MeloPresto™ Research Program

The MeloPresto Research Program invites researchers, theorists, artists, teachers and instrument builders to explore the **isomorphisms of music** and what follows from them. An **isomorphism** is a one-to-one correspondence between two structures that preserves the relationships inside each.

The MeloPresto Music System's solfa-named button-field is isomorphic with any rank-2 temperament of Just Intonation based on the octave and tempered fifth. The System's primary focus is the syntonic temperament: its valid tuning range includes modern **12-edo** (the **e**qual **d**ivision of the **o**ctave into 12 steps), 1/4-comma meantone, 31-edo, and many other tunings of historical and ethnographic interest, and also Just Intonation up to the 11-limit. MeloPresto's button-field, note names, staff, tonnetz, nomenclature, etc. are all isomorphic with that underlying temperament, and are therefore isomorphic with each other.

This document states the program's conjecture, describes the MeloPresto setting in which the conjecture is tested, gives the timeline on which the MeloPresto applications and lessons are expected to become available, and lists the research that the MeloPresto Music System — and its novel support for Dynamic Tonality — enables in six areas: cognition, composition, education, ethnomusicology, theory and instruments.

The conjecture

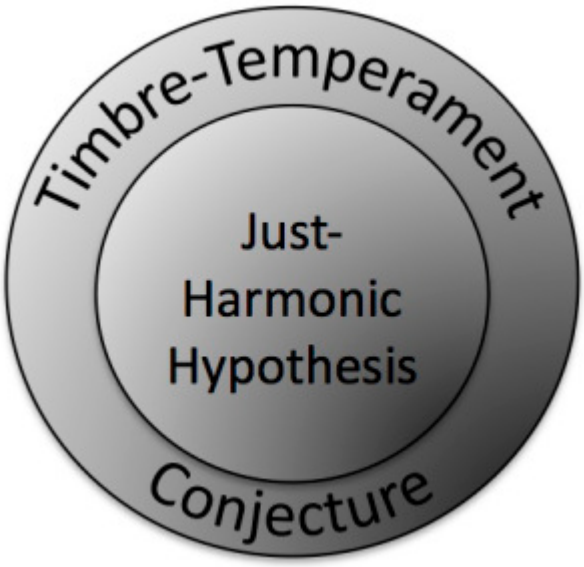
A partial is one of the single frequencies that make up a sound. A timbre is a sound's set of partials and their amplitudes, and a harmonic timbre is one whose partials are whole-number multiples of its lowest partial. An interval is the distance in pitch between two notes. In Just Intonation, every interval is a ratio of whole numbers.

Rameau, Sauveur, Helmholtz and others observed that the intervals between the partials of a harmonic timbre equal the intervals between the notes of Just Intonation. Taken together, their observations amount to a hypothesis.

> **Just-Harmonic Hypothesis.** If the notes of a tuning are in Just Intonation and the partials of a timbre follow the Harmonic Series, then the partials align with the notes, and the alignment produces intervals — and relationships among intervals — that are useful to composers.

The MeloPresto Music System places every note on a lattice that is generated by two intervals: P8, the perfect octave, and M5, the major fifth (the interval that TiMS, the West's Traditional incoherent Music System, calls the "perfect fifth"). A temperament identifies each partial of the Harmonic Series with one position on that lattice; the Harmonic Series is the whole-number multiples of a lowest frequency. Dynamic Tonality, which is optional in the MeloPresto Music System, uses spectral alignment: it shifts each partial of a sound from its Harmonic-Series frequency to the frequency that the temperament gives to that partial's position. The program generalizes the hypothesis accordingly.

> **Timbre-Temperament Conjecture.** When a timbre's partials are spectrally aligned to a temperament's notes, then the alignment produces intervals — and relationships among intervals — that are useful to composers.



The Timbre-Temperament Conjecture explains everything that the Just-Harmonic Hypothesis explains, because Just Intonation with a harmonic timbre is one case of a spectral alignment. It may explain much more. Little of that has been proven, which is why it is a conjecture that motivates a research program and not yet accepted musical science.

The conjecture extends tonality; it replaces none of it. What a musician knows about tonal music stays true in the tuning and timbre in which the musician learned it. The conjecture adds tunings, timbres and effects in which much of that knowledge also applies.

The MeloPresto setting

MeloPresto at Launch

The user interfaces. The MeloPresto Music System's user interfaces include its note names, its staff, its button-field and the tonnetz. The note names are tonic solfa with movable Do: Do, Re, Mi, Fa, So, La and Ti, which are independent of key. The MeloPresto Staff is a chromatic staff labelled with those names; a chromatic staff gives each of the twelve notes of the 12-edo octave its own line or space. A jammer is the MeloPresto instrument, and a jammist is the person playing it. A jammer has a button-field: an arrangement of note-buttons, each of which starts and stops one note. The button-field uses the Wicki-Hayden layout, in which a chord or a scale has one shape wherever it is started. The tonnetz is the harmonic note network whose triangular regions represent major and minor triads; a triad is a chord of three notes. The button-field contains the tonnetz.

What MeloPresto requires. MeloPresto requires no tuning other than 12-edo and no particular synthesizer. It does not require Dynamic Tonality.

The invariances. Invariant means unchanging despite changes to octave, key, tuning and the like. The button-field has three invariances, and none of them requires Dynamic Tonality:

1. **Interval-shape invariance:** each interval — and hence each unique sequence or combination of said intervals — has one unique shape wherever it is started on the button-field.
2. **Fingering invariance:** when using electronic transposition, to play a given sequence or combination of intervals in any key, one presses precisely the same note-buttons, not just the same pattern of note-buttons.
3. **Tuning invariance:** any given sequence or combination of intervals has the same shape and fingering in every tuning of a given temperament.

The applications and lessons. MeloPresto Jammer is the instrument application. MeloPresto Score is the notation application, which writes the MeloPresto Staff. Jammer Shujaa is the music game. MeloPresto Core Lessons are free lessons designed to help novices reach competence radically faster. MeloPresto Synth is MeloPresto's own synthesizer.

Dynamic Tonality at Launch

What it is. In Dynamic Tonality, the tuning can change while notes sound, and the partials of the timbre stay spectrally aligned with the notes of the tuning. A chord is consonant when its notes sound smooth together. With spectral alignment, a chord that is consonant in one tuning stays consonant as the tuning changes.

How MeloPresto enables it. MeloPresto's user interfaces are isomorphic with the temperament and not with any one of its tunings, so the note names, the staff and the fingering stay the same when the tuning changes. MeloPresto identifies each note by its position on the lattice, so a synthesizer can calculate the note's pitch in the tuning of the moment. Dynamic Tonality is thus a capability of a synthesizer. MeloPresto Synth has it. A MeloPresto Sound file (`.melosound`) stores the partials from which MeloPresto Synth synthesizes one instrument's sound, so that the partials can be spectrally aligned with any tuning. A musician who plays another synthesizer, or who stays in 12-edo, still has the whole of the MeloPresto Music System.

The syntonic temperament. The syntonic temperament is the temperament of rank 2 (two independent generating intervals) whose period is P8, whose generator is M5 and whose first comma is the syntonic comma, 81/80. The period and the generator are the two intervals from which the temperament builds every other interval. A comma is an interval that a temperament identifies with unison. Version 1 of MeloPresto supports the syntonic temperament only.

Tunings. A tuning is the active period and generator, which determine the size of every interval. The valid tuning range (VTR) of a temperament is the range of tunings across which a stated set of intervals keeps its order of size. The generator control spans about 686 to 720 cents at a period of 1200 cents; a cent is 1/1200 of P8. That range includes these tunings, where N-edo is the tuning that divides P8 into N equal intervals.

Tuning	Size of M5	Where it is used
7-edo	685.7 cents	Thai and West African seven-note music
19-edo	694.7 cents	Western microtonal music (music in tunings other than 12-edo)
Quarter-comma meantone	696.6 cents	European music of the Renaissance
12-edo	700.0 cents	Western music today
Pythagorean tuning	702.0 cents	European music of the Middle Ages
5-edo	720.0 cents	*Slendro*, a five-note tuning of the Indonesian gamelan (an ensemble of tuned percussion)

What Dynamic Tonality adds to tuning invariance. Tuning invariance keeps the shape and the fingering the same as the tuning changes. Dynamic Tonality keeps the consonance as well: with spectral alignment, one fingering gives the same consonant chord in every tuning of the syntonic VTR.

Calendar

Date	Gate	What a researcher can use
11 December 2026	Alpha	MeloPresto Jammer, MeloPresto Score and Jammer Shujaa, confidentially, for members of the MeloPresto Advisory Council
16 April 2027, World Voice Day	Beta	The same three applications, publicly, with MeloPresto Core Lessons
21 June 2027, Make Music Day	Launch	Version 1 of MeloPresto Jammer, MeloPresto Score, Jammer Shujaa and MeloPresto Core Lessons
After version 1		Temperaments other than the syntonic temperament

The MeloPresto Advisory Council is the group of people who review the design of the MeloPresto Music System and advise on it.

Research that needs only the syntonic temperament can begin at the Alpha for members of the Advisory Council and at the Beta for everyone. Research that needs another temperament uses other tools until a later version of MeloPresto supports that temperament. One such tool is 2032, a modal synthesizer, which offers several temperaments.

Cognition

Most of this area concerns Dynamic Tonality. Its last question concerns MeloPresto itself.

Repeat the founding experiments

Nearly every founding experiment in music cognition assumed the Just-Harmonic Hypothesis: its stimuli combined harmonic timbres with Just Intonation or, more often, with 12-edo. Each experiment can be repeated under the Timbre-Temperament Conjecture, with stimuli that are:

- spectrally aligned;
- varied across the syntonic VTR, which includes the tunings in the table above;
- in later work, varied across the VTR of the schismatic temperament, which is closely related to the syntonic temperament and has arguably been used in traditional Turkish music;
- in later work, varied across the VTR of the magic temperament, as a control, because the magic temperament is more distantly related and has been used only by microtonal musicians.

Each experiment can compare listeners whose musical upbringing is mainly:

- Western (12-edo);
- Indonesian traditional (5-edo, *slendro*);
- Thai or Mandinka traditional (7-edo);
- Turkish (Pythagorean tuning).

Experiments to repeat include those on auditory illusions and Krumhansl's probe-tone experiments, in which a listener rates how well one note fits what came before it. They also include the experiment of Janata and colleagues (2002). It found, in the rostromedial prefrontal cortex (a region at the front of the brain), a map of tonal space that is relative to the current key and ordered by the chain of fifths, which is the sequence of notes each one M5 from the next.

Separate nature from nurture

The conjecture supplies one premise that includes the music of many cultures (see Ethnomusicology). An experiment can therefore give each listener two sets of stimuli: one in the tuning and timbre of the

listener's musical upbringing, and one or more in tunings and timbres that differ from that upbringing by a known amount. What stays the same across both sets is a candidate for nature; what changes is a candidate for nurture. A theory of music built from such results would start from first principles of cognition and would not be limited to one culture.

Work of this kind exists: see Milne (2009, 2010a, 2010b, 2011). Milne and Holland (2016) compared listeners' judgments of the distance between two triads with two models: distance on the tonnetz, and spectral pitch-class distance, which compares the partials of the two triads. Both models agreed with the listeners and with each other. Smit, Milne, Sarvasy and Dean (2022) found in Papua New Guinea that hearing major as happier than minor depends on exposure to Western-influenced music. Much remains to do.

Tonal space and the brain's sense of place

The brain has nerve cells that fire according to where an animal is: place cells, grid cells and border cells. The MeloPresto button-field contains the tonnetz, so a chord progression played on a jammer is a path across the button-field. Does the brain use its cells for place to follow a path through tonal space? This question needs no Dynamic Tonality.

Composition

Dynamic Tonality gives a composer new effects.

1. **Polyphonic tuning bend.** A tuning bend changes the size of M5 while notes sound. It is polyphonic: it changes the pitches of many sounding notes together. The Reference Pitch is the pitch given to Re0, the origin of the lattice. Take a bend from 19-edo to Pythagorean tuning with the Reference Pitch unchanged. M5 grows by about 7.2 cents. Each note sharpward of Re0 rises, and each note flatward of Re0 falls, by about 7.2 cents for every M5 between that note and Re0 on the lattice. Because the partials follow the tuning, chords stay consonant throughout the bend.
2. **Tuning progression.** A tuning progression is a planned sequence of tuning bends, as a chord progression is a planned sequence of chords. Sethares's *C to Shining C* (2008) is one chord whose tuning and timbre change (analysis).
3. **Tuning color.** A composer uses a tuning for a short time for the emotional effect of its intervals.
4. **Timbre progression.** The Tone Diamond is a control with two axes. Its X-axis sets how far the partials are spectrally aligned: at X = 0 the timbre is harmonic, and at X = 1 the partials are fully aligned with the tuning. Moving X away from full alignment adds tension to a chord that would otherwise sound consonant, and moving X back removes the tension.
5. **Intonation.** The Tone Diamond's Y-axis moves the intonation of each chord toward 5-limit Just Intonation, which is Just Intonation whose ratios have no prime factor larger than 5. At Y = 0 the tuning is the regular tuning chosen by the generator; at Y = 1 it is Just Intonation. A regular tuning is one in which every M5 has the same size.
6. **Primeness.** Primeness raises or lowers the amplitudes of the partials whose numbers are multiples of one prime. Lowering the amplitudes of the multiples of 2 moves a timbre from that of an open cylindrical pipe (a flute) toward that of a closed cylindrical pipe (a clarinet). The multiples of 3 and of 5 give further timbres, and the multiples of 7 bring out blue notes, which are the bent notes characteristic of the blues.
7. **Temperament modulation.** A piece moves from one temperament to another through a pivot tuning, which is a tuning that the two temperaments share. This effect waits for a version of MeloPresto that supports a second temperament.

8. **Expression by motion.** A jammer's motion sensors can give the jammist continuous control of these effects while both hands play notes.

What a composer can do. Write music that uses these effects, and learn how audiences respond. The most useful first pieces put one effect, clearly audible, inside music that is otherwise familiar.

Education

This area concerns the MeloPresto Music System itself and needs no Dynamic Tonality.

Suppose the single aim of music education were to make it easy for everyone to compose, perform and improvise their own music, knowing what they are doing. The MeloPresto Music System is designed for that aim. It smartens music up; it never dumbs music down.

The system combines four well-known inventions that are isomorphic to one another: tonic solfa with movable Do, the chromatic staff, the Wicki-Hayden layout and the tonnetz. Each shows the same lattice of notes: by name, on the page, under the fingers and as harmony. The invariances follow, so that a learner who masters one fingering has mastered it wherever it is started and in every key.

The hypothesis. A novice using the MeloPresto Music System can reach competence radically faster than a novice using TiMS. The definition of competence must not depend on either system. The MeloPresto Core Lessons are designed to test this hypothesis.

The first learners. The first learners are adults who learned to sing or to play a monophonic instrument (one that sounds one note at a time) at school and now want to learn how music works and to write their own.

Research in this area.

- Define competence independently of TiMS and of MeloPresto.
- Compare the hours to competence of learners who use MeloPresto Core Lessons with the hours of learners who use TiMS.
- Compute the ratio of the Kolmogorov complexities of the two systems. The Kolmogorov complexity of a system is the length of the shortest program that generates it, and compression approximates it. Compress one corpus (a collection of pieces of music) in both notations, across all keys and all tunings of the syntonic temperament, and take the ratio.
- Test whether faster learning retains learners. Koster (2004) argues that fun is learning; on that argument, learners leave music lessons because learning is too slow to be fun.

Ethnomusicology

This area concerns Dynamic Tonality.

The VTR of the syntonic temperament includes tunings from several cultures: Western 12-edo, quarter-comma meantone, Indonesian *slendro* and the 7-edo of Thailand and of the Mandinka of West Africa. A scale, played with one fingering, becomes a different culture's scale as the tuning changes.

Scale	Tuning	Culture
Diatonic	12-edo	Western
Diatonic	Quarter-comma meantone	European Renaissance
Diatonic	7-edo	Thai; West African
Major pentatonic	12-edo	Western

Scale	Tuning	Culture
Major pentatonic	5-edo	Indonesian gamelan *slendro*

That such different tunings lie in one range suggests a conjecture in the manner of Chomsky's universal grammar: the brain is built for the music of the syntonic temperament, and any tuning in the syntonic VTR will serve. Two findings support it. The map of tonal space found by Janata and colleagues (2002) agrees with the syntonic temperament. Sethares (1998) found that the traditional instruments of Thailand and of Indonesia have partials that align with the notes of their tunings.

If the conjecture is right, it explains both why the world's tunings vary and what limits their variation. It also predicts which other temperaments and tunings new music can use.

What an ethnomusicologist can do. Test the conjecture by methods that ethnomusicology accepts and in a form that its journals publish.

Theory

Most of this area concerns Dynamic Tonality.

A hierarchy of rules

Western music theory is known for its rules. They say which pairs of chords make a cadence (a chord progression that ends a phrase), which chords prepare a cadence, in what order chords follow one another, and how counterpoint (the combining of independent melodies) works.

Some rules are true in every tuning of the syntonic temperament. Take Do-mode, the mode whose tonic is Do ("major"), and the chord progression (chord names) `Do5`, `Fa5`, `La5`, `Re5`, `So5`, `Do5` (in the Roman numerals of TiMS: I, IV, vi, ii, V, I). In every syntonic tuning, the progression ends with Do at the pitch at which it began. In Just Intonation it does not. When each note shared by two successive chords keeps its pitch, each pass through the progression lowers the pitch of Do by one syntonic comma (81/80, about 21.5 cents). The schismatic temperament does not identify the syntonic comma with unison either, so there too Do does not return to its pitch.

Other rules are true in one tuning only. M3 is the major third and m3 is the minor third. P8 minus three M3s is the lattice vector (7, –12): seven P8s up and twelve M5s down. Four m3s minus P8 is the same vector. That vector sounds 0 cents only when M5 = 700 cents, which is 12-edo. John Coltrane's *Giant Steps* moves among three keys that are an M3 apart, and his *Central Park West* among four keys that are an m3 apart. Only in 12-edo, therefore, does a cycle of three key changes by M3, or of four by m3, bring the Reference Pitch back to where it began, octaves aside.

The rules therefore form a hierarchy that is still to be worked out:

1. Rules true in one tuning of one temperament.
2. Rules true across one temperament, or across a sub-range of its VTR. What bounds the sub-range?
3. Rules true across all tunings of closely related temperaments. What makes two temperaments closely related?
4. And so on outward.

The Common Practice Era (European music from about 1650 to 1900) can be read as a research program of its own: the exploration of the rules true in a narrow sub-range of the syntonic VTR, the sub-range that suits harmonic timbres. That program gave music theory its present rules. Dynamic Tonality opens the remainder of the syntonic VTR to the same exploration.

What Dynamic Tonality gives a theorist

1. Consonance in every tuning of a temperament, through spectral alignment. Harmonic timbres are consonant in a narrow sub-range only.
2. Tunings as points on one continuum. Each tuning is a bead on a string, and the string is the VTR of the temperament. A composer can move from bead to bead and back.
3. Control of the tuning and of the timbre while playing.
4. One fingering on the button-field for every tuning in the VTR.

Research in this area

- **Harmonic function as geometry.** How is the function of a chord in a key described by positions and directions on the lattice? Mathieu (1997) suggests that the axis of M3s matters as much as the axis of M5s. This question needs no Dynamic Tonality.
- **The shape of the tuning continuum.** Treat notes a P8 apart as one note, and notes of equal pitch as one note. As M5 changes, the lattice then has the shape of a cylinder at most tunings and of a torus (the surface of a ring) at every N-edo. A rigorous proof is still to be written.
- **Diatonic set theory.** Diatonic set theory is the mathematical study of the diatonic scale. MeloPresto uses its well-formed scale: a scale generated by stacking one generator interval within a period, such that the scale has exactly two sizes of scale step, or one size when all its steps are equal (Carey and Clampitt, 1989). How does what remains of diatonic set theory generalize across tunings when timbres are spectrally aligned?
- **Neo-Riemannian theory.** Neo-Riemannian theory is the study of chord progressions as moves between triads that share two notes. MeloPresto uses those moves on the tonnetz. How does what remains of the theory generalize across tunings?
- **Orbifolds and topos theory.** The same question stands for Tymoczko's orbifolds, the geometric spaces in which each point is a chord, and for Mazzola's use of topos theory, a branch of abstract mathematics, to model music.
- **Another temperament.** Choose a temperament of rank 2 and explore it with spectrally aligned timbres. Which well-formed scales does it support? Which layouts of a button-field are isomorphic to it? What is its VTR? Which of its scales, modes, cadences and chord progressions does it share with the syntonic temperament, and which are its own? Which are invariant across its VTR? The result is a map from which composers and theorists can explore that temperament in detail. This work uses tools other than version 1 of MeloPresto.
- **Temperaments of higher rank.** Does the same lattice of interval vectors extend to temperaments of rank 3 and above, and what shape does the tuning continuum have there?

Instruments

A jammer that plays Dynamic Tonality needs two kinds of control. Its button-field controls the notes. Other controls, such as its motion sensors or small thumb-operated joysticks, give continuous control of vibrato, of pitch bend (a bend of one note's pitch), of the tuning, of the Tone Diamond and of primeness. Because the jammist controls the ordinary effects and the new ones together, a jammer needs unusually high expressive potential.

The design of such instruments belongs to the research field called New Interfaces for Musical Expression (NIME). Dynamic Tonality gives that field new questions and needs its answers.

On a phone or tablet. MeloPresto Jammer puts a button-field on a touch screen, and its tuning control is continuous. A MeloPresto preset file (`.melopreset`) stores a jammer's sound, tuning, timbre, envelope (how a note's amplitude changes while it sounds) and motion mapping.

As dedicated hardware. A phone was not designed as a musical instrument. As jammists become virtuosos they are likely to need a jammer built for the purpose, with physical note-buttons, internal motion sensors for orientation, thumb-operated joysticks, and optional external sensing of position. Several manufactured instruments already have isomorphic layouts, among them the Lumatone and the Exquis.

Research in this area.

- Which motions of a hand-held jammer best control which effects?
- How can a camera's view of a jammer's position add to what its internal sensors report of its orientation?
- What mount keeps a phone in playing position without limiting the jammist's fingers? The lapsed patent application WO2006050577, *Motion Sensors in a Hand-Held Button-Field Musical Instrument*, shows one answer.
- What is the best design of a hardware jammer?

Join the program

Apply on the home page of melopresto.com, and say which research question interests you. Members of the MeloPresto Advisory Council receive the Alpha.

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