

Creating with Constraints

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Abstract

Musicians have long framed their creative activity within constraints, whether imposed externally or consciously chosen. As noted by Leonard Meyer, any style can be viewed as an ensemble of constraints, requiring the features of the artwork to conform with accepted norms. Such received stylistic constraints may be complemented by additional, voluntary limitations: for example, using only a limited palette of pitches or sounds, setting rules to govern repetition or transformation, controlling the formal layout and proportions of the work, or limiting the variety of operations involved in its creation. This article proposes a fourfold classification of the limits most often encountered in music creation into material (absolute and relative), formal, style/genre, and process constraints. The role of constraints as a spur and guide to musical creativity is explored in the domains of composition, improvisation, performance, and even listening, with examples drawn from contemporary composers including György Ligeti, George Aperghis, and James Tenney. Such musical constraints are comparable to self-imposed limitations in other art forms, from film (the Dogme 95 Manifesto) and visual art (Robert Morris's *Blind Time Drawings*) to the writings of authors associated with the Oulipo (*Ouvroir de littérature potentielle*) such as Georges Perec and Raymond Queneau.

Keywords

constraints, creativity, precommitment, problem finding, canon, freedom, Oulipo, contemporary music, music composition

[I]n art as in everything else, one can only build upon a resisting foundation: whatever constantly gives way to pressure, constantly renders movement impossible. My freedom thus consists in my moving about within the narrow frame that I have assigned to myself for each one of my undertakings. I shall go even further: my freedom will be so much the greater and more meaningful the more narrowly I limit my field of action and the more I surround myself with obstacles. Whatever diminishes constraint, diminishes strength. The more constraints one imposes, the more one frees one's self of the chains that shackle the spirit. (Stravinsky 1947, 65)

Igor Stravinsky's *Poetics of Music* invokes the necessity of constraints for musical creation: without a "resisting foundation" that sets limits on the endless possibilities, directed movement is not possible at all. This metaphor has an intuitive appeal: without anything to push or react against, we are left to flail helplessly as if drifting in zero gravity. However, the second half of Stravinsky's statement is by no means evident, and at first glance even self-contradictory. How can more limitations and obstacles result in "greater" and "more meaningful" freedom?

One would assume that freedom would thrive in a field free of obstacles, and certain psychologists have emphasized the importance of an open, uncritical approach ("brainstorming") in encouraging creativity, characterizing constraints largely as negative limiting factors (Rosso 2011, 3). On the other hand, psychologist Patricia D. Stokes agrees with Stravinsky that properly chosen constraints can in fact *promote* creativity by limiting and directing cognitive processes (Stokes 2006, xii; Joyce 2009, 5–6), and

cognitive scientist Margaret Boden goes still further: “far from being the antithesis of creativity, constraints on thinking are what make it possible” (2004, 95).

There are of course innumerable constraints, whether acknowledged or not, that affect every act of artistic creation. Leonard Meyer (1989, 3–23) observes that musical style is fundamentally a set of constraints, some unconscious and some conscious. Meyer develops a hierarchy of constraints: *laws* (transcultural universals of music cognition), *rules* (such as the style-defining norms of tonal counterpoint and harmony), and *strategies* (creative approaches within the framework of laws and rules that are specific to individual composers or even individual works). An important distinction must be made between *imposed* constraints—boundaries, norms, or habits received (often implicitly) from an outside source—and *chosen* constraints: explicit, self-imposed limitations. These are not always clearly differentiated, and (as Jon Elster observes) what starts as an imposed constraint can later become a chosen one in a changed context. For early cinematographers, filming in black-and-white was an imposed constraint—it was simply the only technology available. After the advent of colour film, though, the choice to shoot in black-and-white became a chosen constraint, a technical limitation consciously selected for an aesthetic purpose (Elster 2000, 4). An artist can choose to submit to a pre-existing constraint, as when an author decides to write within the rules and conventions of a given genre, form, or language. Chosen constraints can also be original inventions: a familiar musical example is Schoenberg’s choice to compose within the strictures of his own twelve-tone method. The examples in this chapter all deal with consciously chosen constraints, which would be classified by Meyer as *intraopus* (work-specific) strategies.

Why constraints?

Artists choose to work within constraints—whether imposed or chosen, received or newly invented—for many different reasons. As attested by many creators, the beginning of a project is often particularly fraught with difficulty. The “terror of the blank page” can seem particularly daunting in contemporary art and music: if everything is permissible, why choose any one element over another (Stravinsky 1947, 63)? The challenge of beginning has seemed especially daunting in the fractured landscape of twentieth-century music. Statistician and graphic artist Edmund Tufte notes that the choice of an initial element helps to overcome this challenge by limiting future choices:

That initial element contains an enormous number of built-in decisions that limit the scope of the intellectual or visual problem at hand, thankfully preventing the paralysis that results from the overwhelming unlimited scope of decision contained in a blank page or empty space. The initial element provides a leverage point for expression. Also that starting element helps to find a problem that one can actually make progress on. (quoted in Joyce 2009, 24)

Starting from the establishment of an initial element, the process of making a work continually produces new constraints, since every choice made by the artist limits future decisions. As philosopher Jon Elster observes, as a novelist writes the plausible continuations of the text are progressively narrowed: “As the characters unfold and the story develops, the constraints become—are made to become—tighter and tighter” (2000, 214). Once the novel’s setting and situation is established, we tend to expect its protagonists to behave “in character” and look askance at sudden breaks in the continuity or direction of the plot. (This assumes that the writer subscribes to general stylistic principles of plausibility, psychological realism, and the satisfaction of narrative norms: the automatic writing of the

Surrealists, for example, does not incur these narrowing constraints.) Faced with a daunting infinitude of possible starting points at the outset of writing, the writer may be left with only a few acceptable options at the end. Elster speculates that novelists may even “write themselves into a corner” by invoking so many contradictory constraints that there are no valid solutions at all: he attributes Stendhal’s inability to complete his novel *Lucien Leuwen* to this dilemma.

Tufte and Elster’s observations that constraints help to define and refine problems are confirmed by researchers in cognitive science and artificial intelligence. Constraints are an essential element of theories of problem solving, often described in terms of directed exploration of a conceptual “search space” or “solution space.” Constraints may be used as heuristics to “prune the search-tree,” directing or limiting the search process: “They make some locations easier to reach than they would have been otherwise; and they make others inaccessible, which would have been accessible without them” (Boden 2004, 91). Many musical endeavours can be presented as what computer scientists call *constraint satisfaction problems*—an idiomatic piece of Renaissance counterpoint, for example, must satisfy rules governing vocal range, melodic motion, allowable vertical sonorities, and so on. Constraint satisfaction problems are well suited to solution through programs using directed search algorithms: the computer can “dynamically define a combinatorial space” and “navigate it in search for solutions” (Truchet and Assayag 2011, xvi).

A constraint satisfaction problem may combine both hard constraints, which must be met without exception, and soft constraints that are desirable but not mandatory. A balance of hard and soft constraints can model complex situations more accurately than the use of hard constraints alone: “In many real-life problems, a large number of constraints must be met *en masse*, but none is individually necessary: each constraint ‘inclines without necessitating’” (Boden 2004, 124). Researchers have applied constraint programming to a variety of musical contexts, including tonal polyphonic composition (Anders and Miranda 2010), development of hierarchical rhythmic patterns (Sandred 2010), and computer-assisted orchestration (Carpentier 2011).

In these cases, constraints play an essentially *regulatory* role, ensuring that the solutions produced meet the requirements of a particular musical language, style, or genre. Search efficiency is improved when the process can ignore solutions that do not satisfy all the necessary desiderata. Joe Bennett (2012, 142–43) extends Leonard Meyer’s notion that constraints are essential to defining genre and style in his description of pop songs as governed by limits on material (a short instrumental introduction, a single key) and form (length of approximately three minutes, repeating choruses, phrase lengths of 4-, 8-, or 16-bars). In addition to enforcing the rules of a received style or genre, constraint can help to organize and regularize a new style or experimental practice, preserving the consistency of the new language and preventing any unconscious slippage back to familiar habits. Stravinsky is not alone among twentieth-century composers in his devotion to constraints—the use of carefully chosen constraints was an important technique supporting the modernist imperative to “make it new.” Examples include Schoenberg’s avoidance in his atonal music of sonorities like triads or seventh chords that might evoke tonal function, or Charles Seeger’s rule-based “dissonant counterpoint” (Spilker 2011).

The highly regulated musical problems solvable by constraint programming are much more clearly delimited than the complex and overlapping demands a human composer faces when starting a new work. Like many creative endeavours, composition is “an ill structured problem requiring creative mechanisms to transform it into a well structured one, through the identification and application of

internal constraints throughout the process” (Pearce and Wiggins 2002, 2). Focusing and clarifying the structure of the creative problem through the imposition of constraints is an example of what Getzels and Csikszentmihalyi (1976) have termed *problem finding*: this phrase is introduced their longitudinal study of art students and artists to describe the process of developing and posing problems before tackling their solutions. The emphasis in the psychological literature, they note, has been mainly on problem *solving*, which assumes that the solver is already confronted with a well-defined challenge. For the artist, however, creating a problem is as much a part of the creative process as resolving it:

[P]rior to its emergence, there is no structure and no task. [...] After the problem emerges, the skills of the artist take over. Control and ordering begin. The crucial step, one to which little attention has been paid, is how a situation where there is no problem to be solved gets transformed into a situation where a problem ready for solution exists. What needs to be examined is not only how artists solve problems they are already working on, but how they envisage and then formulate such problems in the first place. For the formulation of a creative problem is the forerunner of a creative solution. (Getzels and Csikszentmihalyi 1976, 4–5)

When “not only the solution but the problem itself must be discovered ... the primary mode of thought required is usually called imagination or creativity” (82). The imposition of constraints is often essential to turning a vaguely defined task into a well-structured problem that can encourage innovative and creative solutions. Novelist Gilbert Sorrentino describes, for example, his “desire to invent problems only the invention of new forms can solve” (quoted in Levin Becker 2015, 14).

The application of constraints in ways that frame new problems and encourage imaginative solutions supports Stravinsky’s contention that constraints can result in increased freedom. A related argument for the role of constraints in expanding freedom and the ability to innovate draws on the observation that all artists are already working under innumerable unconscious constraints. As critic and author Daniel Levin Becker notes, by choosing constraints rather than accepting them unwittingly from an outside source, creators can move from an apparent (but false) freedom towards a consciously delimited field of action governed by constraints of their own selection:

Writers are constrained whether or not they acknowledge it—not just by the strictures of poetic forms like the sonnet or the haiku, but also by the conventions of their chosen genre, the format in which they publish, even the grammar and lexicon of their native (or adopted) language. Embracing a set of carefully chosen rules is meant to focus the mind so narrowly that those obscure pressures and preoccupations fade, revealing paths and passageways that one would never notice without the blinders. (Levin Becker 2015, 12)

Similarly, author Raymond Queneau argues that the freedom of Surrealism and “automatic writing” is only apparent, not real: “Inspiration which consists in blind obedience to every impulse is in reality a sort of slavery. The classical playwright who writes his tragedy observing a certain number of familiar rules is freer than the poet who writes that which comes into his head and who is the slave of other rules of which he is ignorant” (quoted in Bénabou 1986, 41). Perhaps the most sustained investigation into creating with constraints is the work of the Oulipo (*Ouvroir de littérature potentielle*), a French literary collective founded by Queneau and François Le Lionnais in 1960. We will consider numerous examples from Oulipo authors such as Queneau and Georges Perec later in this chapter.

Recognizing the constraints that we already labour under can thus be a first step towards innovation. Margaret Boden notes that at its most profound, creativity goes beyond the recombination of elements or the exploration of a conceptual space to fundamentally transforming the space itself, revolutionizing the available range of solutions (2004, 95). One way to change a conceptual space is to drop or negate a constraint: as an example, Boden points to the invention of non-Euclidean geometries, which drop the axiom forbidding parallel lines from meeting (66). In music, she suggests, we could consider Schoenberg's abandonment of certain tonal constraints as a comparable revolution: Schoenberg "stepped right out of the (by now much-deformed) conceptual space of tonality, into a new field governed by different rules" (72). Of course, in reaction to the extraordinarily broad possibilities of atonal music, Schoenberg soon adopted new, self-imposed constraints in the form of the twelve-tone method.

Closely linked to the idea that constraints can encourage innovation as well as enforcing stylistic norms is the observation that constraints may lead creators to produce ideas and forms that might never have occurred to them otherwise: there can be an element of *surprise* in the response of the creative mind to the demands of a highly constrained situation. The effort required to fulfill the constraint may bring forth unexpected solutions, whether by inhibiting the internal censor of the superego or encouraging non-linear thinking. Daniel Levin-Becker describes how Georges Perec used constraints as a way to reach "willed objectivity": "a way of foregrounding the technical in order to take enough pressure off the personal that it can express itself more or less organically" (2012, 182). Perec's work is often highly personal and emotionally vivid, even (or especially) when writing within strict limits: arguably, the constraints help the author to reach into emotional territories that are otherwise too psychologically shielded to be accessible. In musical writing, following strict procedures such as canon can often yield melodic shapes and motives quite different than a composer's default style: the constraint brings with it its own proclivities and demands that can lead to unique and unexpected musical outcomes.

Finally, we can observe how the imposition of constraints introduces an added element of difficulty, bringing a degree of intensity to the creative process that may also make itself felt in the completed artwork. In the nineteenth and twentieth centuries, the modernist notion of the artist as a fighter and art as struggle leads to statements such as Charles Baudelaire's "Because the form is restricting, the idea springs forth more intensely" (quoted in Lloyd 2002, 51). The force required to express oneself through a constrained form focuses and concentrates expressivity. The successful negotiation of difficult constraints can be a demonstration of virtuosity and artistic mastery: consider the canons in Bach's *Musical Offering* or *Goldberg Variations*, which draw attention to their rigorous technical demands while remaining satisfying as musical and expressive constructions.

As we have seen, artists have a complex and many-sided relationship with their constraints, which may function as strategies for breaking writer's block, elements in building a system or codifying a style, spurs to novelty and innovation, windows into the subconscious, or even as an obstacle course for the creative will. While many creations produced within constraints have a ludic, cerebral quality, others are intensely expressive and engaging. Jean-Jacques Thomas has argued that in their later Oulipian works, Georges Perec and Jacques Roubaud should be seen "as literary libertarians, as escape artists," struggling against the "impersonal nature" of the constraints (2006, 122). In the battle between the creative will and constraints, artists may even choose to break the rules they have set for themselves.

György Ligeti identifies, for example, a significant departure from the system in Pierre Boulez's otherwise rigorous *Structure Ia*.

It is impossible to tell whether this state of affairs is to be regarded simply as a lapse on the composer's part, or as an intentional introduction of 'unpredictability' into the construction—a 'gratuitous action,' as a minor revolt against automatism. (Ligeti 1960, 47)

In his own writings, Boulez has described such deviations as "local indiscipline" (1976, 66). Oulipo writers also engaged in the occasional intentional defiance of a constraint, drawing on the philosophical notion of *clinamen* (James 2009, 141–56). Other artists define constraints only in a loose and provisional way, making rule breaking commonplace—for example, Nicolas Donin describes the use of temporary, disposable rules in the compositional process of Stefano Gervasoni. The composer's writing process included various short-lived rules applied to musical motion (direction and distance) and pacing: however, "[a]t each new iteration of one rule, the rule itself could be modified, disputed, or stopped. Rules could pile up or even contradict each other" (Donin 2012, 20). Far from the global, "hard" constraints of Benjamin's canons or Schoenberg's twelve-tone method, Gervasoni's provisional rules suggest an ongoing negotiation between the two extremes of constraint and choice.

Classifying constraints in composition

Constraints can intervene in musical creation in a number of different ways. In the pages below, I sketch out a fourfold typology of constraints: material, formal, style/genre, and process. This is not intended as an exhaustive categorization of constraints for all art forms, but rather as a way of conceptualizing the families of constraints most often applied in musical creation. As we shall see, constraints of different categories are often combined with one another: writing a tonal fugue, for example, requires not only specific imitative relationships between temporally distinct materials (a relative material constraint) but also working within a basic organizational model of expositions and episodes (a formal constraint) and adherence to rules of dissonance treatment and harmonic progression (a style/genre constraint). All four types of constraints may be either imposed or chosen, inherited or newly invented. While the majority of my examples are drawn from twentieth- and twenty-first-century concert music, I have also attempted to link musical constraints with those applied in the other arts.

1) MATERIAL CONSTRAINTS

Limitations on material are perhaps the conceptually simplest of all constraints. In the plastic arts, we might consider how the sculptor's medium sets limits on the tools to be used and the forms that can be created: a sculpture carved out of marble imposes very different constraints on the artist than a sculpture shaped in clay. The artist who draws in charcoal pencil and the photographer who chooses black-and-white film choose material constraints that forbid the use of colour. For the contemporary composer, the notion of material can encompass a wide range of meanings, from the specific combination of instruments and sound sources used a work (akin to the artist's medium) to the more abstract musical "material" formed by specific constellations of pitches, rhythms, and other parameters: a composer might, for example, take a twelve-tone row or a particular rhythmic motive as the central material of a piece, to be shaped and developed in various ways. Particularly in music, which is built so substantially on the relationships between sounds, it makes sense to differentiate between *absolute* material constraints (which either forbid or require the use of certain objects) and *relative* material constraints (which demand certain relationships between objects).

i. Absolute material constraints

One of the easiest ways to constrain material is to forbid the use of particular elements, working from a limited palette of options. Writers associated with the Oulipo were particularly drawn to *lipograms*, texts that intentionally omitted one or more letters of the alphabet. The best-known Oulipian lipogram is Georges Perec's *La Disparition* (1969), a novel written entirely without the use of the letter *e*. The excerpts below present the opening of Perec's novel, followed by its English translation in Gilbert Adair's 1994 *A Void*, obeying the same constraint.

Anton Voyl n'arrivait pas à dormir. Il alluma. Son Jaz marquait minuit vingt. Il poussa un profond soupir, s'assit dans son lit, s'appuyant sur son polochon. Il prit un roman, il l'ouvrit, il lut; mais il n'y saisissait qu'un imbroglio confus, il butait à tout instant sur un mot dont il ignorait la signification.

Incurably insomniac, Anton Vowl turns on a light. According to his watch it's only 12:20. With a loud and languorous sigh Vowl sits up, stuffs a pillow at his back, draws his quilt up to his chin, picks up his whodunit and idly scans a paragraph or two; but, judging its plot impossibly difficult to follow in his condition, its vocabulary too whimsically multisyllabic for comfort, hurls it from him in disgust.

In addition to some simple substitutions—for example, Perec uses the brand name “Jaz” in place of the French word for watch (*montre*)—the simple constraint of banishing the letter *e* also has more profound and pervasive results. The French text must avoid the feminine pronoun *elle* (though it can use the masculine *il*)—similarly, the English text cannot use the word *he* or *she*, leaving the translator to repeat the name “Vowl” instead of using a pronoun in the second sentence. Even the verb tenses are affected by the constraint: in French, Perec opts for the *passé simple* (*il alluma*) rather than the *passé composé* with its *e* (*il a allumé*), while Adair chooses to reframe the text in the present due to the unavailability of *-ed* endings. It should be added that the text also follows unstated high-level style/genre constraints: that the text be grammatically correct, that the novel contain a coherent narrative, etc.

f tre corde
senza ped.

pp
una corda
8b
staccatissimo, leggero

Example 1—György Ligeti, *Musica Ricercata* (1951–53), movement III, measures 1–8. Copyright © Schott Music GmbH+Co, KG, Mainz, Germany. Copyright © renewed. All rights reserved. Used by permission of European American Music Distributors Company, sole U.S. and Canadian agent for Schott Music GmbH+Co, KG, Mainz, Germany.

György Ligeti’s *Musica Ricercata* offers a suggestive musical counterpart to Pécès’s *La Disparition*. Different lipogrammatic constraints are applied throughout the multi-movement piece. The first movement explores the possibilities of just a single pitch class, A, spread across the range of the piano—a second pitch class, D, appears only in the very last sonority of the movement. The second movement limits itself to three pitch classes (E♯, F♯, and G): as in the first movement, the final pitch class G only appears relatively late in the movement. The gradual expansion of the pitch palette is continued into the third movement (see **Example 1**). Here, the four pitch classes C, E♭, E♯, and G are the exclusive pitch material. This constraint poses considerable challenges: the limitation of material does not make it easier to compose by limiting the range of choices, but rather poses unique demands—especially since, like Pécès, Ligeti is also bound by tacit style/genre constraints ensuring musical coherence by requiring formal balance and closure.

The choice of these particular four pitch classes has unique stylistic implications—the presence of E♭ and E♯ against the C is reminiscent of the combination of minor and major thirds idiomatic to jazz and blues, and Ligeti has responded with vigorous, often syncopated rhythms. The playful character of this movement is in sharp contrast to the previous movement, marked *mesto, rigido e cerimoniale*, an affect brought out by the solemn minor seconds available within the limited collection of pitch classes. Similarly, the constraint determines how the minor third “call” motive in measure 1 on the notes C and E♭ can be transformed: at measure 6, the same motive appears transposed to the only other minor third possible within the composers constrained palette, E♯–G.

Absolute material constraints are common in music. Pedagogical works like Bartók's *Mikrokosmos* frequently limit themselves to a small collection of notes ("five-finger exercises"), and any work written exclusively within a single mode or scale—from Dmitri Shostakovich's C major "white note" fugue (op. 87) to Olivier Messiaen's *Mode de valeurs et d'intensités*—could similarly be seen to operate within a constrained set of materials. Constraints can be defined on various parameters and at various levels. A work like Ravel's *Bolero* operates with a significant restriction on the variety of melodic phrases. Similarly, literary lipograms can be applied not just to letters, but also to words: an example is Paul Griffiths's novel *let me tell you* (2008), which uses only the words spoken by Ophelia in *Hamlet*. There are also situations in which one element of the texture is highly constrained, while others are more free. Peter Cornelius's 1853 song "Ein Ton" (op. 3, no. 3) keeps the vocal line on a repeated B, while the piano accompaniment plays freely, setting the sustained tone in new contexts. Luciano Berio used a similar idea repeatedly in his career, in the song "Monotone" (*Chamber Music*, 1953) and his *Sequenza VII* for oboe, which is performed over a sustained B drone. A similar persistent pitch (now a Bb) is heard in his late Sonata for Piano. Focus on a single note is also a feature of Giacinto Scelsi's 1959 *Quattro Pezzi per Orchestra (ciascuna su una nota sola)*—albeit with significant liberty and pitch smearing—and Bernd Alois Zimmermann's *Stille und Umkehr* (1970).

The material constraints we've observed so far all restrict the available materials to a specific, limited palette: we might call these "only use *x*" constraints. It's also possible to frame material constraints that set no prohibitions on the materials that can be used, but instead require that certain material be included: these are "must include *x*" constraints. Again an example can be found in the works of Georges Perec: his monumental novel *La Vie mode d'emploi* (translated by David Bellos as *Life, a User's Manual*) was written in conformity to a carefully constructed *cahier des charges*, a to-do list for each chapter of forty-two specific elements to be included within the text. These elements include quotations, objects, activities, names of places, and so on—the specific way they are referenced in the chapter is left to Perec's invention (James 2009, 141–56; Oulipo 1981, 393).

The use of multiple quotations in the third movement of Luciano Berio's *Sinfonia*, "In ruhig fließender Bewegung," offers a musical situation with echoes of Perec's *cahier des charges*, though framed in a much less rigorous way. The initial decision to use the Scherzo of Mahler's Second Symphony as a *cantus firmus* for the entire movement is a far-reaching "must include *x*" constraint, even though Berio often reduces the Mahler score to just "a few skeletal features" (Osmond-Smith 1985, 46). Indeed, adaptations and retellings of all sorts (like the films *West Side Story* or *O Brother, Where Art Thou?*) can be considered as examples of the "must include *x*" requirement, insofar as they require sufficient references to the original source to sustain the effect of intertextuality. Berio adds new materials atop this *cantus firmus*: a wide array of quotations from composers including Debussy, Ravel, Strauss, Hindemith as well as contemporaries like Boulez and Stockhausen. According to David Osmond-Smith, the choice of materials "was in part a matter of circumstance": the movement was composed while Berio was on holiday, so the sources were limited to "the few scores that he had with him, those that happened to be available from Catania public library, and his own memory" (39). The movement is also given a spoken text, drawn largely from Beckett's *The Unnameable*. Like Perec's wrestling with his *cahier des charges*, the fitting together of the chosen quotes in an artistically satisfying way was a significant part of Berio's compositional challenge.

A particularly significant subset of absolute material constraints comprises those associated with *instrumentation*. Instruments and voices are physically limited to certain ranges of pitch, dynamics, and

timbre (even with the use of extended playing techniques). A composer's selection of a particular ensemble of instruments results in a number of limitations on the types of sounds available. Choosing to write for string quartet, for example, means renouncing the use of the broad timbral contrasts available in a more diverse ensemble. Knowledge of instruments' ergonomic limitations also influence composition: a composition for piano must work within the ergonomic limits of handspan and "the constraints on what could be realized by two hands and ten fingers" (McAdams 2004, 412). A composer may choose impose additional instrumental constraints by adopting added technical limitations: consider Ravel's Piano Concerto for the Left Hand or August Wilhelmj's arrangement of the second movement of Bach's Orchestra Suite No. 3 to be played only on the solo violin's G string ("Air on the G string"). Writing for students adds a different set of instrumental constraints since technical difficulties must be minimized: this affects pedagogical works like Bartók's *Mikrokosmos* or works including children and amateurs such as Britten's *Noye's Fludde*.

While every instrument or combination of instruments poses its unique abilities and drawbacks, we are most likely to recognize the choice as a constraint when composers write for instruments with obvious limitations on pitch range or timbral variety. Twentieth-century examples include John Cage's *Suite for Toy Piano* (1948) or Stockhausen's version of *Tierkreis* (1974–75) for music boxes. Electronic music and studio recording can suggest new kinds of constraints as spurs to creativity, such as deriving all sounds from a single source sample or avoiding instruments that might be expected in a given genre—as in Peter Gabriel's album *Melt*, which uses no cymbals (DeSantis 2015). Constraints are invoked even when a composer chooses to write a score for unspecified instrumentation, as in many compositions by Christian Wolff or Michael Finnissy's *Moon's goin' down* (1980) for "any solo wind instrument or voice" with a range of one and a half octaves. Making a score playable by any instrument means eschewing instrument-specific techniques such as double-stopping, glissando, fluttertongue, or multiphonics.

ii. Relative material constraints

In addition to the absolute material constraints discussed above, which indicate particular musical objects or features to be avoided or included, we can observe another large class of material constraints that govern the *relationships* of one object to another. An example of such a constraint is the Oulipo's "apéro constraint," which demands that vowels and consonants appear in strict alternation. Note that under this limitation all twenty-six letters are still available—there is no absolute constraint on material—but they can only be combined in a way that respects the relative material constraint.

Traditional tonal music is full of relative constraints on pitch material: tonality itself is far less concerned with absolute pitch content than with the comprehensible relationship of pitches to a hierarchy of chords and keys. Similarly the dissonance treatment rules of counterpoint are defined in terms of intervals (relations between pitches), not isolated pitches. To our list of relative material constraints we could add chord-type constraints, chromatic aggregate completion (a major principle in the music of Witold Lutosławski among many others), and the row transformations of twelve-tone music. This category of constraints also includes rules governing the repetition of material, whether temporarily separated as in canon or presented simultaneously (but transformed), as in the mirror symmetries used by Béla Bartók and other twentieth-century composers.

Example 2—Elliott Carter, *Esprit Rude/Esprit Doux* (1984), measures 42–47. Copyright © 1985 Hendon Music, Inc. Reprinted by permission of Boosey & Hawkes, Inc. The lower staff is for clarinet in B \flat , sounding a major second lower than written.

The use of constraints is a “persistent characteristic” of Elliott Carter’s creative process (Vermaelen 2004, 168). Carter follows a particularly demanding and far-reaching set of constraints in his flute/clarinet duet *Esprit Rude/Esprit Doux* (1984): since these govern the relationships between pitches and not the overall pitch content—all pitches of the chromatic appear freely—they can be considered relative, not absolute, material constraints. Each of the two instruments is assigned a strictly limited intervallic vocabulary. The flute can move by intervals of 3, 4, 5, 6, 10, and 11 semitones (plus their octave compounds) while the clarinet is limited to the intervals 1, 2, 6, 7, 8, and 9. This constraint is strictly applied throughout the piece. Starting at the end of measure 43 (**Example 2**), each of the two instruments plays a series of tremolos on intervals from their respective repertoire. The combination of the tremolos into four-note chords obeys yet another constraint, this time on chord type: with just a few exceptions, each of the chords is one of the “all-interval tetrachords” (in pitch-class set theory, the set classes 0146 or 0137 and their inversions). For large stretches of the piece, the rhythms are also subject to a relative material constraint, this time a temporal one: after the joint attack at the downbeat of measure 6, simultaneous attacks are forbidden (this stricture loosens near the end of the piece, with several shared onsets scattered over the last two pages). The rhythms also obey a “must include x ” constraint, projecting a large-scale polyrhythm of 21:25 between the voices marked by accented attacks or phrase beginnings (Coulembier 2009).

A still more demanding relative material constraint applied to the temporal dimension of music is canon. In its most general formulation, canon implies the strict repetition of one musical line at a controlled temporal interval, either in identical or altered form (transposed, inverted, etc.). Canon is comparable to intervallic constraints in the pitch dimension, but with the prescribed intervals measured in time rather than pitch. Viewed as a compositional constraint, canon requires that every event performed by the *dux* (leader) requires a corresponding event in the *comes* (follower). Canon often interacts with limits on the vertical intervals allowed—another relative material constraint, defined in the pitch domain—as in the dissonance treatment of modal and tonal counterpoint.

Lilting gently (♩ = c.36 / ♪ = c.180)

SOLO *dolcissimo, vibrato*

p *sempre sostenuto, sin al fino* *poco cresc.* *mf*

dim.

Example 3—George Benjamin, *A Lullaby for Lalit* (2001), measures 1–5. Copyright © 2003 by Faber Music Ltd. Reproduced from *Three Miniatures for Solo Violin* by permission of the publishers. All rights reserved.

George Benjamin’s *A Lullaby for Lalit*, the first of his *Three Miniatures for Solo Violin*, is a strict canon with an unusual transformation applied to the *comes* (**Example 3**). Rather than a verbatim or transposed version of the *dux*, the *comes* transforms the twelve pitch classes of the *dux* into just four—all the pitches of a given augmented triad are mapped to one of the violin’s open strings:

the <i>dux</i> pitches	G–B–D \sharp	map onto the violin’s	E string	in the <i>comes</i>
"	A \flat –C–E	"	A string	"
"	A–C \sharp –F	"	D string	"
"	B \flat –D–F \sharp	"	G string	"

The initial C \sharp and A, for example, are both answered five sixteenth notes later by an open-string D, while the B \sharp and G \sharp of measure 2 are answered by an A in the second half of the bar. To keep the resulting canon playable by the solo violin, Benjamin is necessarily subject to significant instrumental constraints: over any open string in the *comes*, for example, any new notes played in the *dux* must be available on an adjacent string. *A Lullaby for Lalit* is far from an obvious canon—in fact, the “encoding” of the *comes* works explicitly to reduce any immediate sense of delayed repetition. Benjamin speaks admiringly of such inaudible canons in the music of Webern, calling them “an entirely new type of self-generating musical fabric—which simultaneously exploits and disguises its provenance” (Benjamin

2003, 22). Benjamin's use of constraints plays a major role in his compositional process, providing a starting point to escape the "terror of the blank page" and encouraging "problem finding," the development of new creative challenges to be resolved. Though the constraint is not instantly comprehensible, it has an effect on the work's sound in many subtle ways: the repeated open strings are a prominent part of the texture, and Benjamin frequently uses melodic augmented triads and major thirds (as in the first measure) due to their unique role in the canonic encoding. The composer's commitment to the constraint leads to the regular and consistent unfolding of a texture unlikely to be imagined by any other route.

2) FORMAL CONSTRAINTS

If material constraints regulate the construction of a work "from the bottom up," governing the available types of content and their interrelations, formal constraints work from the top down and are essentially neutral in terms of content. A sonnet or an alexandrine is a formal constraint, governing the layout of verse lines or the number of syllables per line, but not the actual words chosen by the poet. In music, we could consider the *formes fixes* of medieval music or the classical sonata form as archetypal formal constraints. These complex forms were shaped by a long cultural tradition, but formal constraints can also draw on simple schematic rules—for example, the use of palindrome by composers from Machaut to Webern—or be newly invented by the composer.

Georges Aperghis's *Recitation 11* (1977–78) is written under an elegant invented formal constraint, clearly visible in the work's score—the first eight lines are shown in **Example 4**. The solo voice starts with the exclamation "Comme ça!" ("Like that!")—in each subsequent line, new measures of recited text are added before and after the material of the previous line. The result is an accumulative process, gradually growing from the middle out. Such "*génération par le milieu*" is a feature of Aperghis's self-described creative process: a sequence taken as a foundational "pillar" is considered as a "middle"—afterwards, the composer adds material "like an onion, from both sides, like infinite parentheses to arrive at the beginning and the end" (Aperghis 2010).

Formal constraints can also govern the size and proportions of an artwork: consider for example how a painter's composition must be adapted to a canvas of a given size and shape. Musically speaking, size equates most clearly with length. In some cases, the limits on length are an imposed constraint, set by the available technology: Jon Elster, for example, discusses how the three-minute playback time of a 78rpm record set an external limit on the length of early jazz recordings (2000, 192–95). The length of a composition may be externally limited by the commissioner—the New York Vox Novus festival, for example, has produced numerous concerts featuring premieres of new one-minute compositions—or chosen by the composer as a precompositional constraint. Internal proportions may also be subject to formal constraints: consider the strictly regulated proportions of Guillaume Dufay's motet *Nuper rosarum flores* (1436) or the demanding pre-planned forms of Brian Ferneyhough's Third String Quartet (Hasegawa 2016).

A complex handwritten musical score for voice and guitar. The score is written on ten staves. The lyrics are in French and include phrases like "GOMME-CA!", "VA LUI DEMANDER", "ET PUIS?", "GRANME PAR GRANME", "RIEN", "QU'AMOI", "TU NAURAS", and "SOUS DE TOM". The notation includes various rhythmic markings such as triplets (3), sextuplets (6), and quintuplets (5), along with dynamic markings like *mf* and *ff*. There are also some performance instructions like "(Rire)" and "GOMME? NUIT".

Example 4—Georges Aperghis, *Recitation 11* (1977–78), excerpt. Copyright © 1982, with kind authorization of Editions Salabert.

A musical score titled "BEAST" for string bass. The title is written in large, bold, capital letters. Below the title, it says "FOR STRING BASS" and "(for Bassl Weidinger)". The score is written on a grid of horizontal lines. The notation consists of a series of hand-drawn waveforms representing the pitch of the instrument. Below the grid, there is a block of text in cursive script providing performance instructions: "Tune the E-string down to G4. The piece begins with a unison (arpeggio) on the open G-string and the (stopped) E-string. The graph indicates changes in frequency of the beats produced by these two strings sounding together, as the pitch of the lower string is very gradually changed. (A perfect unison would have a beat frequency of zero; the augmented fourth between the open G-string and the open E-string should have a beat frequency of approximately 16 beats per second.) The sound should be as continuous as possible, and very resonant, though not necessarily loud." The signature "James Tenney" and the date "11/71" are at the bottom right.

Example 5—James Tenney, *Beast* for string bass (1971) from *POSTAL PIECES*. Copyright © Sonic Art Editions. Used by permission of Smith Publications, Sharon, Vermont, 05065.

Instead of restricting the maximal length, a composer can also set a limit on the size or format of the score: a particularly striking example is the series of *Postal Pieces* written by James Tenney from 1965 to 1971 (Polansky 1983, 193–203). Though the notation for each piece fits on a single postcard, many of pieces are quite long in performance—a recent recording of *August Harp*, for example, clocks in at just over forty minutes. One of the challenges posed by the constraint, then, is using the minimal space of the postcard to organize a long span of music in an interesting and aesthetically appealing way. The postcard for *Beast*, a double bass solo, represents a striking response to this challenge (Example 5). Tenney describes the piece’s design in his text instructions for the performer:

Tune the E string down to Eb. The piece begins with a unison (*arco*) on the open A string and the (stopped) E(b) string. The graph indicates changes in the frequency of the beats produced by these two strings sounding together, as the pitch of the lower string is very gradually changed. (A perfect unison would have a beat frequency of zero; the augmented fourth between the open A-string and the open E(b) string should have a beat frequency of approximately 16 beats per second.) The sound should be continuous as possible, and very resonant, though not necessarily loud.

The notation indicates not the sounding pitches, but rather the frequency of the beats produced by the interference of the two held tones. The sinuous line of the score shows gradual cyclic changes of the beat frequency from 0 Hz (beats per second) to a maximum of 15 Hz, with intermediate arrival points at 1, 3, 6, and 10 Hz. Inspired in part by the formal constraint on score size, Tenney arrived at an unusual creative solution that offers considerable sonic complexity through a very efficient notation.

Formal constraints are often associated with combinatorial procedures. Raymond Queneau's *Cent mille milliards de poèmes* (1961) is a classic example: the work consists of ten sonnets, each following the same rhyme scheme and using the same end rhymes. As a result, "new" sonnets can be produced by selecting one of the ten first lines, followed by one of the ten second lines, and so on—a grand total of 10^{14} (one hundred trillion) different combinations. A well-known musical precursor is the musical dice game (*Musikalisches Würfelspiel*) attributed to W. A. Mozart (Hedges 1978, 183). The compositional constraint underlying both combinatorial works, of course, is the requirement that each unit be constructed so that it is interchangeable with any of the other units occupying the same position—for Queneau, this is a matter of prosody and rhyme, while for Mozart the main parameters are melodic continuity and harmonic function.

3) STYLE/GENRE CONSTRAINTS

As Leonard Meyer notes, constraints of style are most often a form of "tacit knowledge" (1989, 10): a hierarchy of laws, rules, and strategies that is constitutive of the style yet not available as explicit knowledge to its practitioners. Meyer goes as far as defining style as the result of "a series of choices made within some set of constraints" (3). Styles and genres are evolving cultural agglomerations with no single author or creator. As Jon Elster notes, genre constraints—or as he calls them, "conventions"—may be "freely *chosen*, in the sense that it is up to the artist whether to submit to the laws of the genre," but "are not *invented* by the artist" (2000, 175). Most often, styles and genres are comprised of a large set of closely interrelated rules and norms, including both material (absolute and relative) and formal constraints. There are also often high-level constraints governing the properties of a work as a whole. We have already discussed how Perec's *La Disparition* and Ligeti's *Musica Ricercata* not only meet their clearly identifiable material constraints, but also satisfy unspoken requirements of their respective genres. The novel, like most fiction, is bound by a requirement of "psychological plausibility or verisimilitude" (Elster 2000, 216) and narrative laws of closure and economy. The mystery novelist who reveals in the final chapter that the murderer was a distant cousin never previously mentioned in the book has broken a fundamental constraint of the genre.

Style is most likely to be perceived as a constraint when it is the object of conscious choice—that is, when artists choose to work in a style that contrasts with their typical practice. James Joyce sets himself style constraints in several chapters of *Ulysses*, parodying newspaper headlines, romance novels, or even

(in the *tour de force* “Oxen of the Sun”) a succession of stages in the evolution of the English language, ranging from mock Anglo-Saxon to a torrent of contemporary Dublin slang. A Oulipian landmark in style constraints is Raymond Queneau’s *Exercices de style* (1947), in which the same mundane story is told in a variety of styles (ninety-nine in all): a fortune teller’s prognostication, a bureaucratic letter, in rhyming alexandrines, etc.

The musical score consists of two systems. The first system (measures 1-4) is marked *pp sempre* and *Très doux*. The right hand begins with a piano (*p*) dynamic and features a complex texture of chords and sixteenth-note patterns, with a '6' marking. The left hand has a steady bass line with eighth notes. The second system (measures 5-8) continues the piece, with dynamics ranging from *p* to *pp*. It includes markings for *dim.*, *più p*, and *pp*. The right hand continues with its complex texture, and the left hand maintains its bass line.

Example 6—John Rea, *Las Meninas*, iv. “Von fremden Ländern und Menschen” (à la mémoire de Claude Debussy), measures 1–8. Copyright © 1991 by John Rea. Reproduced with permission of the composer.

John Rea’s *Las Meninas* presents a musical parallel to these literary style constraints. As a series of “transformational variations” (Rea 1994, 27) on Schumann’s *Kinderszenen*, the work presents rereadings of each piece through the stylistic lens of other composers, all born well after Schumann’s death. The project, Rea writes, was inspired by Picasso’s forty-four variations on Velasquez’s painting *Las Meninas*. He describes the process of composition in terms of a vertiginous chain of subjective listening experiences, all centering on the Schumann miniatures: “For me, *Las Meninas* exhibits a listening subject (me, the composer) listening to various listening subjects (including Schumann himself listening to Chopin, someone he deeply admired) listening to the music of the *Scenes from Childhood*” (personal communication, 10 October 2016). The first piece of *Kinderszenen*, “Von fremden Ländern und Menschen,” is subject to four different variations in Rea’s piece, dedicated to two living composers (José Evangelista and Alexina Louie) and the memory of two late ones (Claude Vivier and Claude Debussy). The Debussy variation, excerpted in **Example 6**, combines elements of the Schumann piece with Debussy’s piano prelude “Voiles” (1909), cleaving closely to the texture of the Debussy work but twisting the pitches to recall the harmonic progressions and melodic outline of Schumann. Insofar as the variation is a “chimera,” Rea’s project could be viewed as a complex “must include *x*” constraint—enough features of the two works must be heard to make their mutual presence felt throughout (Brauer et al. 1996, 42). The challenge Rea poses himself could be framed as a stylistic constraint, a requirement that the variation paraphrase Schumann in the recognizable style of another composer, whether

achieved through direct quotation or more oblique modeling. Music of course has a long history of stylistic “character variations”—a variation set such as Bach’s *Goldberg Variations* recasts its theme within the constraints of diverse genres, including canon, fughetta, and French overture.

Language constraints form a special subset of style/genre constraints. We do not typically tend to think of writing in a given language as a constraint, but of course it poses restrictions on both the available materials (words) and how they can be syntactically combined. The constraint becomes more evident when language is a matter of choice and not simply the author’s native tongue. Consider Samuel Beckett’s decision to write his later novels in French: “I began to write in French with the desire to impoverish myself still more” (Janvier 1969, 27). The nearest analogy in music to writing in a different language is the venerable “model composition” exercise: composing a fugue in the style of Bach, a sonata exposition in the style of Mozart, etc. David Cope’s generative models of pre-existing musical styles demonstrate a particularly close degree of attention to stylistic norms and constraints, framed as the guiding principles for new computer-created works (Cope 2004). Here, the creative process focuses on the creation of a computer program ensuring stylistic regularity, not working out the details of individual pieces.

We could also consider the possibility of inventing a new language (a constructed language or “conlang”), which will then constrain any work written in the language. A musical example can be seen in the music of Harry Partch, who developed an independent musical notation founded on principles of acoustic consonance. As a consequence of his extended just intonation, Partch developed a unique orchestra of keyboard and percussion instruments. While the strictures of his “language” were invented by Partch and not received from a more general cultural practice, the scope and coherence of his invented constraints produces an effect much like working in an established tradition, with deep interrelationships between theory, tuning system, scales, and chords. Contemporary works for a newly rebuilt set of Partch instruments are now being commissioned by the Ensemble Musikfabrik—the commissioned composers will need to adapt their writing to the particular material constraints of the Partch instruments, though they need not necessarily adopt all the style/genre constraints called for by his theories: for instance, a composer could replace Partch’s scalar, hierarchical conception of pitch with a thoroughly atonal approach.

4) PROCESS CONSTRAINTS

The constraints discussed so far—on material, form, and style/genre—have all dealt with characteristics of the artwork itself, affecting the creative process in several ways, sometimes well-known, sometimes undocumented and only hypothetical. We can also look at constraints imposed on the *making* of an artwork: “*Process constraints* constrain how it is that the work is done (i.e., they limit possible approaches), whereas *product constraints* constrain the intended or expected outcomes of the work (i.e., they limit possible solutions)” (Rosso 2011, 75). Process constraints are frequently invisible—they may not leave any clearly recognizable trace in the final product, despite playing a substantial role in channelling and shaping the artist’s work. Consider a sculptor in wood who chooses to work with hand tools only, avoiding all power tools—this constraint does not govern any specific trait of the final sculpture, although an expert eye might detect how the chosen tools lead to particular visible results. Similarly, for a filmmaker, budget limitations or the specific filming methods may be a decisive creative constraint, though they are not an explicit feature of the film itself. Process constraints may be either externally imposed or freely chosen. A well-known set of chosen process constraints is the Dogme 95 Manifesto, created in 1995 by Danish directors Lars von Trier and Thomas Vinterberg in reaction to

the special effects and slick post-production of big-budget movies. The manifesto centers on a “vow of chastity”: cameras must be hand-held, all filming must take place on location (not on a set or soundstage), non-diegetic music cannot be used, etc.

A common and deep-reaching process constraint involves the limitation of revision or editing: whether intentionally imposed (as in the Surrealists’ automatic writing) or due to intrinsic features of the medium. Jon Elster discusses the particular constraints placed on the nineteenth-century author of a serialized novel: since each chapter once printed cannot be rescinded, the author cannot go back and revise early parts of the story as he writes the later chapters (2000, 193). Similar instances are common in the plastic arts: for example, the artist painting a fresco has no opportunity to alter the painting once the plaster has dried. Artists frequently face limitations on the time available to realize their works, whether external or self-imposed. Each of the graphite sketches in Robert Morris’ *Blind Time Drawings* (1973) were made by the artist with his eyes shut (a significant added constraint!), executing certain pre-planned drawing tasks under specific time limits (Morris 1994, 244–45).

For the contemporary composer, a commission can impose a long-term time constraint: deadline pressure is only rarely discussed in the musicological literature, but doubtless has a substantial effect on the scope and content of the creative work produced. Brian Ferneyhough describes pedagogical exercises with self-enforced limits on the time of composition: writing a one-hour piece in one minute, or conversely, writing a one-minute piece in one hour. These exercises can suggest different ways of approaching musical notation, ranging from “a few scribbles” to a greater degree of specificity and intensity (Ferneyhough 2005). Note that these process constraints on the *time* of composition are very different than the formal constraint on the *length* of a composition discussed above (a product constraint). Musical and literary communities have embraced self-imposed time constraints in events such as February Album Writing Month or National Novel Writing Month. These challenges are often conceived of as a way to circumvent self-criticism or writer’s block and encourage Allen Ginsberg’s “first word/best word” philosophy—the time pressure forces the artist to assemble a substantial work in a strictly limited timeframe. Whimsically, the name of the Dutch collective Instant Composers Pool suggests that improvisation is nothing more than composition under an extremely strict time constraint—the limit case of *zero* time to compose.

Process constraints can also prohibit or require particular techniques or operations. We have already observed how certain modes of creation (the serialized novel, the fresco) prohibit subsequent revision. An essential element of these creations is a precommitment (Elster 2000, 193) to accept the final results without tinkering or editing. A similar precommitment to accepting the outcome of a process can be seen in the use of Oulipian operations such as the “S+7” procedure, the automatic replacement of each noun in a source text with the noun found seven places later in a chosen dictionary. As critic Alison James has observed, this type of essentially arbitrary replacement is deterministic, but due to its unforeseeable results operates like a kind of automated quasi-chance (2009, 126–31). Similarly, the development of the *cahier des charges* of Perec’s *La vie, mode d’emploi* is based on constructive procedures so Baroque and complex that their results seem virtually random (Oulipo 1981, 387–393).

Musical examples of this type of precommitment to the “unexpected and unintended” include various process-based and conceptual compositions, which share an ethic of non-interference that can be understood as a process constraint forbidding subsequent reworking. These works are entirely determined by the definition of a background concept or process: as conceptual artist Sol LeWitt wrote,

“The idea becomes a machine that makes the art” (quoted in Boden 2010, 139). Composer Steve Reich describes the aesthetic of works such as *Pendulum Music*, *Come Out*, and *Piano Phase* in his influential essay, “Music as a Gradual Process”: “Though I may have the pleasure of discovering musical processes and composing the musical material to run through them, once the process is set up and loaded it runs by itself.” In such processes, Reich notes, “I accept all that results without changes” (Reich 2002, 34–36). In strict “process pieces,” the composer denies any temptation to seek an “interesting” or “pleasing” ordering, accepting instead the automatic results of the generative procedure. Significantly, there is no room for the “artistic” exercise of taste, judgment, or craftsmanship after the establishment of the initial idea—these are explicitly forbidden by the process constraints. This lack of artfulness has often been the focus of critics of conceptual art, who lament its lack of individuality and expressiveness—but of course these are qualities intentionally disallowed by the conceptual artist’s process constraints.

One can note the vast difference between the constraints of strict process composition and the material constraints of Ligeti or Carter discussed above. After a composer establishes a strict global process, all the remaining local level decisions are filled in automatically. For Ligeti, the situation is radically different: the global material constraint (using only the pitches C, E \flat , E \natural , and G) tells nothing about the moment-to-moment unfolding of the piece: Ligeti must make constant decisions about which pitch to choose next, how long it should be, where to make a phrase break or pause, etc. This exemplifies what Christelle Reggiani has called a “biphasic” approach: first the formulation of the constraint, then its application or working-out (quoted in James 2009, 130).

The renunciation of local authorial decision making in conceptual works in favour of an impersonal, all-controlling process is closely linked to the use of chance procedures. Much of John Cage’s work—for example, his *Imaginary Landscape No. 4* (1951) for twelve radios—abandons the composer’s prerogative to choose specific sounds, accepting instead the results of chance. The notion of chance has spawned a considerable body of generative or algorithmic music, as created by David Cope, James Tenney, and many other composers—often with the use of computers. An important issue facing algorithmic composers is whether or not they will allow editing or rewriting of the generated results or accept them “as is”—at an extreme, generative music can be subject to the constraint that the algorithm’s results are accepted with “zero interference from the human artist” (Boden 2010, 150.)

Constraints in improvisation and performance

We have seen so far a number of reasons that composers might choose to impose constraints on themselves, as well as a categorization of the types of constraints applied in musical composition. Yet to be explored is the application of constraints in other domains of music-making besides composition: in particular, improvisation and performance.

Improvisation is defined by Aaron Berkowitz as “spontaneous creation within constraints,” emphasizing that despite its apparently free execution, it observes both “musical (i.e., stylistic) constraints and performance/performer (i.e., physical/physiological) constraints” (2010, 1–2). Style/genre constraints play a major role in all improvised music—even Derek Bailey’s “non-idiomatic improvisation” implies a limited set of stylistically appropriate productions. The stylistic constraints of jazz, incorporating a wide variety of conventions affecting scales, chords, rhythms, and form, help to enable communication both within the ensemble and with an audience.

The choice of a framework for improvisation, as when jazz musicians improvise over a standard tune or a Baroque soloist plays impromptu variations over a ground bass, amounts to accepting a “must include *x*” material constraint—simultaneously, style/genre constraints govern how newly improvised parts can be combined with the given material. Jazz pianist Bill Evans’s 1963 album *Conversations with Myself* offers a striking instance of improvisation within the “must include” constraints of a particular framework—in this case, the pianist used the studio technique of overdubbing to layer two or even three improvised piano tracks on top of one another. Each subsequent track needed to fit not only with the given forms of the selected jazz standards (such as “Round Midnight” or “Stella by Starlight”) but also with the previously recorded takes (Larson 2005, 241–42). In many ways this is similar to the way any improviser dialogues with his/her fellow performers, but the use of overdubbing allows this dialogue to take place between a single performer and his past self, confounding the distinction between improvisation (in real time) and composition (outside real time). Philip Johnson-Laird describes how a jazz bassist improvises lines that fit the pitches implied by a given harmonic progression while following a few simple rules governing the overall contour of acceptable melodies. The former is likely to be a matter of conscious reflection based on an understanding of jazz harmony, the latter a form of “tacit knowledge” (1988, 212). Harold Powers (1980, 46) notes a significant difference between “improvisation of details elaborating a fixed item” (as in playing over a jazz chord progression) and “improvisation loosely guided by a modal model” (as when an Indian vocalist or instrumentalist performs an *ālāp*). The former case is typical of music with strong “constraints of ensemble performance” (the requirement that parts synchronize), while the latter is closer to a model of linguistic production, as when an orator extemporizes a speech on a given topic.

Davide Sparti notes that as improvisers shape a musical form in real time, each musical statement “is at the same time a constraint and a springboard for the following statement” (Sparti 2016, 182). Improvisers collectively generate constraints as they play. They can also choose explicit constraints that focus group improvisation or spark unexpected responses by posing added challenges. Material constraints are not uncommon in improvisation: Pauline Oliveros’s text score *Quintessential*, for example, requires each player of a quartet to improvise strictly within a repertoire of five pre-determined sounds of their choice (Oliveros 2013, 109). Improvisatory “game pieces” such as John Zorn’s *Cobra* establish complex systems of rules for interaction between players that govern which members of the ensemble play together and the relationship of their improvisations to both the production of the other musicians and music previously performed. The rules of *Cobra* are mostly formal constraints—they are relatively neutral on the content of the improvisation, but strictly control time and inter-performer relationships.

While musical scores certainly present a number of interpretive challenges for performers which must be met if the work is to be performed faithfully, the notion of a *performance* constraint implies that there is an easier, normative way of performing a given passage which is disallowed by the outside imposition or voluntary choice of a constraint. In an article on performance constraints, Sarah Callis and her co-authors (2015) differentiate between “found resistance,” which is already present in the score—for example a performance direction that requires the performer to take a more difficult approach to realization than the most obvious, easiest technique—and “made resistance,” which is chosen by the performer: for example, choosing “a challenging or obscure fingering or bowing” to attain a particular interpretive result.

An example of “found resistance” can be seen in Georges Aperghis’s remarkable *Recitation 14* (1977–78). The score indicates a pre-composed performance constraint: the performer breathes in deeply, holds his/her breath as long as possible, and then speaks the rhythmically notated text “without renewing his/her breath.” The spoken text is repetitive and fairly long—combined with a dramatic notated *decelerando* that makes the last lines much longer than the first, speaking the text in a single breath presents a considerable physical challenge. Callis’s co-author Neil Heyde describes his process of coming to terms with a counter-intuitive up-bow marking in Fauré’s First Cello Sonata, another source of “found resistance”: “It was only in later experimentation with the reversed/uncomfortable bowing that I found it much more effective than my natural inclination to use a down-bow, as the increased physical work required to push out the *forte* increases the intensity of the sudden dynamic change and encourages a continued momentum into the next bar. This is, at least in part, the consequence of the increased physical resistance present in the act of producing the sound.”

As an example of “made resistance,” Callis and Heyde point to Artur Schnabel’s unusual fingering choices in his 1935 edition of Beethoven’s piano sonatas. As Schnabel writes in his preface, his fingerings are not necessarily the easiest ones, but rather are chosen to bring out a certain musical interpretation: “Some fingerings in this edition may appear somewhat strange. In explanation of the more unusual ones let it be said that the selection was not made exclusively with a view towards technical facility, but that rather often it originated from the desire to secure—or at least encourage—the musical expression of the passages in question” (quoted in Callis et al. 2015).

Any instrument brings with it a set of physical limitations and affordances: as for other constraint types discussed previously, we tend not to recognize these limitations as constraints until they become the object of a conscious choice. For a cellist accustomed to modern instruments, changing to a Baroque cello and bow for a Bach solo suite might pose significant limits on their accustomed playing style, requiring creative solutions to reach a musically satisfying result. A pianist familiar with the Goldberg Variations will need to adopt new strategies to play them on the harpsichord, which lacks the piano’s variable dynamics. In some cases, a musician may play a standard instrument in an unusual way: consider Jimi Hendrix playing a guitar solo with the instrument behind his back: a “showboating” demonstration of virtuosic mastery, perhaps, but also a way of enhancing the suspense and intensity of live performance. Music teachers often suggest various forms of constraint to develop technique and deepen interpretations: most of these methods are intended for the practice room only, but their results can carry over into the concert hall. Examples include practicing at extremely slow tempi or playing in unusual ways: brass players, for example, may set themselves the challenge of playing with little or no mouthpiece pressure.

As we have seen, constraints are omnipresent in the domains of composing, improvising, and performing. Beyond these domains, we might even consider the possibility of constraints on the act of listening, acknowledging that musical listening entails more than passive reception and frequently implies an active, even a creative role. A constrained listening implies listening “against the grain,” in a way that poses out-of-the-ordinary challenges to the ear and mind. Pauline Oliveros has observed that listening can be global or focused, inclusive or exclusive—in other words, we may consciously choose to focus on certain sounds, bracketing others from our attention (2005, 13–15). Pierre Schaeffer’s “reduced listening” (*écoute réduite*) demands a mode of listening that does not seek to identify the source or meaning of a sound, but rather recognizes only its acoustic characteristics. By forestalling our

usual classification of sounds by source and type, reduced listening can offer a renewed appreciation of the sounds themselves.

The constraints discussed in this chapter can operate either unconsciously (in the form of tacit knowledge) or consciously, and can be either imposed from outside or freely chosen by the artist. Constraints may be part of a venerable, shared tradition (like the stylistic rules governing Western tonality) or newly invented for a particular creative project. An awareness of the role of constraints in the creative process can be valuable both to artists refining their creative process and to consumers of art seeking a deeper understanding. Paradoxically, as Stravinsky recognized, limits and obstacles can enhance creativity by increasing our freedom to innovate and escape from conventions.

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