PERIODICITY and MUSICAL TEXTURE [1]

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In a general sense, musical texture refers to the temporal and registral distribution of notes in any given passage. Sparse texture consists of few notes per time unit, and/or spread over a wide registral range, where each component can be heard individually. Dense texture is composed of many notes sounding close together in time, and/or compressed into a limited portion of the registral range. Most typically, the identification of texture applies to a relatively dense backdrop to a melodic line. This is precisely analogous to the figure/ground relationships of the two-dimensional field, and the perceptual issues correspond to those developed by Gestalt psychologists to explain visual perception.[2] During the 20th century in particular, some composers have focussed on the design of these "background textures", even to the point of omitting the foreground melody altogether. When the listener's attention is drawn to the overall sonic image and the interplay of the component elements rather than on any one individual line, it becomes appropriate to describe the entire passage as "textural". The analysis of texture in itself is thus a natural response to the composition of texture in itself, and embraces an investigation of all the specific characteristics of a passage that can be appreciated in this more global way.

The perception of a passage as textural depends on several factors. In some cases, a listener may have little option but to listen texturally. An investigation into aural perception reveals that humans have a perceptual threshold whereby separate sound events occurring at intervals faster than about 20 per second (periodicity of about 0.05") will inevitably fuse into a single sound.[3] The general region of events happening at a rate faster than 10 times per second (periodicity of <0.10") has been traditionally reserved in music for trills, tremolo, ornamentation, arpeggiation, etc.[4] Even in passages with lines moving at a slower rate, the specific design may prevent the individual parts from being heard distinctly. A common factor of such a design is in registral and/or temporal intertwining. Registral intertwining results from frequent voice-crossing, presenting difficulties for the ear trying to distinguish one line from another. This effect can be maximized by similarity of timbre and dynamics. Temporal intertwining involves rhythmic dissonance[5] on a low foreground level. The more complex the dissonance and the faster the rate of attacks, the more difficult it is to extricate the separate parts; a slow 2:3 relationship is quite easy to distinguish compared to a quick 7:8:9.[6]

In other cases, the listener may choose to listen texturally. The very option of choosing indicates that the passage presents components which can be perceived individually, but the listener prefers to focus on a longer-range level -- i.e. that more

time will be allowed to elapse before interpretations of grouping structure are made. Such a decision is usually derived from the context, though tempered by the training, mood and concentration of the listener. For example, a high degree of redundancy[7] within individual lines may suggest that a focus on the interaction of the various lines will prove more interesting. Sometimes, the opposite is true, and the redundancy of individual parts is so low that the listener cannot deal adequately with the excessive input of information. In these circumstances, a common strategy is to abandon the effort to follow the structural organization and focus instead on immediately-perceptible foreground aspects such as timbre, dynamics and density -- i.e. the textural characteristics.

Textures do not require an audible periodicity, but as they are often calculated and described in terms of their averages, periodic rates can figure as a type of statistical average determining the density (i.e. frequency of note attacks or events)[8]. Therefore, in a textural context, periodicity can function as "a coefficient of density".

Changes in density and configuration can create a sense of depth in a texture. This sense can be emphasized by a fluctuation achieved through a change in the number of layers participating. For example, a texture that grows from an ungrouped pulse to a layering of two clearly-defined strata and then dissolves back into a single line expresses an increase and decrease of depth, thereby drawing the listener's attention to that parameter. Likewise, when varied short durations are assigned to several instruments simultaneously, a high density of note attacks is produced. The effect, often described as a thickening of the texture, needs very little time to be grasped, making textural thickening a very convenient technique for providing contrast between passages. Such manipulation can be mastered to produce extremely well-controlled balances of density, tension, etc.

The composition of textural passages was championed by composers such as Xenakis, Stockhausen, and Ligeti as they searched for new ways of organizing sonic material. Stockhausen promoted the term "statistical field" to refer to the situation where characteristics such as timbre, duration, and register remained similar throughout a passage.[9] The term accompanied a new compositional approach whereby the composer would select the precise way in which specific properties would be distributed among various instruments.[10] The textural approach was a very appropriate one for many 20th-century composers who wished to move beyond traditional uses of harmony and meter while retaining a degree of large-scale control. It permitted the composer to establish "global" properties for each texture and then to construct formal designs that would produce varying types and degrees of contrast. Contrasts in timbre, dynamic level, durations, register, etc. could be extended hierarchically; a passage incorporating high contrasts in several parameters could be juxtaposed with one of low contrast. For composers such as Ligeti and Stockhausen, such an approach proved conducive to fascinating designs.

Ligeti realized that attempts to serialize durations could result in an undifferentiated rhythmic shape:[11] when a series of durations are distributed with equal frequency over a given period of time, the resulting textures can produce a bland durational profile.[12] Because we employ a mode of listening that extends temporally beyond adjacent pairs of notes, the effect of the contrast between two durations can be dulled by a lack of contrast between adjacent groups of durations. Conversely, choosing to listen to a passage texturally often requires a broadening of the temporal focus. In such a case, the listener receives data from a longer than normal time period before codifying it. Since non-codified data is retained only in the short-term memory buffer, that time period is restricted by the limit of the perceptual present.[13] However, the composer can help the listener extend the time period by minimizing the rate of information presented by the music.

Various 20th-century composers have experimented with the perceptual boundary of 0.05", below which the ear cannot perceive a distinct order of pitches. Boulez describes his explorations in terms of timbral manipulation:

> Below a certain level of perception, that is to say beyond a certain speed, a succession of chords will be perceived as a mixture of timbres rather than as a superimposition of pitches. Effectively these chords do not obey accepted harmonic functions and our perception is unable to analyze the phenomenon of these fleeting pitches. The vertical intervallic relationships are there to create a sound-object and not to establish functional relations. If such a chord is attched to a horizontal line, without any internal modifications, its identity is absorbed by our perception: as a timbre-object the chord thickens the line.[14]

Ligeti's aim, similarly, was to combine sounds at speeds above the boundary, thereby producing changes that would cause slow overall "transformations in the 'molecular state' of sound".[15] He thus explains his use of foreground dissonance in the textural / ornamental region:

> Since you cannot play an instrument fast enough to produce a succession of notes at a rate of twenty per second, I built the rhythmic shifts into the music. For instance, twenty-four violins would play the same tune but with a slight time-lag between them. The figurations were almost identical but not quite.[16]

In a textural passage, a particular state of densities and proportions is often maintained for a sufficiently long period of time that perceived changes can be understood as a modification of the basic state. Works such as *Atmosphères* were influential in their presentation in textural passages of unprecedented length. The minimal movement, exemplified by the music of Steve Reich, also had considerable influence in training listeners to listen "texturally". Some examples of texture in 20th-century Western compositions have been directly influenced by music of other

cultures, such as that of Indonesia, which have long traditions of music we would consider textural.[17] This influence is also reflected in the formal schemes of texturally-constructed compositions, which often show a different aesthetic from the more typical goal-directed schemes of, for example, tonally-structured works of the Romantic period. Musical designs created through the juxtaposition and manipulation of textures invites a different type of listening: one where the sense of time is already extended to a temporal "scanning", where sequential arrangement of the elements is not as crucial, and the listener must allow for a greater window of simultaneity.

Partly for these reasons, early modern explorations of texture often maintain similarity in several parameters for a relatively long time-span, resulting in a certain static quality. However, such similarity is not a prerequisite. Any complex sound will convey a sense of texture when the ear has difficulty in segregating the component parts. The third movement of Lutoslawski's *Concerto for Orchestra*, for example, contains a passage where the "textures" are separated by rests and last for a few seconds only, producing a foreground rhythm by their pattern of occurrence.[18] Despite their brevity, these bursts of sound appear very similar in construction to other more clearly textural passages. There is an impression of a textural fabric from which short fragments have been extracted.

Even in 20th-century music, textures are frequently presented in the traditional function of a backdrop to melodic material. In musical contexts, the figure/ground phenomenon refers to the perception of one prominent sonic image as being distinct from other sounds present in the musical texture. The clarity of the distinction between the melody and the accompanying texture can vary according to compositional concerns, but the perception of a layer as textural implies a certain degree of constancy in one or more components. When there is sufficient ambiguity considerable concentration may be required in order to maintain the contrast between the two. Ambiguity can arise from the lack of strong identity in the figure and/or from prominent activity in the ground which rivals that of the figure in claiming attention. The establishment of a clear identity (*Gestalt*) is therefore crucial to effective separation between figure and ground. Analysis of complex 20th-century works such as those referred to below show that the establishment of *Gestalten* can be approached in a variety of ways, and the boundary can be clear or blurry.

Background textures seem to fall into two distinct types, each creating a different perceptual effect. One type operates in rhythmic unison, typically in a regular pattern, and produces the effect of texture through a continuous differentiation in pitch and timbre. When the regularity is within the sub-pulse to pulse range, this creates a regular grid against which the rhythmic irregularities of a melody can be highlighted. A rather different effect is produced when the melody is contrasted with a smooth or grainy textural background of a more uniform density, without any audible pulsation. This type of texture often displays a foreground

rhythmic dissonance created either through an overlay of different pulse subdivisions or by more additive means such as the continuous repetition of a very short figure.

The most prolonged static texture of Bartok's *Music for Strings, Percussion and Celesta*, forming around m.196 of Movement II, provides an example of the rhythmic unison type [Ex.1 [19]]. The accompaniment texture is composed of several independent parts, each repeating a five-note segment derived from the preceding material, and all moving at a constant eighth-note rate. Despite the 5/8 implication of the pattern repetition, the passage is notated in 2/4. As the passage is preceded by material in a 2/4 meter, Bartok may have retained that notation merely for convenience of performance, as the focal melodic theme in the piano exhibits a highly irregular rhythmic structure. However, more likely the 2/4 barring is intended to de-emphasize the 5/8 period of the texture by providing another layer of subtly dissonant periodicity.

Even at d=144, the texture's eighth-note articulation (giving a periodicity of ca. 0.2") is relatively slow for a background effect[20] and the contrast in rate between theme and background is not as pronounced as usual. However, the prominence of the theme is ensured by its rhythmic profile, dynamics, articulation, and orchestration. In other words, the texture is heard as texture partly because of its background function. The delineation between theme and texture is also enhanced by the constant regular movement and the restricted pitch content of the texture. The theme incorporates sufficient rests between chords to allow glimpses of the background, but no more than one cycle of the texture is ever heard between two note attacks of the theme. The theme and texture are aligned on the level of the eighth note, as is characteristic of this work.

Another set of textures which exhibit rhythmic consonance, and often rhythmic unison, occurs in the third movement of Lutoslawski's *Concerto for Orchestra*. The textures provide a complex background for a familiar theme moving primarily in long notes.[21] They are of two types: sparse short segments of quarter-notes played by lower strings (pizz) and brass, and denser, longer segments played alternately by horns and woodwinds [Ex.2a and 2b]. The denser textures exhibit an interesting construction: each instrument plays only two pitches yet the composite effect produces two layers, one of repeated static chords and the other of a chordal line moving up and down. When the same set of textures returns at a slightly faster tempo, the melodic line is reduced in complexity, encouraging the listener to focus more on the accompanying texture. The passage is much longer (24"), has more inner complexity, and incorporates some internal shifting of patterns. The texture gradually thins, though the eighth-note pulse is always articulated, and the reduction of activity is balanced by movement in a previously static pulse [Ex.2c].

A passage of three bars' length in Lutoslawski's work seems textural despite its brevity and relatively long durations, because it exhibits temporal symmetry.

This symmetry indicates a closed system rather than a goal-directed passage, and the careful dovetailing of recognizable harmonic patterns conveys this characteristic to the alert listener. One layer of sustained notes in the horns is the background for three other layers. Together they produce a simple composite rhythm of a quarter-note articulation which aligns with the melodic material. Three groups of instruments play dissonant, internally symmetrical duration patterns [Ex.3]. The pitch patterns of each group form harmonies which, though internally consonant and beginning on a perfect fifth, also exhibit dissonance during the three bars; that relationship helps maintain their independence.

Textures constructed through a superpositioning of different subdivisions are considerably denser than those exhibiting rhythmic consonance on the foreground level such as those just described. Three related passages in the first movement of Lutoslawski's *Concerto for Orchestra* present an interesting opportunity to study both types within a similar framework. In each case, they accompany the slow second theme of the movement. At mm. 40ff, each of the two component lines of the background texture move in eighth notes. The pivots in the scalar figures of the clarinet provide the only plausible accent point in the clarinet line, resulting in a "Type B dissonance" with the accents of the oboe.[22] In combination with the 5/8 grouping length, the (irregular) insertion of some shorter groups, and the difference in character of the contours, considerable irregularity is audible [Ex.4a].

At the next statement of the same theme, a related but more complex accompanying texture is constructed [Ex.4b]. Dissonance is extended to the foreground level by the simultaneous presentation of different subdivisions of the dotted quarter-note. (On the other hand, the coinciding of those subdivisions emphasizes the pulse.) The scalar pattern which appeared previously in eighth notes now appears in sixteenths. It maintains the same period of time between pivots, and thus covers a much greater distance in register. The other layer previously played by oboe now appears in canon, the two parts of which can be clearly heard as distinct layers, because the accents and the difference in pitch/registral level prevent them from fusing.[23] Simultaneously, another figure in celli and bassoons emphasizes the dotted half duration by sequential pitch patterns. As this line moves mainly by step, it is similar to the clarinet's line of the previous statement. Therefore, the changing of the clarinet movement from eighths to sixteenths may have been a crucial move to maintain segregation. The lyrical theme is easily distinguishable from the various textural layers by its tempo, its lyrical nature, and by its recognizability from the previous statement.

At the third statement, the shortest duration in the texture returns to the eighth note, so the only foreground dissonance is a 2:3 ratio of two divisions of the dotted quarter. This time the texture is very full, due to parallel harmonies in the strings, a lack of rests, and a slow sustained line in trombones in addition to the foreground dissonances [Ex.4c]. The distinction between figure and ground tends to reverse in this passage, owing to an increase in activity in the ground and the

familiarity of the theme itself. The different layers of the texture are individually modulated by dynamic shaping or harmonic thickening, thereby emphasizing their independence. Subsequently, the various lines are interrupted by an increase of attack density and a decrease in pitch movement. This interruption serves in part as an anacrusis to a major downbeat of the theme.

The chorale section in the third movement of the same work contains more examples of accompaniment texture characterized by foreground dissonance. The first full statement of this texture is in mm.715ff. Celesta, harps, piano, and percussion all play repeating patterns, each of which contributes a different subdivision of the half note in the ratio 3:4:5 [Ex.5]. The effect is a reinforcement of the half-note period and, with the aid of the percussion rolls, a thickening of the texture. The piano and celesta patterns also articulate the two-bar period through repetition. This grouping provides a subtle continuation of the two-bar period already established and thereby helps maintain the vibrancy of the hemiola effect of the chorale theme. The subdivisions are at quite a fast rate, falling within the textural/ornamental zone. Their function as texture is therefore easily grasped, as the density of note attacks is too high to be perceived as rhythmic.[24]

Also in the third movement, fragmented texture occurs as accent to a variation of the passacaglia theme [Ex.6]. Texture is produced by the superpositioning of trills, tremolo, and fast-moving triplet figures. What makes this texture unusual is its fragmentation and its function as ornament on a larger scale. The segments are separated by much sparser writing, so there is a considerable accent resulting from the initiation of each textural fragment. Since the component parts cannot be distinguished, the textural fragment is grasped as one single, if prolonged, anacrusis to the following beat. This effect is reinforced by a dramatic crescendo in the horns, and by the periodicity of the texture's recurrence.

Bartok's *Music for Strings, Percussion and Celesta* contains a few passages where a high density of note attacks and the overlaying of several parts create an opaque texture. The first such instance begins in m.78 of the first movement [Ex.7], where a shimmering celesta sound presents a fluid backdrop to fugal material in the strings. The celesta figure exhibits periodicity on two levels: foreground attack points and grouping by pattern repetition. As the theme's grouping is irregular, the periodic grouping of the celesta pattern creates a dissonance with it. The extremely short durations produce the effect of an articulated sound complex, although the pitches may be perceived as clustered into two groups through auditory streaming.[25] Further blurring of the celesta micropulsation is provided by the tremolo in the strings, which is also periodic, but dissonant with the foreground attacks of the celesta. Given the tempo and notation, the tremolo will differ from player to player (reflecting motor skills). The tremolo's coloration function is confirmed by its registral placement between the pitches of the two theme statements. There are strong echoes of this passage in Movement III [Ex.8 and 9].

Ligeti is one of the masters of maintaining and manipulating textures over extremely long periods of time. The third movement of his *Chamber Concerto* presents several textures each constructed by the same means: multiple periodicities overlaid in close and complex relations to each other. Although the movement is by no means static, it contains no discernable melodies; instead, each voice functions as a component of one of the various textures. Attention is sustained by the interplay of the periodicities of the component layers, by pitch/registral movement throughout a specific texture, and on a larger scale by contrast between the various textures involved. Since the various textures are created through the superpositioning of differing periodicities, the movement provides an excellent model for analysis.

Each texture involves several instruments each playing a pitch repeated at a certain periodic rate. The pitch movement is very restricted, either remaining on one pitch or moving in a single direction by small intervals or through glissandi. The textures are contrasted by several means: timbre, pitches, contour and dynamics; the rate of reiteration; and the relationship of the periods produced. Ligeti describes the resulting textures as:

> the type labelled 'like a precision mechanism' ... characterized by a specific rhythmical configuration: a state ... represented in terms, not of a 'smooth', but of a 'fine-ground' continuity, so that the music is seen as if through a number of superimposed lattices.[26]

The nine distinguishable textures in the movement are listed in Ex.10. The first 47" of the movement (up to m.12) can be considered as presenting one distinct texture, though it contains three distinguishable sub-layers due to variations in timbre and durations. Each instrument presents a series of pitches [Ex.11a]; each pitch is reiterated a variable number of times but always quickly, and initiated by an accent. Each instrument starts independently and exhibits different grouping rhythms. The overall texture is modified by progressive widening of the pitch, timbre, and duration choices. Initially, a constant 32nd-note movement, unison pitch, and timbral similarity produce an overall effect of a fine-grained texture with irregular punctuation from the pattern of accents.[27] Gradually a cluster is produced as each instrument moves to the next note of the series. A "rhythmic cluster" is also produced, as the new durations are initially either 7 or 9 notes per second, temporally "adjacent" to the 8-notes-per-second rate of the original subdivisions [Ex.11b]. Piano, strings, and harpsichord enter soon afterwards. Though linked to the initial woodwind layer by similar pitches and durations, they are differentiated by timbre and by much briefer pauses between groups of notes. Piano and harpsichord maintain the fast reiterations while the strings introduce slightly slower durations. The sharing of the same pitches links the three layers; however, perceptual fusion is thwarted by the fading out of the woodwinds.

Eventually, sustained notes are added to the texture, producing a cluster which continues sounding until the end of the passage. Although these notes are

obviously contrasted from the rapid reiterations of the rest of the texture, their durations are so long that they considerably exceed the perceptual present. Therefore, within a few seconds they tend to fade into the background, adding color rather than movement or contrast. More significant are the slightly longer durations introduced by the strings which effectively slow the pace and modify the listening focus. In mm.8-11 the longer durations combine with repetition, enabling the listener to hear the 5:4:3 dissonance of the string patterns. The patterns coincide every beat, initially articulating a 1" period and delineating a tempo change by coinciding ten times throughout a rallentando before dying away [Ex.11c].

Texture C has a structure similar in many respects to the preceding passage, but results in quite a different effect. All instruments (except double bass) start simultaneously, the subdivision durations are shortened, the registral range widened, and the rests omitted. All play slow descending and/or ascending chromatic lines [Ex.12], and the number of instruments changing pitch at any one time gradually increases. Uniformly soft dynamics, medium durations, and similar articulations increase the tendency for the various parts to fuse. As the precise rate of reiteration is chosen by the individual performer, a subtle dissonance of attacks produces what the composer describes as "a 'granulated' continuum". A striking characteristic of this texture is the incorporation of glissandi. The string glissandi are quite slow, taking up to 3" to move the distance of a semitone. By contrast, the trombone remains on its first pitch for almost one and a half minutes, then takes only 5" for a glissando covering a major sixth. Both are quite audible, but the trombone glissando is more prominent due to its speed.

Although Texture C continues for almost a full minute, it is overlapped by Texture D [Ex.13a]. This new layer is quite distinct, as it is introduced by the double bass fortissimo at the significantly slower rate of about 3 per second (0.36") -- thereby moving out of the ornamental/textural zone and into that of the sub-pulse. The other strings then join in. Each group of notes in this texture is assigned a different but relatively slow rate of recurrence, varying from periods of ca 0.2" to 0.67", thereby extending even into the pulse zone [Ex.13b]. Ligeti notates the various rhythms in different tempi as well as by different subdivisions. This strategy produces an extremely complex relationship between the instruments, with virtually no coinciding of attacks.

Texture E begins with *staccatissimo* reiterated chords in harpsichord and piano. The periods of their durations mediate between those of the woodwinds and the strings; their attacks create a 5:6 dissonance which coincide every beat (ca. 0.91"). The similarity of their durations, articulation, and pitch aggregates contribute to their fusion and to their segregation from the other instruments. Texture F represents another instance of a "granulated continuum". It consists of string pizzicato chords played softly but "*as rapidly as possible*", creating a frenzied effect which cannot (should not) be dissociated from the actual state of tension in the

performer.[28] The incorporation of slow glissandi on the middle note of each chord is reminiscent of Texture B.

In Texture G, several instruments present a much slower reiteration of very short notes, all on the same low pitch. A rather comical effect is produced by the contrast of the low register and slow articulation with the preceding frenzied texture in the strings. The sense of texture is challenged by the (relatively) long periods, which tend to make the notes sound as distinct entities rather than as grains in a continuum. It is therefore possible to perceive an irregular rhythmic line resulting from the composite pattern of notes. The durations are outside the textural / ornamental region, so to hear them as fused into one layer involves a considerable stretching of temporal focus. A focus on one specific timbre enables the listener to hear the lines as independent and periodic. After several seconds, five more voices join in simultaneously. Together with two notes added to the piano part, they produce a cluster in a high register. The new entries present periods slightly faster than those of the lower layer, but slow enough to suggest a connection. This interpretation is reinforced by the piano link, which plays its high notes in the same rhythm as its low ones. The registral gap creates an odd effect, stretching the fusion/fission boundary [Ex.14]. After a few seconds, some instruments begin to slow down while the others maintain their original pace. The effect is quite startling, creating a slight perceptual dizziness and causing a segregation of layers. The instruments which slow down theoretically do so together, but since they are playing intricate subdivisions at different rates, there is ample opportunity for minor variations which can cause further perceptual blurring.[29] In addition, the first rallentando coincides with the final glissandi in the viola and cello as they finish the previous passage. At m.50, violins enter at *ff possible* (*pizzicato*) and ca.13" later, viola and cello similarly; all play notes of the high cluster already sounding. Such a beginning is reminiscent of Texture B, with an exchange of registers. Violins I & II should theoretically be consonant with trombone and horn, as those instruments are at the same tempo, and playing multiples of the same subdivisions. However, there is no insurance that they will start in phase, and in fact as the brass are maintaining their own tempi, it is likely that there will be some discrepancy. Ligeti is naturally aware of this tendency, and instructs:

> The players left by the conductor on their own keep as accurately as possible to their individual tempo... however, since they cannot measure the tempo, but only estimate it, tempo fluctuations may occur. Synchronization of the (non-conducted) parts is not to be striven for; in fact, slight shifts in the metre are welcome.[30]

Again, theoretically only, cello and piccolo have the same periodicity. More likely to be perceptible is the relation of attacks in harpsichord and piano: when harpsichord reaches d=40 they should be in a 1:1 proportion.[31] This alignment should become audible because no matter how inaccurately the parts are aligned, the parts will converge momentarily. Such an approaching unison can easily attract attention.

The last section of the movement consists of trills and sharp attacks which together form a slightly uneven pattern of pulses on the same high pair of pitches (Db/Eb). There are two possible interpretations. On one hand, the irregularity links this passage to the irregular accents of the first texture of the movement, and thus contributes to a sense of closure. In a different context, this interpretation would likely be the only plausible one. However, the context of the movement suggests that these few notes are delineating another (very sparse) texture produced by overlapping periodicities. The passage may therefore be interpreted as several layers of periodicity moving quite slowly and out of phase. Despite the fact that the intervals between attacks in the same timbre are not strictly periodic, they are easily interpretable as slowing down. The composite pattern is not regular, but can be sensed as increasing the durations between attacks. In either interpretation, the sparseness of the texture conveys a dispersal of energy appropriate to the end of a movement.

There are numerous instances in Ligeti's work where two or more lines are easily perceived as forming one distinct layer; these passages share some properties with the types of texture already examined. However, in many cases the resultant textures are confined to a narrow pitch band, and exhibit a collective modulation in shape, note density, dynamics, etc. Therefore they exist in a state somewhere between texture and melody and can be more easily thought of as "textural strands". When such strands coexist, their interplay can produce a “contrapuntal” design. An examination of these strands provides an interesting survey of perceptual effects, especially those involving fusion and fission.

In the first movement of Ligeti's *Chamber Concerto*, for example, harpsichord and piano enter simultaneously with a *pp* "cadenza" figure played as fast as possible. The motor skills of the performers and the differing actions of the two instrument ensure that they will not be in rhythmic unison. Nevertheless, the simultaneous entries, the similarity of the figures and the sharing of the same pitch range and dynamic level ensure that they can be heard as two twisted strands of the same layer. Subsequent pairs of entries in the strings playing very similar lines form a type of canon [Ex.15]. Similar passages occur later in the movement such as at m.29 when all strings except double bass play *prestissimo, senza tempo*, in a very narrow pitch band. There, all four begin simultaneously and move together to *sul ponticello*, then *ordinario*, then *sul tasto*; the timbral shifts fuse the four together firmly.

Forming a contrast to the "canonic entry" in the strings is a textural strand presented by the woodwinds [Ex.16]. Although the woodwinds' layer incorporates dynamics, pitches, and short durations similar to those of the strings, it is readily perceptible as a distinct stratum. The factors which contribute to the sense of fission include a more measured rhythmic notation which removes the franticness of performance associated with the directive "*as fast as possible*". In addition, a *legato* articulation contributes to the difference in character. Most noticeably, the woodwinds begin simultaneously and continue in rhythmic unison, presenting a

strongly unified texture.[32] The rhythmic unison is especially striking as it involves very subtle variations of a general regularity; the number of subdivisions per beat differs by only one from the neighboring beats. As the duration of the notes is altered from one beat to the next by less than 0.02", the effect could be considered comparable to microtonal shifts in pitch. The fact that three instruments exhibit identical fluctuation links them even more firmly than if they were playing a more rigid periodicity. It implies a common modulator, and is thus similar to the effect of the timbral shifts in the string passage described above.

The effect of slight rhythmic variations in a horizontal context is fundamentally different from slight variations in vertical arrangements. The latter applies to situations in which simultaneous subdivisions of a beat differ by only one from each other. The effect was discussed with reference to Texture A of the third movement in terms of a "rhythmic cluster". A slight variation in the horizontal realm produces a rubato effect and blurs a sense of beat, while slight vertical deviations subtly articulate the pulse but blur the rhythm. In the latter case, the number of attacks per beat increases. Such an increase in note density changes the texture to an opaque one, while the coinciding of attacks at the beginning of each beat can subtly emphasize that period.

Another instance of a textural strand is also in the first movement of Ligeti's *Chamber Concerto*, when woodwinds enter simultaneously on a sustained note [Ex.17]. When they do begin moving they are in rhythmic unison for one beat before diverging slightly. The beginning unison strengthens their fusion, which is otherwise slightly weak because the rate of movement is slow. The difference between a quintuplet subdivision and a sextuplet at d=60 is ca.0.03", and the density of attacks is a mere 10-16 per beat (and per second). The listener may therefore be able to perceive the specific rhythm of the 5:6 and 5:6:7 ratios. Further fusion is provided by a brief unison pause, as well as by a common dynamic shaping.

In the second movement of the same work, a high-pitched cluster suddenly appears at *fortissimo* in six instruments. The instruments are tightly fused, moving quite erratically with an alternation of very fast movement and sustained notes, all accented and con fuoco. As the strand continues, the activity increases until the sustained notes are dropped altogether and the movement becomes relentless in regular durations of ca 0.11". Gradually the volume decreases and durations lengthen until they are almost 1.5". The passage is approximately 1½ minutes in its entirety, with the slowing down beginning halfway through. The effect of the regularity and the absence of dissonance between mm.50-58 is quite striking in the context of the overall arhythmic nature of this work.

Canonic passages share many characteristics of musical textures, and some 20th-century composers have used imitation and canon for the creation and thickening of textures. The perception of canons depends on the ability to identify the basic theme or figure: hence the tradition of introducing the melody first in

isolation, or clearly contrasted from the background. The first few notes of the melody are the most crucial, as they are normally the signal which alerts the listener to a new entrance. For similar reasons, activity is traditionally reduced in the continuing voice at the point where the new voice enters. Registral separation is a great advantage in distinguishing the independence of the various canonic voices, so that they will not fuse into textural strands. Timbral separation, though it would seem useful, seems to be rare. This rarity may be due simply to the development of canons within homogenous timbral ensembles (choirs, string quartets, piano). Also, the similarity between voices could be jarred by the appearance of the same melody in radically different orchestrations. Whether a cause or an effect, the similarity of timbre present in many canons creates a tendency for canons to fuse into texture. As with other textural forms, this mode of listening can be encouraged by the musical context, the performance, and the listener's approach.

A cascading texture whose melodic simplicity disguises rhythmic complexity is produced by scales in canon in Bartok's *Music for Strings, Percussion and Celesta*.[Ex.18]. Five voices each present a four-octave descending scalar figure in eighths; the entries are at 5 eighths' delays. The octave recurrences form a rhythmically dissonant period of 7 eighths, thus producing a clear 5:7 ratio. The harp emphasizes the 5 eighths' period with a descending perfect fourth figure. The passage "dissolves" into rhythmic consonance simply by a reduction of voices. When only one voice is left in the texture, the harp drops an eighth rest from its pattern, creating an interval of 4 eighths' duration, as preparation for the next section in a 2/4 meter.

Another interesting canonic texture in the same work occurs in the fourth movement [Ex.19]. Cascading entries of the first three bars are somewhat reminiscent of a passage in the second movement (mm.287ff), being mainly of eighth-note movement imitating at exact pitch. The texture is considerably more dense, however, due to delays of only one quarter note (ca.0.25"), and to a slightly more differentiated rhythmic pattern (1-1-1-1-1-1-2). The bar period is emphasized by accented Bb's in violin I instead of the A of all other voices. The descending one-bar pattern is soon replaced by a two-bar figure incorporating a repeated one-bar rhythmic pattern. The change, accompanied by rests in each instrument as it moves to the new pattern, temporarily disrupts the sense of texture. However, as the new figure moves primarily in quarter notes, with imitation also at a delay of a quarter note, it is possible to lapse back into a textural listening. On the other hand, a listener might "track" only the first entry in the highest voice, hearing the others as subsidiary. This tendency, in combination with the bar-length period strongly articulated since m.121, would emphasize the rhythmically dissonant effect of the violin I entry in the middle of m.127. It enters with ostensibly the same rhythmic pattern but a different contour; the dissonance is emphasized by dynamics and notated accents. The second phrase of violin I enters after six quarters instead of four. Although this entry further disrupts the regularity of bar- and two-bar figures, it does re-align the figure with the established meter. Imitation continues, but the

dissonance is gradually neutralized by the repetition of the rhythmic figure 1-1-2 which fuses the voices into a more static texture once again, in preparation for the subsequent section.

Lutoslawski's *Concerto for Orchestra* produces a textural thickening through a mixture of quasi-canon and heterophony in the second part of the third movement. The passage displays properties of a textural strand, as it is restricted to a narrow registral band with foreground dissonance. Although the delay of the canonic entry combined with the prominent oboe timbre creates the effect of imitation, the first five notes are in octave unison with the piccolo. Six beats later, the piccolo repeats the fragment, and this time it is echoed twice at delays of one beat, again with octave unisons at the beginning of each entry [Ex.20].

Later in the same movement, a double binary figure derived from the chorale section is turned into an ostinato and treated canonically. The entries are at a delay of six quarters, dissonant with the double binary figure but holding the half-note unit in common [Ex.21]. The particular design of the figure results in the even-numbered entries producing a mirror image, and the odd-numbered ones moving in parallel motion, so the general effect quickly merges into texture. The fifth and sixth entries are at half-note delays only, subtly underlining the canonic structure by the reference to stretto.

Ligeti is known for his use of micropolyphony, a term referring to the creation of textures by means such as "inaudible canons" which move too quickly and/or in too dense a context to be perceived of as such. By the time of the *Chamber Concerto*, however, he was beginning to explore different approaches and test the limits of textural listening. He explains:

> The methods [of compositional technique] vary from piece to piece ...and also by degrees: experiences with one piece lead to modifications in technique... [The] closely woven musical network which is characteristic of the second movement of Apparitions [1957] ... was the origin of 'inaudible' polyphony, or micro-polyphony, in which each single part, though imperceptible by itself, contributes to the character of the polyphonic network as a whole. In other words, the individual parts and the musical configurations arising from these parts remain subliminal, but each part and each configuration is, in relation to the overall structure, transparent in the sense that all changes in detail lead to changes, however slight, in the total effect.... I began to thin out the dense polyphonic network ... even more radically in the works after 1968. The individual parts were still more or less subliminal, but now and again there emerged musical shapes at a level of the individually perceptible. Typical of this thinned-out micropolyphony -- now resembling the transparency of a drawing rather than the opaqueness of a painting... [is] the Chamber Concerto...[33]

Such explanations on the part of the composer emphasize the attention which can be given to the designing and manipulation of musical texture, and the extent to which perceptual issues are accepted to play a role. They also suggest the extent to which a composer may refine his or her treatment of textural issues throughout the course of a lifetime, thus stressing the need for analysis to reflect this kind of development.

In conclusion, we can see that the study of textures involves several aspects. On a basic level, any texture must be described, in terms of its component elements, their configuration, and their interrelation. Presumeably, as more data is gathered, more general types will be identified and a more specific vocabulary will be evolved.

Textures are often categorized in terms of dense and sparse: these terms refer to the density of events and as such reflect one of the most immediately salient characteristics of a passage. In addition, a useful distinction can be made between textures which move in rhythmic unison and those which exhibit rhythmic dissonance. The latter can be further subdivided into simple, lower-order rhythmic dissonances, and those of a much higher complexity. Examples of different types of rhythmic dissonance can be found juxtaposed in the third movement of Ligeti's *Chamber Concerto*. This work also provides an unusual example of textures composed strictly from periodic events, providing a valuable model for studying textural passages in terms of their density coefficient.

Some works evoke mood or atmosphere by association with our physical environment, through the use of specific references in temporal density.[34] Mood and atmosphere are difficult to describe without resorting to poetic imagery and other non-measureable allusions. However, the fact that specific combinations tend to evoke specific reactions seems undeniable.[35] Passages which are faster, higher, louder, and denser are generally more tension-producing than their opposites.[36] Slow and sparse textures, though not in themselves indicative of serenity, for example, are nonetheless taken to be more appropriate in portraying this mood than fast and dense ones.

These issues lead us to the physiological basis of the faster periodicities. Tremolo, for instance, logically suggests a quivering, which is precisely how it would be conveyed by a string player (probably the most traditional producer of tremolo figures). Quivering implies a state of excitement or nervousness and therefore tends to imbue a slow-moving passage with a sense of anticipation or anxiety. Traditionally, a distinction is preserved between the various levels (ornamental to phrase) which are then kept in a certain proportion. At a slow tempo, all are within a slower range than at a fast tempo. The pulse is the main indicator of the general mood, and its subdivision by sub-pulse and degree of filling-in by ornament or the properties of the background texture give the specific character to the passage. A texture without a pulse level and without a contrasting figure can be considered free of the pulse associations, and hence of the intrinsic correlations to

human limb movements. It can therefore be more capable of evoking more intangible, ethereal states and creating unfamiliar shifting environments.

Intertwined with a description of a texture's components and affect is a recognition of the perceptual issues. Current research in the cognitive sciences is valuable in such an investigation, and will increase in usefulness as analysts propose hypotheses of mental strategies and perceptual impressions for testing. The perception of textures appears to depend above all on the fusion of the separate components of the musical passage or layer. The chance of such fusion occurring is almost certain in some cases, due to the constructs of our listening patterns. Factors which promote fusion include a high density of attacks and a shared registral, timbral, and dynamic range. In more ambiguous cases, the musical context, the composer's intentions, the performer's interpretation and the listener's mode of hearing may all influence the result.

The specific function of a texture, whether as background, melodic substitute, structural delineator, or the focal point of the work, is a crucial aspect of textural study. Textures can occur as background to a contrasting melody, or can provide a steady-state or slowly-changing sonic image as the focus of a passage. In some works, a type of polyphony is achieved by the interweaving of textural strands. A strand exhibits properties of texture but the components remain within close registral distance of each other. The works by Bartok and Lutoslawski analyzed here seem to demarcate the textures carefully, to maintain contrast between textures and other coexisting or juxtaposed layers. The presence of trills or tremolo accompanying many rhythmically-dissonant textures helps blur rhythmic complexities. They reinforce the opaque nature of the texture, and focus attention away from the harshness of the dissonant rhythms. Textures which exhibit rhythmic unison or consonance are usually confined to similar timbres, simple rhythms, and a reduction of melodic change. These factors help to maintain the fusion which is essential to perception of a texture as a single sonic image.

Perhaps the most striking aspect of a study of textures in 20th-century music is the extent to which a change of texture serves as a section delineator. In the absence of harmony, the delineation of formal structure is frequently achieved by contrast in various parameters, of which foreground rhythm is one of the most significant and quickly-apprehended. Such delineation through contrast can occur horizontally or vertically. The degree of contrast perceived between layers or juxtaposed passages depends on several factors. A sudden dramatic contrast in period length will clearly produce a noticeable structural boundary. However, a slow transition from one such passage to the other will have a very different effect, as memory processes will be involved. Textures of very similar configurations may be perceptibly different because of our sensitivity to slight changes in density. A structural boundary can appear more marked if the preceding passage has continued for a long time, as the established periodicities will be more resistant to change.[37]

Foreground properties become more crucial in determining boundaries when traditional tonal and metric structures are absent. Whether abrupt or gradual, changes in texture become significant contributors to the defining of large-scale compositional structure. In retrospect, the dissolving of active melodic material into a more textural passage has been a traditional signifier of structure for centuries. Our tolerance of the distant harmonies of a bridge passage, for example, is directly related to the lower information content, usually achieved through the neutralization into texture. The differentiating factor of many variations in the theme-and-variation form is often best described as textural contrast. Formal structure in Baroque instrumental music especially is often clarified by sharp delineation on a textural level. However, it is only in the absence of easily-analyzable harmonic and melodic structures that we have been led to a more analytical study of textures in themselves. The proliferation of composers who approach the design of a work through conscious manipulation of texture encourages the examination of their material from a similar perspective. As the beauty of some of these textural designs is revealed to greater depth on close scrutiny, the study of musical textures finds its own reward.

ENDNOTES

1. This paper is adapted from Chapter 4, and *passim*, of the author's Ph.D. dissertation: *An Investigation of Periodicity in Music, with reference to three twentieth-century compositions: Bartok's Music for Strings, Percussion & Celesta, Lutoslawski's Concerto for Orchestra, Ligeti's Chamber Concerto*; hereafter referred to as *IPM*.

2. See below, p.4; also Deutsch, "Memory and Attention", p.118, and Tenney, *Meta+Hodos*, p.40, for further discussion of figure and ground in music.

3. Bielawski points out that this region corresponds to that of phonemes in speech. See Mountain, *IPM*, Appendix D, for a summary of the various estimates of this boundary.

4. Passages described as "a wash of sound" and "coloristic" usually involve such temporal density. My investigation reveals considerable correspondence between various functions and periodicities in music: other identified levels are those of the sub-pulse (recurrence of an aural event approximately every 0.10"-0.5"), the pulse (about 0.5"-1.5") and the super-pulse (about 1.5"-4.5"). The tendency of composers to maintain these zones for their respective functions is illustrated by the peculiar effect of passages

that mix a function with a non-typical rate, such as the melody of Mendelssohn's *Midsummer Night's Dream*, or of Lutoslawski's *Concerto for Orchestra*. See Mountain, *IPM*, 61-63, 143-144.

5. Rhythmic dissonance refers to the lack of alignment between two (or more) series of pulses or other periodicities; rhythmic consonance exists when one level of periodicity is a simple multiple of another (most commonly in a 2:1, 3:1 or 4:1 ratio). The concept was developed extensively by Yeston (1976) and crucially refined by Krebs (1987).

6. Texture "A" of the third movement of Ligeti's *Chamber Concerto* provides examples of the latter; see below, p. 8, and Ex. 11b.

7. Redundancy is a term from information theory, referring to the factor which controls the rate of information transmitted without necessitating an interruption in the flow of transmitted words or music. Significant bits of information are usually encoded in more than one way, repeated more than one time, or surrounded by low information content, so that the receiver will have adequate time to process the message. The traditional telegram presents a rare case of minimum redundancy; conversely, an ostinato is a musical example of high redundancy.

8. Periodicity simply refers to the repetition of any event at regular intervals in time. It was chosen as a tool for investigation for two reasons: 1) because its presence in music, especially at the level of the pulse and super-pulse, can strongly influence our perception of music; and 2) textural passages are easily modelled (and sometimes composed) by superimposing different layers of periodic events, just as complex tones can be modelled by sine waves.

9. For a description of the characteristics and origins of statistical fields, see Ligeti, "Metamorphoses of Musical Form", *passim*; also Stockhausen, "...how time passes...", 15, 30ff.; Tenney, *Meta+Hodos*, 67-68.

10. Xenakis combined this stage of the decision-making with probability theory, thus developing his "stochastic" music. See Xenakis, "Towards a Metamusic", 3ff.

11. Ligeti, "Metamorphoses of Musical Form", p.10. See Mountain, *IPM*, p.28 for further support of his arguments.

12. In addition, our listening strategies tend to regard two durations as equal even when they differ slightly, as long as that difference is less than about 8% -- see Mountain, *IPM*, 30ff.

13. The perceptual present refers to "now" as perceived by means of short-term memory; all data back into the immediate past and perhaps into the "predictable" immediate future to a probable limit of 5"-10", i.e. the range of short-term memory.

(See Mountain, *IPM*, Chapter I, "A Clarification of Temporal Issues", for further discussion, and Appendix B for estimates of length.) The short-term memory has two limits: one contextural and the other temporal. The contextual limit refers to the number of chunks of data received -- it is generally estimated that only 5-9 chunks can be retained in the short-term memory. What comprises a chunk depends on the individual's processing strategies, training, exposure, alertness, etc.

14. Boulez, “Timbre and Composition - timbre and language”, p.168.

15. *Ligeti in Conversation*, p.39.

16. He continues: "Later I realised that this was nothing new. The string parts at the end of *Walkure* (Feuerzauber) are such that no violinist can play them, all of them make mistakes, different mistakes all the time. These mistakes add up and create a floating, fluctuating pattern, i.e. *Bewegungsfarbe*. Technically, *Atmosphères* is based on the same principle." ibid., p.40.

17. See for example the third movement of Debussy's *String Quartet*, and the music of Charles Tomlinson Griffes. The Paris exposition of 1889 was reputed to have influenced several musicians of the time by exposing them to music from the Orient. Steve Reich's early experiments were influenced in part by African drumming patterns in which several individuals produce a complex texture through the superpositioning of simple but unequal-length patterns. A Westerner's perception of this music as textural may be quite different from that of the members of the culture in question.

18. See p.6 below, and Example 6.

19. As this study is aimed to investigate perceptual aspects and their possible correlation to specific rates and functions of periodic events in music, the examples include clock-time measurements on the inter-onset interval (IOI) and any regularity resulting from a pattern repetition (PATT). Inter-onset interval is the distance between the onset attacks of two adjacent attacks in a string of attacks. The convenience of such a measurement is that it does not require identical durations to illustrate the audible regularity of their starting points. The term is used widely in the field of cognitive psychology, which is why I chose it over the equivalent term "attack point interval”. The times given are of course approximations, and may vary in performance, but should permit some preliminary comparisons.

20. Textures often move in durations faster than 0.10"; compare for example with the celesta passages' durations of the same work with a periodicity of ca.0.09"; see Exs.7-9.

21. The theme is familiar because it is a variation of the second theme from the first movement, presented at mm.40, 64, and 100. The previous statements are also accompanied by textures. (Ex.4).

22. Krebs has made the very useful distinction between dissonances which arise from groupings of pulses whose cardinalities differ (Type A) and those whose cardinalities are identical but out of alignment (Type B). See Krebs, "Some Extensions of the Concepts of Metrical Consonance and Dissonance", 103ff.

23. Auditory fusion refers to the tendency to hear two or more separate lines as being part of one greater line. It is thought to be an extension of the process by which the brain fuses the various components of a complex sound such as a clarinet tone into one timbre. Factors which contribute to such fusion include the initiation of two lines at the same time, and the simultaneous dynamic and/or frequency modulation of those lines. See Bregman (1990) and McAdams (1982) for more detail. A summary can be found in Mountain, *IPM*, 40-42.

24. In the preceding sections where piano and harp each play alone, they perform quintuplets rather than slower rates. The higher density thus helps establish the textural function from the first entry.

25. Auditory streaming (also known as melodic fission) is the opposite of auditory fusion. It is generally associated with very fast rates of presentation, especially £ 0.10", and refers to the tendency for the listener to segregate different tones of a fast series into two distinct lines. Registral contrast is a typical factor, although contrast in timbre and periodic structure are also strong influences. See note #23, above.

26. *Ligeti in Conversation*, 135.

27. The audibility of the subdivisions' periods can be obscured by the irregularity of the entries, due to the *sforzando* accent on the first note of each group. This is more emphasized in certain performances. Although this produces an interesting effect and ties in with the end of the movement, the effect is weakened by the harpsichord, bringing into question the benefits of such an interpretation. Because the harpsichord is unable to differentiate notes by volume, its periodicity is quite audible.

28. In other words, it would not sound quite the same produced electronically, because we can both hear and imagine the difficulty of producing such an effect.

29. Ligeti relates this process to the analogy of malfunctioning machinery: "what attracts me is the idea of superimposing several levels, several different time-grids moving at different speeds, and so very subtly achieving rhythmical deviations. That is what I meant when I said the machine breaks down." *Ligeti in Conversation*, p.108.

30. Score to *Chamber Concerto,* p.80.

31. The piano articulates a period of 3 x septuplet sixteenths at a tempo of d=60, while the harpsichord arrives at a period of 2 x septuplet sixteenths at a tempo of d=40. Each of these produces a periodicity of 0.43".

32. The importance of "onset synchrony" (i.e. beginning at the same time) in the promoting of perceptual fusion is discussed in McAdams, "Spectral Fusion", 287-289.

33. *Ligeti in Conversation,* 135-137.

34. Bartok, for instance, meant the passage beginning at m.35 in the third movement of *Music for Strings* to represent the wind. (Lendvai, p.82.) He is also quoted as referring to the sound of the sea incorporated into the same work; see Helm, p.35.

35. One is reminded of Sloboda's experiments which sought to discover exactly which musical elements produce the effect of a chill runnning down the spine -- he found surprising agreement on specific points in specific pieces as causing the effect. (Sloboda, "Why do musical events cause emotional responses?", *passim.*)

36. Tenney said, in 1961, "I know of no attempt to define these conditions [relating to musical intensity] explicitly, much less to explain them in non-musical terms. It is a common fact of musical experience that a greater subjective intensity is usually associated with a rise in pitch, and increase in dynamic level or in tmepo, etc. Similarly, a change from a "smooth" or "mellow" timbre to a "harsh" or "piercing" timbre, or form a more consonant to a more dissonant interval, is felt as an increase in subjective intensity." *Meta+Hodos,* p.35. Berry incorporates such evaluating of "superior" accentual factors in his discussion of accent in *Structural Functions of Music,* 339ff..

37. This is assuming that at least one level of periodicity is at the level of a super-pulse or faster, as otherwise the regularity may not be perceptible. The resistance to change is related to, though not identical with, the preconditioning effect discussed by Berry (*Structural Functions*). Clarke claims support from Longuet-Higgins and Steedman for his statement that "there is considerable resistance to a perceptual reinterpretation of metrical structure".

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