

Harmonia: Physiological Signal-Driven Music for Remote Relationship Maintenance

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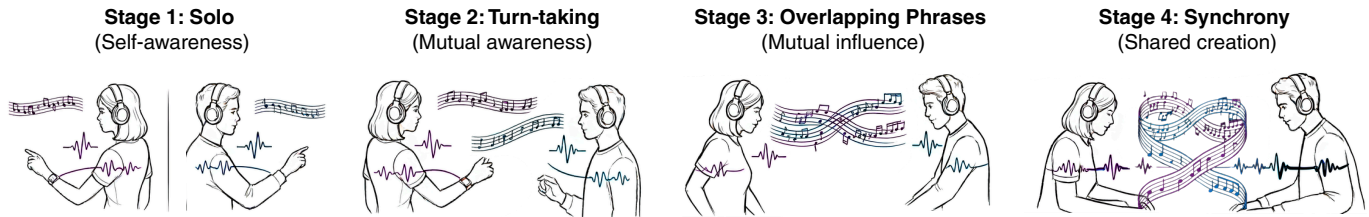


Figure 1: Harmonia’s four-stage interaction structure, inspired by cooperative vocal turn-taking [14]. Participants progress from self-awareness (Solo), to mutual awareness (Turn-taking), to mutual influence (Overlapping Phrases), and finally to a shared creation (Synchrony), as physiological signals increasingly shape a shared musical experience.

Abstract

In remote intimate relationships, current communication technologies provide limited support for conveying physiological presence and for reflecting changes in relational intimacy over time. We present **Harmonia**, an exploratory technique that translates real-time physiological signals into ambient generative music, creating a shared channel for remote co-presence that evolves with the relationship. By using music as a medium of physiological expression, **Harmonia** enables subtle and continuous experiences of connection between remote individuals.

CCS Concepts

• **Human-centered computing** → **Collaborative and social computing systems and tools**; Sound-based input / output.

Keywords

Physiological signals, generative music, remote intimacy, co-presence

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1 Introduction

As remote intimate relationships (e.g., romantic partners, close friends, and family) become increasingly common, the need for

technologies that support continuous and ambient connection at a distance has grown [5]. Existing communication technologies remain largely semantic, offering limited support for the physiological dimension of human presence. Prior work has explored visual reconstruction [7, 21], breathing [8, 19], and heartbeat [11, 16, 18, 22] as channels for remote connection. However, these systems typically focus on a single physiological signal, require explicit engagement, and provide episodic rather than continuous awareness. None integrates multiple physiological dimensions into a shared ambient medium capable of reflecting evolving interpersonal intimacy.

Music offers such a possibility. Rooted in physiology rather than learned syntax, music conveys emotional and social information through continuous cues such as rhythm, breathing, and physiological resonance [4, 9, 14]. It communicates affiliation, intimacy, and social distance across cultures and even species [12, 14, 17]. Yet although recent work has explored music generation from physiological signals [13], little is known about how physiologically mediated music can support the development and maintenance of remote interpersonal relationships.

We propose **Harmonia**, an exploratory technique that translates real-time physiological signals into personalized generative music to support presence and interpersonal connection between remote individuals. Rather than transmitting messages, Harmonia uses music as a medium of physiological expression, enabling people to perceive each other’s physiological presence through a continuous and ambient shared experience. Harmonia further adapts musical sharing to relationship context, allowing interpersonal connection to evolve from individual awareness to shared expression and co-creation.

Harmonia advances prior work in three ways: (1) physiological signal-driven music generation supports continuous, ambient awareness between remote individuals; (2) a layered music design connects physiological states with shared musical expression; and



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(3) a four-stage interaction design that structures this progression across different relationship contexts.

2 Workflow

Inspired by cooperative vocal turn-taking, **Harmonia** structures the shared experience in four stages that progress from self-awareness to interpersonal synchrony [14, 15].

The progression begins with **Stage 1 (Solo)**, where attention to one's own bodily and emotional presence is expressed through an individual musical voice. **Stage 2 (Turn-taking)** introduces recognition of the other: the two individuals remain distinct but begin to attend and respond to one another. In **Stage 3 (Overlapping Phrases)**, their connection becomes increasingly reciprocal, with overlapping musical phrases reflecting how each person's state may shape the shared experience. Finally, **Stage 4 (Synchrony)** frames connection as a coordinated whole, in which the two individuals create something together without losing their distinct identities. Stage transitions are user-initiated, allowing each pair to control the pace of progression.

3 Design and Implementation

Harmonia consists of three components: physiological sensing, music design, and generative interaction.

3.1 Physiological Input

Harmonia uses the EmotiBit wearable to capture heartbeat, breathing, and electrodermal activity (EDA) in real time. Detected PPG pulse peaks directly trigger rhythmic events. Breathing rate (BR) is estimated from PPG-derived respiratory sinus arrhythmia and 3-axis accelerometer (ACC) signals using NeuroKit2, and mapped to phrase length and dynamic contour. EDA is mapped to harmonic tension and note density.

All signals are normalized against a short individual baseline recorded at session start to account for inter-individual physiological variability [10].

3.2 Music Design

3.2.1 Fixed layer: timbre as identity. Each participant selects an instrument that serves as their persistent musical identity throughout the interaction. This timbre remains stable across all stages, allowing participants to recognize one another's musical presence.

3.2.2 Dynamic layer: physiology as expression. Physiological signals continuously shape musical parameters in real time, translating moment-to-moment physiological changes into musical expression. Table 1 summarizes the signal-to-music mappings.

Table 1: Physiological Signal to Music Parameter Mapping

Sensor	Signal	Musical Parameter
PPG	Heartbeat pulse	Beat-triggered note onset
	Pulse rate variability	Rhythmic regularity
	Breathing rate (+ACC)	Phrase length
EDA	Skin conductance level	Harmonic tension
	Skin conductance slope	Note density, textural activity

3.3 Generative Pipeline

Together, **Harmonia** uses a modular music generation pipeline. The current prototype uses a parametric synthesis approach via SuperCollider¹, where physiological features directly drive MIDI generation and audio rendering with low latency.

Because respiration rate and pulse-rate variability are estimated over short rolling windows, we update slowly varying parameters (phrase length, rhythmic regularity) continuously while triggering fast events (note onsets) directly from detected pulses, keeping the mapping responsive within each one-to-three-minute stage.

4 Demo Experience

At our booth, two attendees sit across from each other, each wearing an EmotiBit and noise-isolating headphones. An opaque panel approximates remote interaction, while a small opening is reserved for physical contact in Stage 4. Due to time and space constraints, each five-to-seven-minute session includes a brief physiological baseline, Stage 1, and one activity selected from Stages 2-4.

During **Stage 1 (Solo → Self-awareness)**, each participant hears their own body become music: their heartbeat triggers notes, and their breath shapes each phrase. They then experience one of three activities representing progressively more direct forms of connection:

- (1) **Stage 2: Turn-taking → Emotional Communication.** One participant responds to an emotional stimulus, such as an expressive passage or a short video, while the other listens to changes in their partner's music and attempts to sense how they are feeling.
- (2) **Stage 3: Overlapping Phrases → Collaborative Activity.** The pair creates a painting on a shared digital canvas while hearing their physiological music shift in the background. Drawing on collaborative digital creativity for interpersonal connection [1, 3, 20], the activity encourages mutual influence while keeping the pair aware of the music.
- (3) **Stage 4: Synchrony → Physical Connection.** Inspired by the interactive video *When We Touch Each Other*² and research on mediated touch [2, 6], this stage uses co-located hand contact as a demo proxy for mediated touch between remote partners. Participants reach through the opening to touch hands and sense how physical contact affects their musical streams.

Across these stages, the two musical streams move from separate to intertwined, allowing the pair to hear possible rhythmic and harmonic alignment. Individual visitors may also experience Stage 1 alone.

A shared speaker and display allow onlookers to follow the interaction in real time. The display combines a live view of the participants with color-coded PPG, heart-rate, and EDA traces, normalized arousal indicators, and an estimate of physiological synchrony. Together, these elements make **Harmonia** as engaging to witness as it is to participate in.

¹<https://supercollider.github.io/>

²<https://youtu.be/8bU2CbWq93Y>

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