Practical Tools for Risset Time Composition and Performance

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ABSTRACT

This paper introduces a framework for composing within Risset time, building on the mathematical principles outlined by Stowell [1] and subsequent research. Central to this approach is the Phase Accumulator with Cycle Count, a tool that integrates absolute and relative temporal addressing into a unified system. This framework allows for precise temporal navigation in Risset-based compositions, supporting the creation of dynamic illusions of acceleration and deceleration.

We explore applications of this framework across Risset rhythms and melodies, introducing techniques such as mute-based transitions, velocity muting, and decoupled melodic progression. By leveraging the dual addressing system, we demonstrate how rhythmic and melodic patterns can be precisely aligned and manipulated to produce compelling temporal effects. Unlike previous approaches that rely on higher-order layering for Risset illusions, we suggest that two layers—1x and 2x—are sufficient to maintain perceptual coherence for rhythmic patterns, simplifying implementation without sacrificing effectiveness.

Our work situates itself within the lineage of Risset-based research, drawing from the mathematical foundations established by Ghisi [2] (2021), and Frane [3] (2024). By addressing practical concerns in implementation and expanding the conceptual framework into melodic domains, we aim to provide composers with intuitive tools for exploring Risset effects. This research highlights the interplay between mathematical constructs and perceptual mechanisms, contributing to the ongoing exploration of temporal illusions in music.

1. INTRODUCTION

Jean-Claude Risset's pioneering work [4] introduced the world to auditory illusions, such as Risset rhythms and glissandos, which exploit the non-linear nature of human perception to create the illusion of infinite acceleration or deceleration. These groundbreaking effects have since inspired researchers and composers to deepen their understanding of the mathematical principles underlying these phenomena and to develop new tools for their implementation. Dan Stowell's 2011 paper, Scheduling and Composing with Risset Eternal Accelerando Rhythms, provided an elegant mathematical framework for constructing Risset rhythms. By focusing on higher-order multiples of time divisions, Stowell demonstrated how rhythmic layers could be structured to sustain the illusion of endless acceleration or deceleration. His systematic approach, based on meta bars and layered time divisions, laid a foundation for Risset-based compositional techniques. Subsequent research has extended these ideas: Ghisi (2021) explored Barberpole tempo illusions that mimic spectral continuity in rhythmic acceleration, while Frane (2024) expanded Shepard–Risset glissandi into novel perceptual and structural contexts. Building on this lineage, our work introduces several innovations that distinguish it from prior contributions. Central to our approach is the Phase Accumulator with Cycle Count, a tool for creating a unified temporal addressing system that seamlessly integrates absolute and relative time domains. This system enables precise navigation across Risset time-space, facilitating the manipulation of rhythmic and melodic elements. Furthermore, we demonstrate that for Risset rhythms, the complexity of Stowell's higher-order layering can be reduced to just two layers—1x and 2x—without compromising the illusion. This simplification not only makes Risset rhythms more accessible to composers. Additionally, our paper extends the conceptual framework of Risset illusions into the melodic domain, introducing techniques like mute-based transitions and decoupled melodic progressions. These methods address the challenges of applying Risset principles to pitched material, offering composers new creative possibilities.

2. NAVIGATING RISSET TIME

2.1 Phase Accumulator with Cycle Count

The Linear Address (LA) originates from the Phase Accumulator with Cycle Count, a mechanism that tracks the continuous progression of time across multiple cycles. The Phase Accumulator combines two components: an integer cycle count (N) representing the number of completed cycles, and a fractional phase Φ indicating the position within the current cycle. Together, these form the Linear Address:

$$LA = N + \Phi \tag{1}$$

Linear address is unbounded in either direction as seen in Figure 1. To convert a linear address into milliseconds, we need to know the rate of the phasor.

$$ms = \frac{LA}{|r|} \tag{2}$$

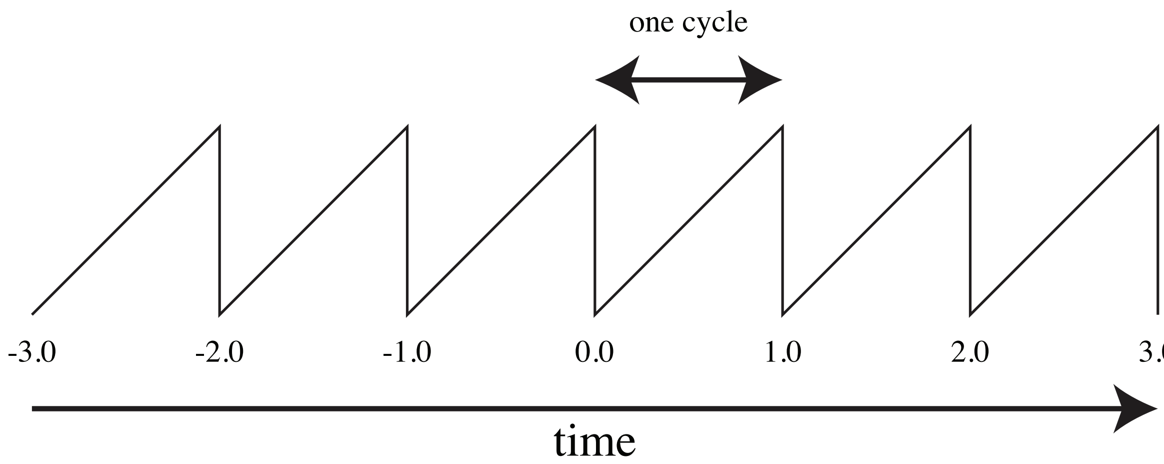

Figure 1. Illustration of a phase accumulator with cycle count. The phasor maintains forward progression even for negative values, ensuring time does not "reverse." Forward movement is represented by the advancing phasor.

2.2 Risset Function

To convert a linear address to a relative value such as ticks, we need to use the Risset Function. This function transforms this linear phasor into a signal that produces the perceptual effects of acceleration or deceleration.

For positive rates (acceleration):

$$y(x) = \exp(x \cdot \ln(2)) - 1 \tag{3}$$

For negative rates (deceleration):

$$y = \frac{\log(x+1)}{\log(2)} \tag{4}$$

The primary purpose of the Risset Function is to map the linear phase input into a transformed value that produces the acceleration or deceleration effect. Positive rates compress the phase progression exponentially, creating the illusion of speeding up, while negative rates expand it logarithmically, producing the illusion of slowing down.

3. APPLICATIONS

3.1 Quantization

The ability to seamlessly convert between absolute units, such as milliseconds, and relative units, such as ticks, unlocks a wealth of possibilities for integrating traditional compositional tools into the framework of Risset-based compositions. This dual addressing system bridges the temporal precision of absolute time with the flexibility of relative time, allowing composers to leverage familiar tools like sequencers, arpeggiators, and other pattern-based techniques.

Quantization in this context refers to the alignment of events within the Risset time-space to predefined rhythmic structures, enabling the use of rhythmic algebra to manipulate and organize temporal patterns. By mapping the linear address of a Risset phasor to relative units, events can be placed and manipulated with precision while retaining the non-linear, perceptual qualities of Risset cycles.

Through-composed lines are an important masking element for Risset illusions. While repetition of patterns is a required element for a Risset illusion, once these are established, melodic lines can flow freely across the metabar but remain temporally quantized to ticks. This creates another element of ambiguity that can help the illusion and serve as an important counterweight to the repetitiveness of the patterns.

For example, a sequencer operating in tick-based relative time can generate patterns that seamlessly integrate with a Risset rhythm, ensuring that each step aligns perfectly with the evolving tempo of the cycle. Similarly, arpeggiators and pattern generators can be configured to modulate parameters or trigger events in synchronization with the Risset phasor, creating intricate rhythmic and melodic textures that are both coherent and perceptually engaging.

This quantization framework empowers composers to experiment with complex, evolving rhythms while maintaining the accessibility of conventional tools. By grounding Risset effects in the familiar language of compositional techniques, this approach offers a bridge between advanced temporal illusions and creative workflows.

3.2 Periodic Modulation

Subdivision of the Risset phasor into smaller beat-relative units enables the creation of phasors that align with the structure of a Risset cycle. These smaller phasors, derived from the primary Risset phasor, serve as modulation sources that are tightly synchronized to the relative beats of the cycle. This process creates a framework for periodic modulation that is inherently linked to the temporal structure of the Risset rhythm.

A subdivided phasor is obtained by scaling the primary Risset phasor to match a desired subdivision. For instance, dividing the primary phasor by n, where n is the desired number of subdivisions, produces a phasor that completes one cycle for every n-th beat. This subdivision can then be crossfaded with its 2x-speed counterpart, where the crossfade is controlled by the primary Risset phasor. The result is a modulation source that evolves smoothly through the Risset cycle, mutating in a beat-synchronized manner as seen Figure 2.

This approach provides a versatile periodic modulation source, suitable for both digital signal processing (DSP) and compositional applications. For example, the smooth transitions between the 1x and 2x layers, driven by the Ris-

Figure 2. A crossfaded phasor over one Risset cycle in linear time.

set phasor, allow for dynamic modulations that remain perceptually coherent and musically meaningful. This technique extends the utility of Risset phasors beyond rhythm and melody, offering a novel tool for time-based modulation in sound design and composition.

The flexibility of this method lies in its ability to produce modulation sources that are not only synchronized to the underlying Risset rhythm but also capable of evolving dynamically within the framework of a Risset cycle. Whether applied to control parameters in DSP algorithms or to generate compositional structures, these beat-relative phasors provide a powerful means of bridging the conceptual gap between mathematical precision and musical creativity.

3.3 Delay

Audio delay effects present a unique challenge within the framework of Risset time due to the continuously evolving nature of the underlying tempo. Traditional delay effects rely on a fixed tempo to calculate delay times, which conflicts with the accelerating or decelerating progression of a Risset cycle. However, by leveraging the ability to calculate exact playback positions at any point in Risset time, we can create delays that maintain a consistent beat-relative rate, regardless of the non-linear tempo changes.

To achieve this, we use techniques such as phase vocoding and granular synthesis, which allow for precise control over playback rates. These methods enable the implementation of delay effects that remain synchronized to the relative beat structure of a Risset rhythm. By dynamically adjusting the playback rate of delayed audio, the delay times can evolve in sync with the Risset cycle, creating effects that are perceptually coherent and rhythmically engaging.

The phase vocoder, introduced by Flanagan and Golden (1966) [5], is a technique that allows for time-stretching and pitch-shifting audio signals independently. This capability is critical in Risset time, where playback rates must be adjusted continuously to maintain synchronization. Similarly, granular synthesis, popularized by Roads [6] (1978), provides a flexible framework for manipulating audio at the microstructural level, enabling the creation of beat-relative delays that adapt to the shifting tempo.

These approaches make it possible to implement delay effects that are not only musically meaningful but also preserve the perceptual illusion of Risset time. For example, a delay set to repeat every two beats in Risset time can maintain its relative spacing as the tempo accelerates or decelerates, ensuring that the delay remains rhythmically consistent. This capability expands the creative possibilities of delay effects, allowing them to function as dynamic, adaptive tools within the context of Risset-based compositions.

By combining precise temporal addressing with advanced playback techniques, this method overcomes the limitations of traditional delay effects in non-linear temporal environments. The result is a system that aligns delay effects with the evolving nature of Risset time, offering composers and sound designers a powerful tool for creating novel, rhythmically adaptive audio effects.

3.4 Risset Rhythm Compositional Techniques

3.4.1 Crossfade

In his 2011 paper, Scheduling and Composing with Risset Eternal Accelerando Rhythms, Dan Stowell introduced the concept of using higher-order multiples of time divisions to construct layered Risset illusions. These higher orders are particularly effective in Risset glissandos, where multiple octaves—typically four or more—are employed to create the perceptual continuity of the pitch ascent or descent. This multi-layered approach ensures a seamless auditory experience as the fundamental frequency shifts through octaves.

However, for Risset rhythms, such extensive layering is unnecessary. Unlike Risset glissandos, which rely on a broader spectral representation, Risset rhythms require only two layers: the base rhythmic pattern (1x) and its double-time counterpart (2x). These two layers as seen in Figure 3 are sufficient to achieve the perceptual illusion of acceleration or deceleration. The transition between the layers occurs at the meta bar, with the 2x layer fading in to handle the transition for accelerating illusions, and the 1x layer fading in for decelerating illusions.

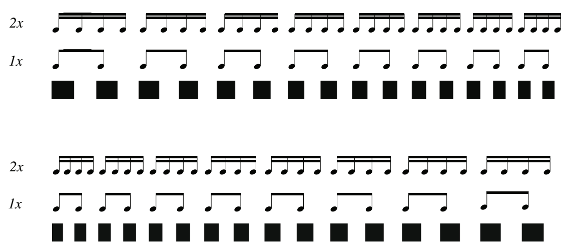

Figure 3. The top figure represents an accelerating Risset pulse with a 1x and 2x layer in linear time. The bottom figure represents a decelerating Risset pulse with a 1x and 2x layer in linear time.

The Risset rhythm crossfade technique begins with these two layers. The 1x layer represents the base tempo of the rhythm, while the 2x layer operates at twice the speed, creating the perceptual effect of continuous tempo evolution.

For accelerating illusions, the crossfade begins with the 2x layer dominant. As the illusion progresses, the 1x layer fades in, ensuring that the faster layer gradually transitions into alignment with the slower phase of the original pattern. At the Risset boundary, the listener perceives the slowest point in the cycle, seamlessly transitioning into the faster pattern as it resets.

The core pattern can be presented multiple times within one Risset cycle, but this also means the two copies of the

2x version of the pattern will also be repeated Figure 4 shows how multiple presentations of an accelerating pattern are layered with their doubles.

For decelerating illusions, the process is reversed. The 1x layer starts as the dominant rhythm, with the 2x layer gradually fading in. As the Risset boundary is reached, the illusion aligns with the fastest phase of the cycle, smoothly transitioning from the slower rhythm into the faster one.

A typical crossfade is generated from the primary phasor. The fade in uses linear phasor directly and a fade out can be generated with a reverse mapping, ensuring smooth transitions at the metabar. By carefully managing these transitions, the technique creates the compelling illusion of infinite acceleration or deceleration without breaking the structural coherence of the rhythmic pattern.

The effectiveness of this method depends on the simplicity and regularity of the rhythmic patterns involved. Complex patterns may introduce unintended artifacts during the crossfade, potentially disrupting the illusion. By balancing the layers and carefully controlling the crossfade, this technique achieves the illusion of a constantly evolving tempo.

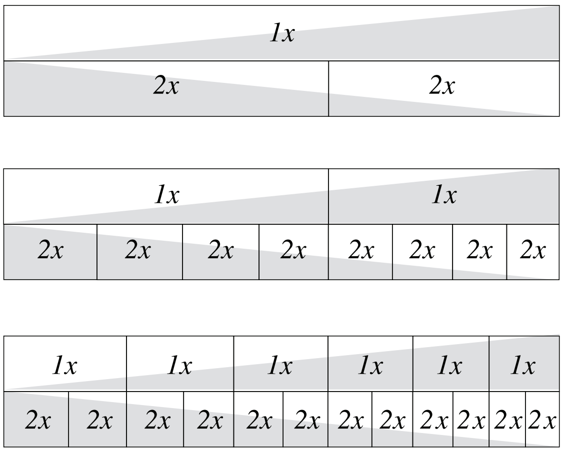

Figure 4. Multiple statements of a pattern can be nested in one Risset Cycle. The patterns are presented 1, 2, and 6 times, including the required corresponding double-speed statements. The diagrams are presented in linear time, with the accelerating patterns compressing as they progress toward the end of the phase.

3.4.2 Mute-based transitions-

One drawback of crossfade transitions is that remnants of the higher or lower order pattern multiples sound like a fade or a DSP process rather than the result of a musical performance. When one simply plays a steady pulse to the end of the Risset phase, the result is an obvious rate transition at the metabar. Layering a 1x and 2x pattern together and choosing a transition point somewhere inside the Risset phase allows the transition point to be disguised when layered with other patterns.

The mute-based transition technique offers an alternative to crossfading for managing transitions between rhythmic layers in Risset rhythms. Like crossfades, this approach relies on layering the base tempo (1x) with its faster counterpart (2x). However, instead of blending the two layers gradually, mute-based transitions use silence and abrupt transitions between them. By the time the pattern gets to the meta bar, the pulse has already transitioned. Figure 5 shows a linear time transition over the metabar.

The key idea behind this technique is to disguise the Risset transition, embedding it somewhere inconspicuous within the phase of the Risset Cycle. Depending on how the transitions are handled, the effect can vary significantly. In Figure 6, voids may occur during transitions, where no rhythmic pattern is heard momentarily. This creates a pause in the rhythmic texture, enhancing the illusion of movement as the listener fills in the gaps perceptually.

In contrast, splice transitions avoid both voids and overlapping layers. Instead, they allow the composer to designate a specific phase point for the transition to occur, resulting in an abrupt change.

Layer transitions, on the other hand, include some overlap between the 1x and 2x versions of the pattern. This overlap introduces a brief interplay between the layers, adding ambiguity to the rhythmic structure. The interaction of the two layers can create intriguing textures and reinforce the illusion of acceleration or deceleration.

Mute-based transitions are particularly effective when applied to compositions with multiple voices or rhythmic patterns. By staggering the transitions of different voices across various points in the Risset phase, obscuring the transition point.

3.4.3 Mute and Crossfade

The mute and crossfade technique combines the principles of muting and crossfading to manage transitions in Risset rhythms. This hybrid approach uses the phase of the linear phasor as a control signal to dynamically adjust the balance between muting and blending layers, offering composers a highly flexible way to shape rhythmic transitions.

Central to this technique is the use of an arbitrary breakpoint generator, which maps the linear phasor phase to a scaling value. This value determines whether a specific layer is muted, partially attenuated, or fully audible during the transition. By varying the scaling dynamically, the technique creates smooth transitions while allowing for moments of silence or reduced intensity, depending on the desired effect.

The crossfade component ensures a seamless blending of the 1x and 2x layers, maintaining the perceptual illusion of continuous acceleration or deceleration. At the same time, the mute component selectively removes or attenuates one of the layers, adding clarity and rhythmic variation to the transition. The balance between these two processes can be adjusted in real-time by modifying the breakpoint function or the phase mapping.

This combined approach is particularly effective for creating intricate rhythmic patterns with a strong sense of motion. By scaling the transitions based on the linear phasor phase, the composer gains precise control over the timing and intensity of each transition. The technique also lends itself well to layering multiple rhythmic voices, where each layer can independently modulate between muting and crossfading based on its respective phase.

The mute and crossfade technique provides a versatile tool for navigating Risset rhythms, offering a range of textures and transitions that balance subtlety and complexity. Its dynamic nature makes it well-suited for both algorithmic composition and interactive performance.

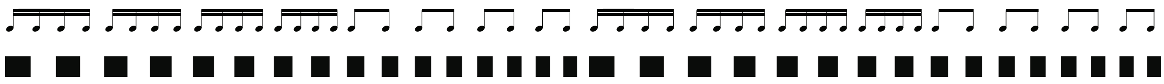

Figure 5. Two accelerating Risset cycles are represented here in linear time. The rhythm begins at 2x time and then shifts to 1x at 0.5 phase. The metabar transition reveals a constant perceptual pulse into the following pattern despite transitioning from eighth notes to 16th notes. Thus, the gear shift into the slower pattern happens "inside" the rhythm and not at the metabar. Moving the location of this transition and layering with other patterns is the key to Risset rhythm illusions.

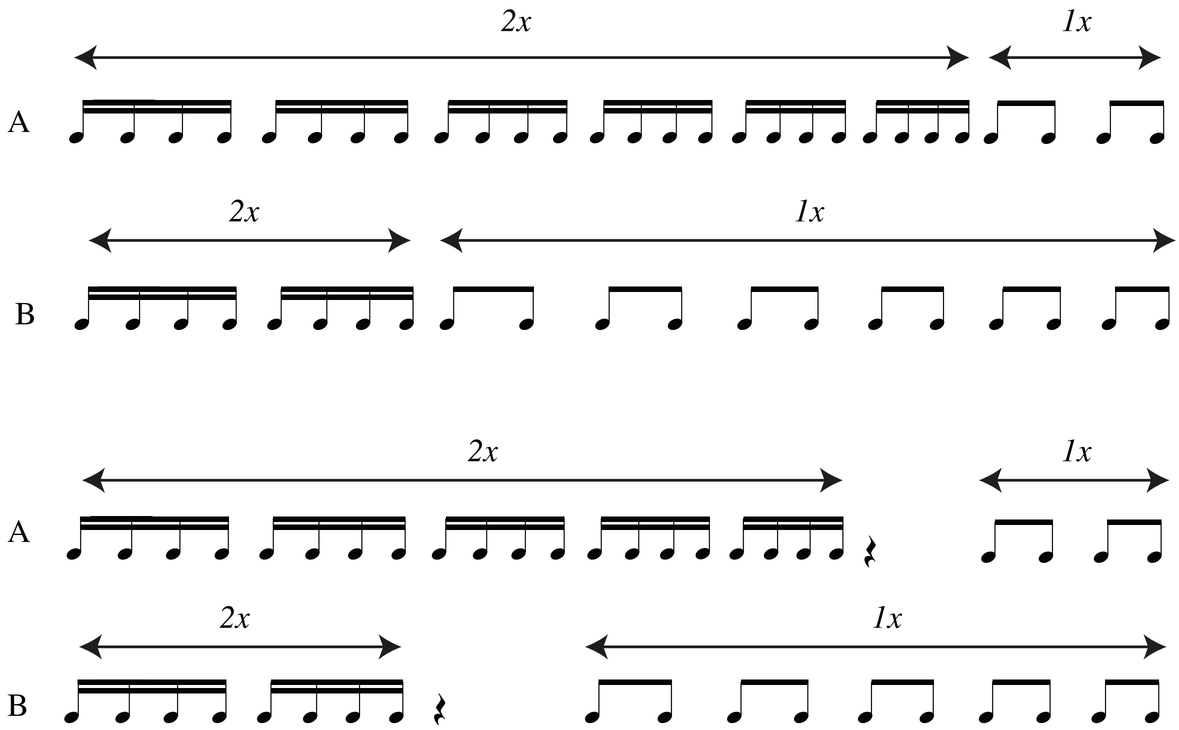

Figure 6. This diagram illustrates a layer of collapsed Risset rhythms in linear time. Two lines transition to their 1x counterparts at different phases within the Risset cycle. In the lower example, the transition entry and exit points are further reduced, creating voids within the pattern, generating ambiguity while another pattern carries the pulse.

3.4.4 Velocity Gating

The velocity gating technique is designed for event-based rhythmic patterns, using velocity attenuation to emphasize the most salient beats while reducing unnecessary complexity. Unlike techniques applied to continuous audio, this method adjusts the velocity of events in both the 1x and 2x layers based on their position in the Risset phase.

In this approach, the velocity of each event is scaled according to the Risset phase, with attenuation applied inversely between the layers. When the 1x layer is dominant, velocities in the 2x layer are reduced toward zero, and vice versa. This ensures that only one layer is perceptually prominent at any given moment, creating clarity in the transition between layers.

A key feature of velocity muting is its ability to simplify patterns by removing events with low velocities after attenuation. Any event falling below a specified velocity threshold is muted, reducing clutter and emphasizing the strongest beats of the pattern. This process highlights the underlying rhythmic structure, ensuring it remains clear and engaging.

This technique works particularly well for event-based sources, such as MIDI sequences or algorithmically generated patterns, where velocity data can be precisely controlled. By aligning attenuation with the Risset phase and removing weak beats, velocity muting offers a methodical approach to creating rhythmic patterns that retain their identity while simplifying their presentation over time.

3.4.5 Progressive Rhythms

Progressive rhythms extend rhythmic patterns across the metabar. While standard Risset loops can sustain endless acceleration or deceleration, progressive rhythms are constrained by their inability to become infinitely faster or slower. As a result, there is a practical limit to how far a progressive rhythm can stretch, depending on the rhythmic material and the perceptual thresholds of the listener. Progressive rhythms are an excellent way to disguise the metabar, distracting the listener's ear with the continuation of a pattern as seen in Figure 7. The use of progressive rhythms is a key technique to creating satisfying Risset time compositions across the meso and macro structural time domains.

3.5 Risset Melody Composition Techniques

3.5.1 Mute transitions

Cyclical melodic Risset phrases (of a duration corresponding to the attentional temporal limits established by Fraisse [7]) can be constructed in a similar manner as Risset rhythm where we start with a 1x and 2x layer. The limitations of

Figure 7. Progressive pulse patterns interleaved with three complete cycles of pulse patterns derived from the Risset phasor. The time domain is linear.

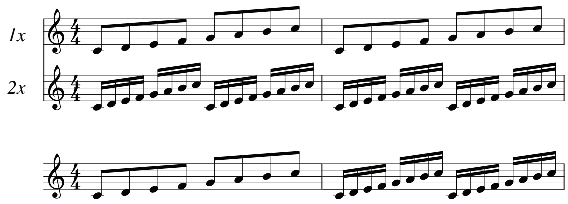

Figure 8. This illustrates a melodic layer played against itself at 2x speed. A mute-based flattened result of the 1x and 2x layers with a transition point exactly at 0.5 linear phase is displayed below. Time is portrayed using relative units.

using crossfades on Risset rhythms is magnified when applied to melodic patterns. Because of this, mute transitions are the favored technique.

In this approach, transitions between the 1x and 2x layers of a melodic pattern are managed by muting one layer entirely before activating the other. This ensures that only one version of the melodic material is audible at a time, preventing the harmonic clashes that might arise from simultaneous playback of overlapping layers as seen in Figure 8.

This technique merely moves the location of the transition away from the metabar. This technique must be applied with layering (with other melodic patterns at a different transition phase) or other techniques like through-composed lines or decoupled melodic patterns.

3.5.2 Decoupled Melodic Progression

The Decoupling of Melodic Progression from Rhythm technique separates the creation of rhythmic patterns from the development of melodic material, ensuring that both elements remain perceptually coherent and independent. This approach starts with a flattened Risset rhythm, where the distinctions between 1x and 2x layers have been resolved into a single cohesive pattern. The melodic progression is then layered onto this existing structure.

To implement this technique, the composer first designs the Risset rhythm using any event-based method, such as crossfading, mute-based transitions, or velocity muting. Performative qualities of the rhythm can be preserved including velocity and duration. At this stage, this layer of the rhythmic illusion is fully constructed and no longer involves active interplay between the original and doubled layers; instead, it functions as a unified, flattened rhythm. Once this rhythmic pattern is established, the melodic sequence is applied. The notes in the sequence are applied step-by-step to the rhythmic pattern, advancing with each event as seen in Figure 9.

The progression of the sequence of notes is a pattern that can be appreciated independently of the underlying rhythm. The independence of these cycles helps obscure rate transitions.

The result is a perceptual experience where the melodic movement appears to "stay constant," smoothly unfolding alongside the evolving rhythm without abrupt shifts or "gear changes."

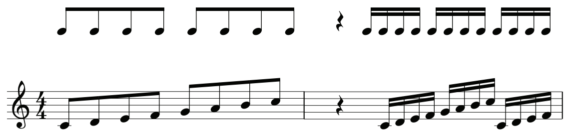

Figure 9. A decelerating Risset rhythm is 'flattened' from its 1x and 2x versions. A melodic progression of C D E F G A B C is applied to the rhythm producing the resulting melodic line.

4. CONCLUSIONS

This paper presents a framework for navigating a RisSet timeline. By introducing the Linear Address as a foundation, the framework enables precise temporal navigation while supporting integration with compositional tools like sequencers and rhythmic pattern generators. Compositional techniques such as mute-based transitions, velocity scaling, and progressive rhythms offer applications that extend the creative potential of Risset effects beyond traditional rhythmic and spectral domains.

By simplifying the layering required for Risset rhythms and expanding to include Risset melodies, this work builds upon existing research while addressing practical concerns in implementation. The framework's adaptability, facilitated by tools like the Risset Function makes Risset effects more accessible for composers.

The methods outlined here are intended to serve as both a theoretical foundation and a set of practical tools, inviting further exploration of Risset time. Future directions might include expanding the system to accommodate higher-order layers, exploring new mapping techniques, or investigating the perceptual thresholds of these illusions. The findings reaffirm the rich potential of Risset-based techniques for pushing the boundaries of rhythmic and melodic composition.

5. REFERENCES

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