# PERFORMANCE PRACTICE OF REAL-TIME NOTATION

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## ABSTRACT

This paper addresses the performance practice issues encountered when the notation of a work loosens its bounds in the world of the fixed and knowable, and explores the realms of chance, spontaneity, and interactivity. Some of these performance practice issues include the problem of rehearsal, the problem of ensemble synchronization, the extreme limits of sight-reading, strategies for dealing with failure in performance, new freedoms for the performer and composer, and new opportunities offered by the ephemerality and multiplicity of real-time notation.

## 1. REAL-TIME NOTATION

The issue of permanency in notation immediately evokes a continuum bounded by pre-determined paper scores at one end and free improvisation on the other. Gerhard Winkler suggests that between these two extremes lies a "Third Way" made possible by recent technologies that support various types of real-time notation [1]. This emerging practice of using computer screens to display music notation goes by many names: animated notation, automatically-generated notation, live-generative notation, live notation, and on-screen notation. These new notational paradigms can be separated into two categories: real-time notation and non-real-time notation (see Figure 1). Real-time notation encompasses scores that contain material open to some change during the performance of the piece. Many works fit this definition, from those that use predetermined musical segments that are reordered in performance to those that are completely notated in the moment of performance. Non-real-time notation accounts for all other uses of the computer display as a notational medium. Both static and animated scores occupy this category. The boundary between these two primary approaches to notation on the computer screen is not rigid and a technique like the live-permutated score can be argued to fit in either category.

It is useful to further categorize an on-screen work by its attributes. These attributes are found in both real-time and non-real-time scores: notation style, interpretive paradigm, time synchronization and location tracking management, degree of on-screen movement, whether the performer reads from a part or a score, and if there is non-notational interactivity (see Figure 2). Notation style refers to the spectrum between traditional symbolic notation and graphic notation. Many real-time notation scores use graphic notation or a combination of traditional symbols and abstract graphics. The interpretive paradigm of a piece determines whether the performer does strict music reading or uses some degree of improvisation to interpret the notation. The method of time synchronization, location tracking, and the amount of on-screen movement can be important in solo and ensemble pieces reading from a computer screen. Relying on eye-movement research, Lindsay Vickery [2] and Richard Picking [3] conclude that common approaches like the playhead-cursor and the scrolling score are unnatural for the performer to follow. I argue for a bouncing-ball-type tracker that embodies expressive and anticipatory tempo information drawing on a performer's skill of following a conductor [4]. The question of whether the performer reads from a part or score has implications for ensemble coordination and the visual size of the music. Works using real-time notation often incorporate non-notational interaction through audio or video processing. In addition to the challenge of real-time notation, the performer must grapple with the issues associated with *musique-mixte* and interactive electroacoustic music.

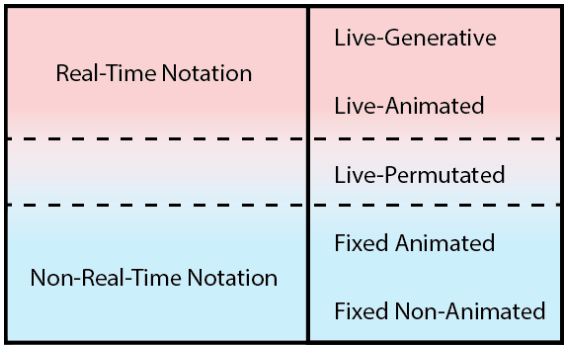


**Figure 1**. Categories of real-time and non-real-time music notation.

## 2. ON THE LACK OF PERFORMANCE PRACTICE GUIDES

The performance practice issues of real-time notation share connections with open form music, indeterminacy, complexity, free improvisation, and interactivity. These issues and their associated challenges pose a formable hurdle for many performers. Many composers have incorporated real-time notation in their practice despite the inherent difficulties. Some have written extensively on the topic of real-time

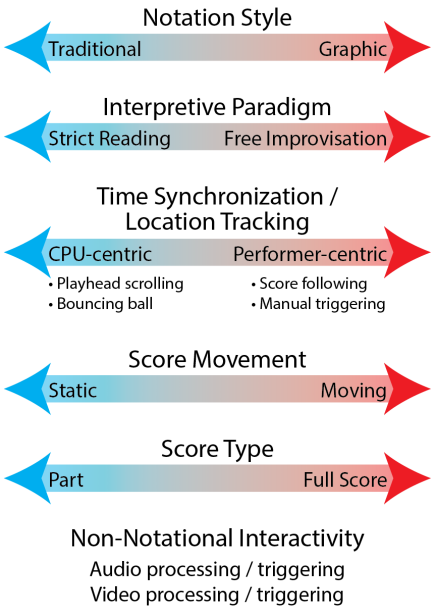


**Figure 2**. Attributes of the real-time score.

notation in an effort to detail new software in the field or to explain the technological or theoretical underpinnings of a new work. With some notable exceptions, few have presented the problems and newfound freedoms that the performer faces in performing such works. Jason Freeman's "Extreme Sight-Reading, Mediated Expression, and Audience Participation: Real-Time Music Notation in Live Performance" is an excellent first attempt at developing a comprehensive guide for the performer [5]. However, Freeman fails to go far enough when describing performer psychology in both the rehearsal and performance experience. In addition, his definition of real-time notation is limited to synchronized ensemble improvisation and audience participation. Freeman largely ignores real-time scores that employ traditional notation symbols.

Many composers and technologists include small reports of performance practice in their research, often mentioned as an ancillary issue. Such remarks read like the following: "The best way to approach the playing of a Real-Time-Score seems to be that of a relaxed, playful 'testing' of the system" [6]. This type of suggestion ignores the real barriers for performers approaching real-time notation and often comes across as composer-knows-best. The trust required between a composer, performer, and a work that exhibits notational agency is not a thing to be taken lightly and requires an in-depth study.

## 3. NEW FREEDOMS FOR MUSICAL EXPRESSION

### 3.1 Freedom From Replication

The composer or performer viewing real-time notation from a distance might rightfully wonder in what ways the added challenges of real-time notation can ultimately benefit a composition. Real-time notation affords both composer and performer with new freedoms in live performance and new means for musical expression.

One freedom is the release from the burden of replication. Since the advent of the phonograph, recorded performances have imparted an increasingly weighty tradition on the shoulders of each generation of performers. Not strictly relegated to the hallowed ranks of common practice music, recordings of contemporary compositions by esteemed new music performers become authoritative in a way that was perhaps unintended. Issues related to the archival worth of such documents aside, composer-endorsed recordings become a type of *urtext* (an *urklang* perhaps) and an immediate arbiter of what is an "authentic" performance of a piece.

Remarking on authenticity and values in common practice music, Bruce Haynes lists ideals that are ever increasingly found in new music:

The shortlist of "Masterpieces" that it plays over and over, repeatability and ritualized performance, active discouragement of improvisation, genius-personality and the pedestal mentality, the egotistical sublime, music as transcendent revelation, *Absolute Tonkunst*…ceremonial concert behavior, and pedagogical lineage [7].

Those ideals contrast those that Haynes asserts ruled musical events before the nineteenth century:

That pieces were recently composed and for contemporary events, that they were unlikely to be heard again (or if they were, not in quite the same way), that surface details were left to performers, that composers were performers and valued as craftsmen rather than celebrities…and that audiences behaved in a relaxed and natural way [7].

By extension, these ideals might have something to say about works written today. Paul Thom affirms this line of thinking when he says, "An ideology of replication leaves no room for interpretation; and yet interpretation is a necessity…in performance" [8]. Works using real-time notation offer freedom from the shackles of authenticity and the burden of being measured against recordings by creating a situation that defies (even undermines) replication.

### 3.2 Improvisational Freedom

While the variable nature of real-time notation guarantees diversity in the source material, it also grants a degree of creative license to the performer through improvisation. Many real-time notation works use graphic notation to guide a performer through improvisation. Karlheinz Essl's *Champ d'Action* (1998) uses a combination of on-screen text and graphic symbols to elicit group improvisation (see Figure 3). Written for an unspecified ensemble of between 3 to 7 soloists, the musicians respond to live-generated universal parameter instructions that must first be translated to their instruments before attempting the loftier goal, "to create relationships by listening and reacting to the sounds that are produced by the other players which could lead to dramatic and extremely intense situations" [9]. Essl describes the piece as a, "real-time composition environment for computer-controlled ensemble," [9] indicating the open-form nature of the work and his relinquished compositional agency to computer spontaneity and performer creativity.

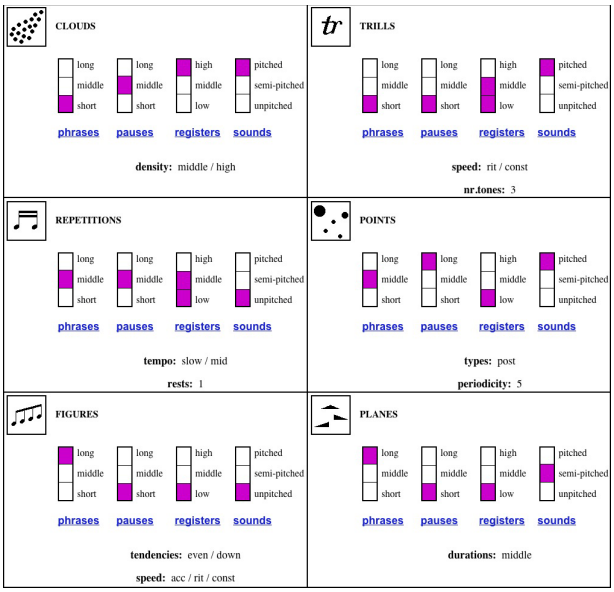


**Figure 3**. Computer-generated instructions in Karlheinz Essl's *Champ d'Action*. Used with permission.

### 3.3 Interactive Freedom

The freedom of direct interaction between computer-generated notation and performer is related to improvisation. Given the appropriate circumstances, the performer can assume direct control over the content of their own notation or the notation of another performer. This is the case in Jason Freeman's *SGLC* (2011) for laptop ensemble and acoustic instruments, in which the laptop ensemble chooses and modifies pre-composed musical fragments for the instrumental ensemble to perform in real-time [10]. While Freeman urges each performer to familiarize themselves with the pre-composed material, he gives complete agency to the laptop performers to create loops, add or subtract notes, change dynamics, transpose, and otherwise alter the notation. In this particular piece, the relationship between laptop performer and instrumental performer can appear adversarial; the instrumental musician is at the mercy of the laptop "re-composer." Freeman counters this initial impression by encouraging pairs of laptop and instrumental performers to rehearse separately, becoming familiar with each other's behaviors and abilities, before attempting an ensemble rehearsal: "This unusual setup encourages all of the musicians to share their musical ideas with each other, developing an improvisational conversation over time" [10].

Freeman's approach to notational improvisation is representative of new interactions made possible in real-time notation. This type of interaction can be labeled permutative interaction, where pre-composed segments are reordered. Other new categories of interaction include formal interaction, where the performer can influence aspects of the large-scale structure of a piece; temporal interaction, where rhythmic augmentation and diminution or tempo modulation can change dynamically; and local interaction, where surface details of a piece like pitches, rhythms, dynamics, articulations, and other expressive elements become dependent on performer input. These are but a sample of the new types of notational interaction made possible by abandoning fixed notation.

### 3.4 Ephemerality and Multiplicity

In the age of abundant documentation, societal pressures to package, brand, and sell a finished artwork choke out the ephemerality of music making. While space limits a fuller discussion of the beauty of impermanence, real-time notation offers a solution to this philosophical and moral problem in the form of multiplicity: each performance presents only one possible version of a piece that exists in plurality. To know one performance is to know only part of the whole. From the performer's standpoint, each performance is unique, free from any historical burden of the past and any comparative critique in the future. The music exists only as it is performed, as any documentation inherently fails to fully represent the work.

Winkler compares the composer of a real-time score to a gardener, "who plants 'nuclei' or germs, and watches them grow, depending on influences from the environment, in this or that way. All versions are welcome" [1, p. 5]. John Cage remarked about his *Concert for Piano and Orchestra* (1957–58) that every performance contributes to a holistic understanding of the work: "I intend never to consider [the work] as in a final state, although I find each performance definitive" [11]. Richard Hoadley asserts that the process is similar to mapping the landscape of a geographic territory without describing every rock, tree, and bush [12]. In this way, the composer acts as cartographer, creating a landscape and releasing the performer to explore its details.

## 4. PROBLEMS IN REHEARSAL AND PERFORMANCE

### 4.1 Traditional Purposes of Practice and Rehearsal

With new freedoms for interaction and improvisation and without concerns about replication in light of the ephemerality and multiplicity of real-time notation, come the practical issues that face musicians in rehearsal and performance. Before exploring some new ways to approach practice and rehearsal, the obvious and less apparent purposes of traditional, fixed notation works should be stated. The most prominent purpose of practice is to learn the details of a piece. Some performers describe their practice trajectory as first translating notational language into physical gestures, gradually linking larger and larger musical units together, culminating in a large-scale coherent interpretation [13]. Other performers may follow the opposite path, beginning from a theoretical understanding of the entire work and moving towards mastering the details of each moment. In either case, what is necessary is an understanding of both the specific and the general, the micro and the macro.

The rehearsal process involves other players and presupposes the micro-macro knowledge gained in private practice to develop an understanding of ensemble interaction. Rehearsal with an electronic component or interactive computer part adds complication. Often in the case of interactivity, rehearsal time is spent navigating the technological prosthetics involved (microphones, loudspeakers, pedals, sensors, and other devices), the temporal modalities employed (fixed, fluid, or interactive accompaniment), and the behaviors of the computer agent (traditional score follow-

ing, coordinated live-input processing, active human-computer joint improvisation, and so forth.) [14].

### 4.2 New Purposes of Rehearsal with Real-Time Notation

Many of the traditional purposes for practice and rehearsal fall away in works using real-time notation. One of the primary hindrances for newcomers to real-time notation is the unfamiliar process of rehearsing. Why rehearse when the notation changes in the moment of performance? The answers that follow do not pertain to every existent work, but are a list of possible reasons for and approaches to rehearsal.

Instead of practicing a work to transcend the physical actions of the surface details to an informed interpretation of the whole, the performer must engage with the real-time score paying attention to behaviors. Much like how the performer of interactive computer music rehearses with the computer to investigate the designed functions, a work using interactive notation can be built with specific responses to human input or a temporally-cued score. These behaviors can be studied in two ways: with an eye for general local detail and with an eye for general large-scale form. The local detail can be as simple as discovering a set of pre-composed fragments, or it can be as complex as deducing the frequency of rhythmic figures, probability of pitches, or variety of graphic indications. In my quartet for viola, bass clarinet, marimba, and computer, *Law of Fives* (2015) [15], a limited number of predetermined pitches are probabilistically selected and assigned to algorithmically-designed rhythmic structures (see Figure 4). In this piece, the pitches are predictable while their order and associated rhythms are variable. Local details can depend on performer input and the rehearsal process defines the way in which the input affects the notational output. In *Law of Fives*, increased dynamic input from one instrument influences the likelihood of rests and random ordering of pitches for another instrument (see Figure 5).

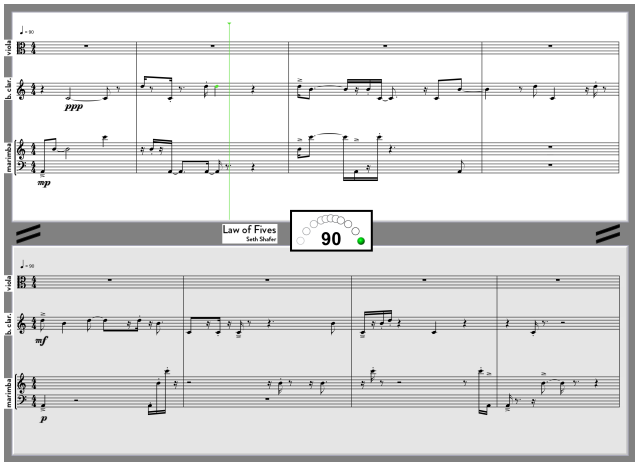


**Figure 4**. Predictable pitch behavior in Seth Shafer's *Law of Fives* (2015).

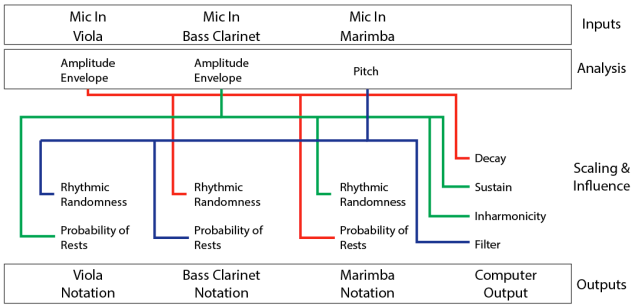


**Figure 5**. Notational variability from live performer influence in Seth Shafer's *Law of Fives* (2015).

Some local detail defies the predictability described previously. In such cases, the performer can benefit from studying the large-scale form. Rehearsal should afford the performer time to play the piece multiple times to gain a sense of any pre-planned or emergent forms. One possibility is that the notational behavior changes significantly at certain time-points. This is a strategy employed in *Law of Fives,* where one can outline predictable large-scale changes in tempo, texture, orchestration, and tessitura over time. In other works, one might find that behavior *y* always follows behavior *x*, or some more sophisticated formula. Another attribute that one can study is the general difficulty level and the modulation of that difficulty throughout the piece.

Some behaviors lie outside of either composer or performer control. A work like Nick Didkovsky's *Zero Waste* (2001) creates a performer-computer-notation feedback loop that highlights inaccuracies in human performance, errors in the computer analysis of the performance, and inadequacies in symbolic notation [16]. Even in a chaotic system certain behaviors can emerge. In *Zero Waste*, the trajectory of cumulative error in the system is toward an increased number of rests near the beginning of each notational output due to performer hesitation and the accumulation of chord clusters due to rhythmic quantization.

Another situation that evades composer and performer control is that of audience participation. Works like Kevin Baird's *No Clergy* (2005) [17] and Jason Freeman's *Graph Theory* (2005) [5] crowdsource certain compositional decisions, making the rehearsal of such works difficult. In this case, simulating audience feedback in rehearsal can clarify which parameters can be anticipated and which are subject to chance. Whatever strategy the composer employs, a major purpose of rehearsal is deducing notational behavior.

A common thread in real-time notation is that some amount of sight-reading is necessary. One purpose of rehearsal is to practice sight-reading the notational output from the system. Even performers confident in their abilities can balk at the prospect of sight-reading live in front of an audience. Substantial time must be dedicated to this task to aid in both the behavioral analysis described previously and developing quick music reading skills. Performers must keep in mind that every repetition of the work that they practice sight-reading is an equally valid version of the piece. Anything displayed in rehearsal can be in the version performed live.

Another important rehearsal consideration is the extent of improvisation involved in the work. Some pieces, particularly those with graphic elements, require a great deal of

improvisation. Others do not ask for improvisation. Whether as a direct result of the notational design or the pressures and human limits of fast music reading, most pieces requiring live sight-reading involve possible improvisation. The composer and nature of the piece are the performer's guide. In the heat of performance, mistakes will occur and the musician must know which elements take priority and which can be neglected. Perhaps the general effect of the work is of prime importance and some brief moments of improvisation are preferable to silence if the performer's sight-reading skills falter. Conversely, perhaps formal connections should be sacrificed to meet the demands of local detail. These realities must be faced directly, ideally with composer input, so the performer knows what options exist when the inevitable mistake occurs.

A practical consideration for the performer during rehearsal is to become familiar with the on-screen graphical user interface. Every piece is different in this respect and the performer must acclimate themselves and glean every useful bit of information they can from the screen. The notational display might follow one of several paradigms. The notation might move: Does it constantly scroll horizontally or vertically? Does it slide periodically every beat, bar, system, or pre-determined span of time? The notation might remain stationary: Does the notation have virtual page turns? Does the screen refresh with new notation periodically? How far can the performer read ahead? The timekeeping and location tracking system can behave one of the following ways: a smooth scrolling tracker, a tempo-quantized tracker, or a bouncing-ball type tracker. The performer must be able to read the notation comfortably from their desired playing position, meaning the music size and distance from display must be adjusted. Other practicalities such as who or what triggers the piece to start, how the piece ends, and if the performer interacts with the screen or software in any unusual ways must addressed in rehearsal.

### 4.3 Performer-Composer Trust in Performance

A successful performance of a work using real-time notation hinges on the trust a performer places in the composer and computer-mediated notation. While there is no formula for building relational confidence, the following factors can help create a more optimal situation for the performer and composer.

Many factors that lead to an ideal real-time notation experience for the performer revolve around the difficulty of the score and the sufficiency of information about the piece provided by the composer. Ideally, the notation should strike a balance between several competing factors: the difficulty of the mechanical instructions like pitches, rhythms, dynamics, and articulations; the visual layout of the score (including the size of the notation font), the use of non-standard symbols, and whether the performer reads from a part or a score; the clarity of the timekeeping mechanism and how tempo modulations are implemented; the amount of expressive interpretation desired by the composer; the amount of improvisation; and the difficulty of ensemble coordination. As the complexity one parameter increases, the remaining parameters must correspondingly decrease in complexity to let the performer divert maximal effort to the most difficult elements. The performer can be best prepared if the composer provides clear and ample information about hardware and software requirements, the graphic user interface, notational conventions, a formal behavioral outline, sample scores, and/or documentation of past performances.

The balance between complexity and simplicity breaks down if performer failure is a conceptual component of the work. Failure in performance is a theme explored by many composers in what some have termed the "post-digital" aesthetic [18]. Any performer can understandably be alarmed at such a prospect. Although it falls outside the scope of this paper to address this aesthetic issue, the optimal experience for a performer put in that situation is one that does not make them appear foolish, even though this is a difficult standard to determine.

For the benefit of the performer, imagine what the ideal performance of a real-time score looks like from the point of view of the composer. A composer wants trust and engagement from the performer, treating the work as musically viable and as expressive as any traditionally-notated piece. A composer wants a performer who is willing to risk sight-reading from the stage, who makes mistakes and continues to engage, and who knows that some performance errors are apparent to the audience while others are not. Above all, the composer wants a musician who attempts to transcend the high demands of sight-reading and ultimately makes music.

## 5. THE COMPLEX SCORE AND THE FUTURE OF NOTATION

A brief examination of the complex score and the associated musical movement called New Complexity provides historical and aesthetic perspective on the issues presented in this paper. The complex score shares some striking similarities to real-time notation. Composers such as Iannis Xenakis, Brian Ferneyhough, and Richard Barrett often ask the player to perform near the limits of what is possible. This is often accomplished by presenting the player with conflicting instructions or goals. The result is a collision of actions, often represented in meticulous, high-density detail. Overloading the performer with notational information often guarantees that every performance is inherently short of perfection.

In a similar way, real-time notation presents the player with conflicting goals: relinquish the security of a fixed score while embracing new performance freedoms, sight-read in front of an audience while performing musically, expose the limits of ability while performing confidently. It also celebrates the beauty of ephemerality and difference. Both the complex score and the real-time score present ensemble coordination issues. Both present problems in rehearsal strategies. In some ways, the real-time score is a logical extension of the complex score in which Barrett's concepts of notation as freedom and improvisation as a method of composition can be realized [19].

Just as the proliferation of fixed paper notation was the product of incremental advancements in printing technology throughout the last few centuries, so real-time notation is a natural outcome of our current technology. As technology becomes more powerful and accessible, the body of real-

time notation works and their associated approaches will likely continue to expand and differentiate. It is the author's hope that this paper builds upon the foundation established in the performance practice of real-time notation and provides a platform for further exploration by seasoned performers of such works.

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