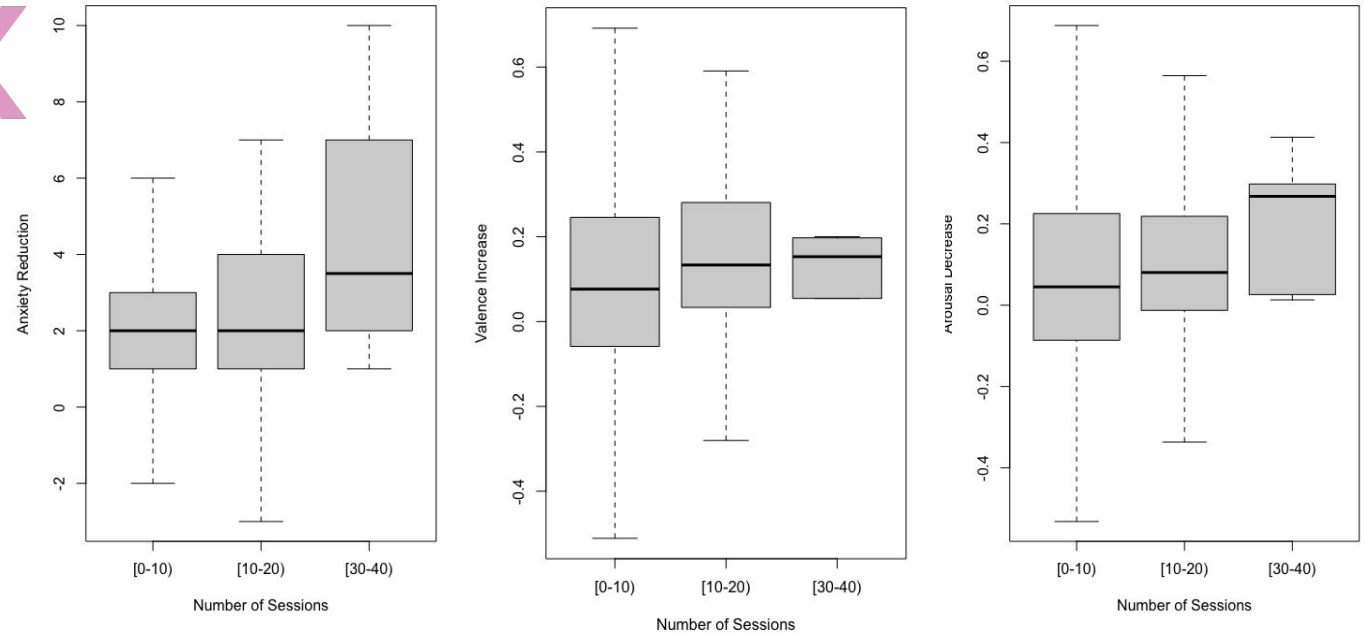
Russell Circumplex Model of Affective States

SUDS

Real-World Data Analysis on a total of 829 data records conducted by **SMART Lab**, a Ryerson University Neuroscience Lab

Anxiety measured by the Subjective Units of Discomfort Scale (SUDS)
Valence and **Arousal** measured by the Russell Circumplex Model of Affective States

Music is a familiar and delightful method of improving mental health, and outstrips meditation and therapy as consumers' go-to modality

Which of the following do you do or use to help you feel less stressed or anxious? (n=915)
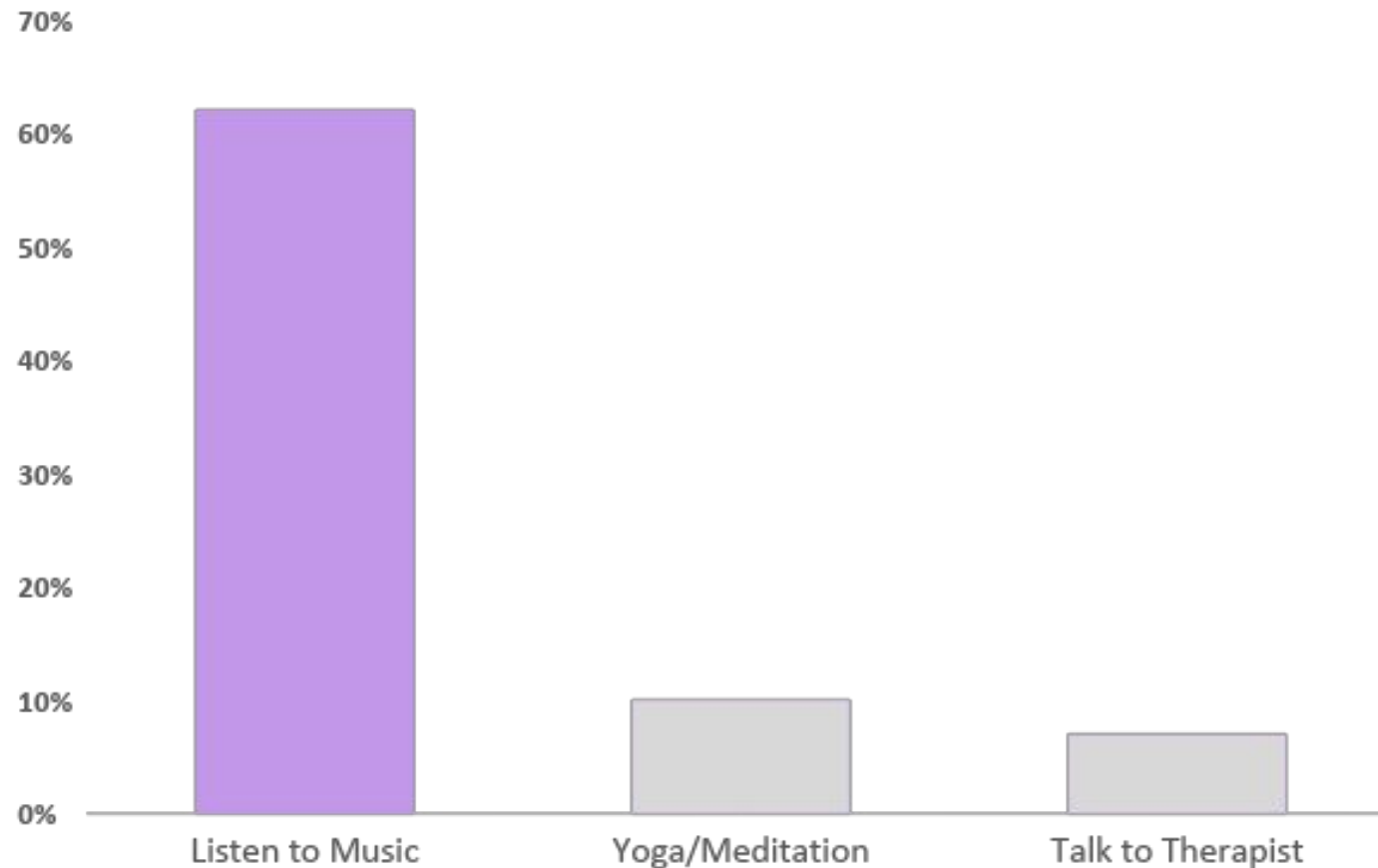
- Passive experiences such as listening to music are **easier** for persons coping with mental health than active experiences such as meditation

- Music represents a compelling feature in digital health to increase **stickiness** and improve user satisfaction (NPS)

Qualitative Impacts: Interviews with Users

Anxiety, Stress, Mindfulness

"When I started [VIBE] it asked me how I feel – I hadn't taken time to reflect on it but just indicating how I felt made **me feel a better right away**." – 54F New York

"I'm trying to avoid the pharmaceutical route as much as I can, so I'm working out and trying other things like music and mindfulness." – 23F Montreal

"If I'm looking for new music I'll use Spotify but I don't use Spotify or their playlists [for anxiety/sleep]. **I would definitely use VIBE for other music** if it was based on my mood." – 24F Toronto

"I tried mediation, but I have a hard time quieting my thoughts, as soon as I start [Headspace] my mind goes crazy – breathe better, clear my mind, fix my posture – it doesn't really help me" – 26F London
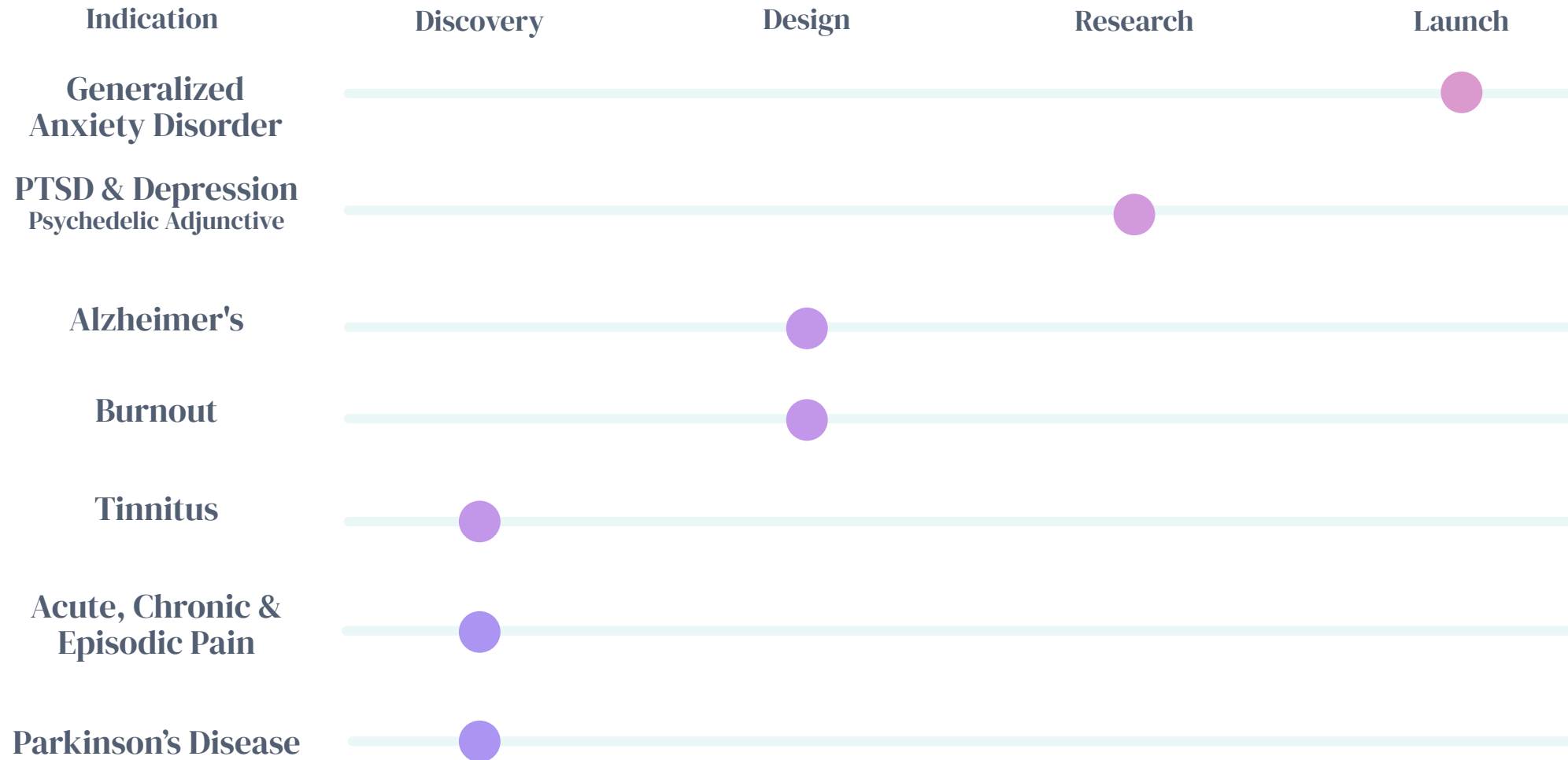
Sleep

"I have been dealing with PTSD, and going to therapy for it, I was having an anxiety attack when I found VIBE… I used VIBE for anxiety at first, but lately **it really helps me get to sleep**." – 24F California

"During the day I use other things to control my emotions like exercise, but I find at night and around bedtime I lose control of my thoughts." – 19F Paris

LUCID

We're building a portfolio of accessible, effective, and personalized music-based solutions in mental and neuropsychiatric health

Indication	Discovery	Design	Research	Launch
Generalized Anxiety Disorder				●
PTSD & Depression Psychedelic Adjunctive			●	
Alzheimer's		●		
Burnout		●		
Tinnitus	●			
Acute, Chronic & Episodic Pain	●			
Parkinson's Disease	●			

Laguna

dayzz

valerahealth

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Aaron Labbé (he/him)
CTO, Co-Founder

L U C I D
Thank You

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www.thelucidproject.ca