

On the *perceptual fusion* in Grisey's *Partiels*: A comparative audio-descriptor analysis of two recordings

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We present a comparative analysis of two different recordings of Gerard Grisey's *Partiels* (1975) to investigate *perceptual fusion* in orchestration. This interdisciplinary study is an intermediary step of a broader project which aims to study the perceptual features of spectral music compositional strategies.

The starting point of this investigation is the exploration of the notion of *instrumental synthesis* proposed by Gerard Grisey (1946 - 1998). *Additive synthesis* allows sound creation by adding sine waves with different frequencies and amplitudes in time. However, *instrumental synthesis* affords the emergence of a new orchestral quality by "synthesizing" it with orchestral sounds (Hasegawa, 2021). This new quality engenders a state that, according to Grisey, is "a hybrid being of our perception, a sound which, without being yet a timbre, is already not quite a chord" (Grisey, 2019b).

Far from being a fixed formula, though, each recording of *Partiels* leads to different sensations in terms of *perceptual fusion*. That being the case, one might argue that an overlooked aspect of auditory fusion pertains to the domain of interpretation. Thus, how could we take into account those unwritten features of the musical realization? We propose an audio-based approach to address this question.

Theoretical background in orchestration

Perceptual fusion is a recurrent subject in musical studies (Bregman, 1994; Huron, 2001; Parncutt, 1989). Recent works proposing models for study fusion in orchestration anchored on acoustics and psychoacoustic properties of sound (Goodchild & McAdams, 2018).

The instruments' acoustical properties related to fusion are linked with the similarity of temporal features, like the attack time; to spectral features, like the spectral centroid; and to spectrotemporal features, such as the spectral flux (Goodchild & McAdams, 2018). Psychoacoustical features linked with the neurosensorial properties of hearing are involved in the process of fusion, like tonal fusion, masking, and co-modulation of pitch, among others (Huron, 2001). Additionally, the sense of fusion is dependent on the synchronization of modulations in sound spectra, afforded by elements of musical performance such as vibrato or tremolo. This means that common motions and variations of spectral components afford the perception of fusion (Chowning, 1999).

With regard to the present study, we explore the following fusion elements: the synchronicity of the acoustic components (*onset synchrony*), the relation between the components by a common periodicity (*harmonicity*), and the coherence of frequency and amplitude behaviors (*spectro-temporal synchronization*) (Chowning, 1999; Goodchild & McAdams, 2018). These elements are linked with the *Gestalt* principle of common fate (Goodchild & McAdams, 2018; Huron, 2001).

Analytical Guidelines

The first part of the *Partiels* is inspired by the time-frequency analysis of a trombone (Féron, 2010). By analyzing the *Partiels*' score, we may infer elements that afford perceptual fusion: **a.** the organization of instrumental subgroups with common attack behaviors (*onset synchrony*); **b.** the harmonic organization inspired by harmonic spectra (*harmonicity*); **c.** the similarity of the attack modes between instruments (*spectro-temporal synchronization*). However, these features being highly dependent on musical interpretation, our investigation combines symbolic graphs with an analytical approach to recordings (Antunes et al., 2021; Rossetti et al., 2022).

Table 1: Audio representation, definition, and analytical interpretation in this study.

Audio representation	Definition	Analytical interpretation
<i>Spectral Flux</i> ¹	Distance between the spectral content of two adjacent <i>FFT</i> windows	Detections of onsets in the musical texture
<i>Spectral Flatness</i> ²	Represents the noisiness of a sound signal	Noise level in the musical texture
<i>Spectrogram</i>	Time-frequency representation of audio	Spectro-temporal description of the musical texture

In this paper, we propose to analyze two recordings of *Partiels*. The chosen audio descriptors (**Table 1**) were inferred from the literature and were related to perceptual fusion in orchestration, the audio descriptors' function, the musicological information about Grisey's compositional process, and the symbolic score information. These sources of information foster an interdisciplinary approach to audio-based musical analysis already proposed in previous works (Antunes et al., 2021; Rossetti et al., 2022). The proposed interpretation for the descriptors of Table 1 is: 1 - *Spectral flux* - Spectral flux relates to the variations of the spectral contents over time, which allows us to observe the musical onsets on the musical texture. This is interpreted as a sensation of novelty in musical texture, mainly linked in this context with the prominence of the instrument attacks. 2 - *Spectral flatness* - The first part of *Partiels* shows a process of inharmonicity accumulation in time. To do so, Grisey introduces noisy sounds with extended techniques, which adds a textural layer to the omnipresent harmonic chord inspired by instrumental synthesis. So, the higher the level of emphasis on the extended technique during the performance, the lower the sensation of fusion, i.e. the sensation of a unique texture afforded by the harmonic chord. 3 - *Spectrogram* - the level of dissimilarity between microtemporal fluctuations of each instrument in the audio spectrum is supposed to influence source segregation.

¹ Böck; Widmer, 2013.

² Dubnov, 2004.

We argue that these three representations provide clues to an exploratory approach to the sense of fusion in the musical texture. So, the stronger the level of musical onsets, the higher the noise content, and the higher the dissimilarity between microtemporal fluctuations, the lower the tendency of the musical texture to afford the sense of fusion.

Analytical corpus

Our methodology consists in studying the performance through the phonogram, which implies being aware that our analysis catches features from both the composition, performance and the musical production (Zagorski-Thomas, 2014). We highlight the following aspects related to the chosen recordings: **a** - the albums were recorded by traditional ensembles which have long-term expertise in recording contemporary music; **b** - both recordings are not too far in time and were released on CD, which means that they shared some standards of production required by the digital domain; **c** substantial differences between the performances were found through research group discussions, forming a rich material to address musicological and perceptual questions. To perform our analysis, we chose 2 different recordings which propose different interpretative solutions to Grisey's score: **Recording 1** - Album *Gérard Grisey – Les Espaces Acoustiques* (1999), conducted by Pierre-André Valade and performed by Ensemble Court-Circuit; **Recording 2** - Album *GÉRARD GRISEY: Les Espaces Acoustiques* (2005), conducted by Stefan Asbury and performed by Asko Ensemble.

Partial Results

Our study comprehends a comparative analysis of the 11 first segments of *Partiels* (following Grisey's score annotation). For this abstract purpose, we will focus on segment 8. In **Figure 2** we briefly present the *spectral flux* and *flatness* descriptors and the *spectrogram* for both recordings of segment 8 of the *Partiels* score². A reduction of the score information is presented in **Figure 1**.

We notice that recording 1 (R1) exhibits high values of *flux* and *flatness* in the first part of the segment (164-166 sec.). In contrast, recording 2 (R2) shows various peaks of *sound flux* and displays an increasing profile of *flatness* throughout the segment. The comparison of the audio analysis with the symbolic graph (Fig. 1) suggests that: **a.** the various peaks of *flux* in R2 are linked to the instruments' strong attacks, which create saliencies in the musical texture; **b.** the increasing profile of *flatness* in R2 is a consequence of the emphasis on extended techniques on Flute 1.

Finally, in the spectrogram of R2, we may notice a modulatory profile in the medium and high frequencies in opposition to more stable frequencies in the lower register, a characteristic that we do not observe in R1. On the assumption that common variations in spectra afford fusion, R2 exhibits more tendencies to segregate into different streams, while R1 has a tendency to produce a more fused texture.

² The sound files and Jupyter notebooks of the present analysis are available on https://gitlab.com/micael_antunes/partiels_orchestration_analysis.git.

Conclusions

By analyzing these audio representations, we may notice that a higher sense of *perceptual fusion* is afforded by R1, while R2 explores more variety in the musical texture. The decreasing profile of *spectral flux* in R1 reveals an absence of onsets through time, with most instruments' onset being condensed at the beginning of the segment.

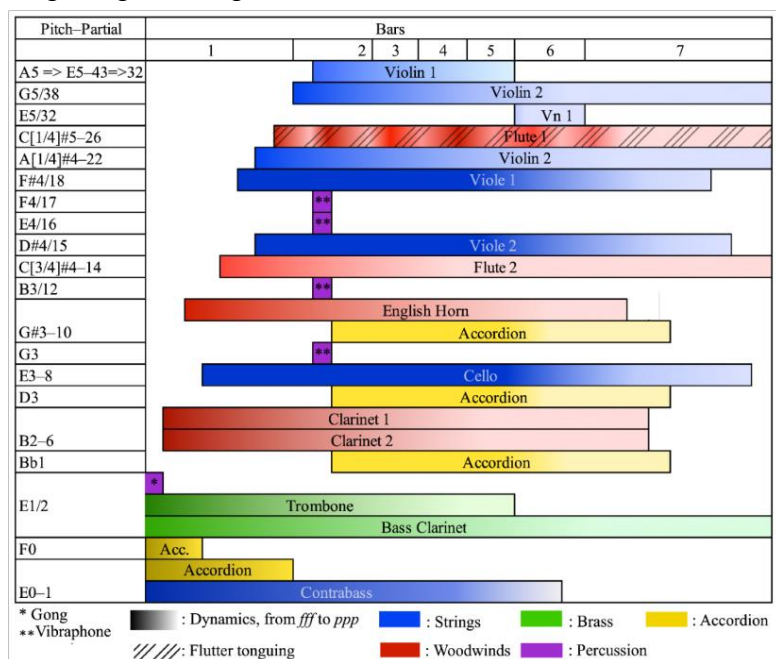


Figure 1: Representation of the symbolic information from the score

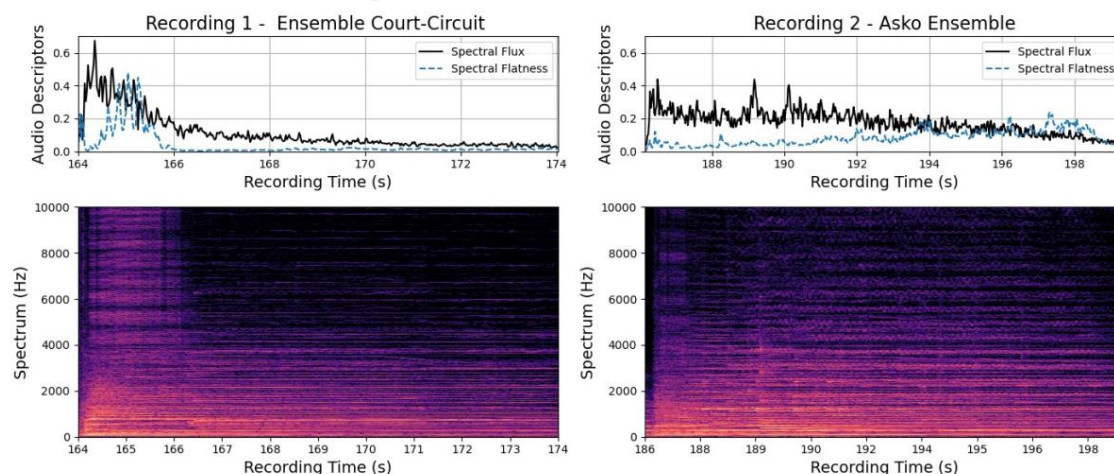


Figure 2: Spectral flux, spectral flatness, and spectrogram for both recordings.

The decreasing flatness profile in R1 also reveals a lower noise level in this recording. Finally, the absence of spectro-temporal variations in high frequencies in R2 suggests that segregation between instruments has been prevented in R1. Broadening our investigation to other segments of *Partiels'* first part confirms these observations.

These preliminary results show that it is possible to identify some audio representations that are significant to an exploratory approach to *perceptual fusion*. This ensemble of representations could offer new insights to musical analysis and interpretation studies. Future steps will expand the analysis to obtain perceptually relevant fusion-related representations. A path toward such a result would be to find better solutions in terms of time-frequency analysis representations to detect the spectro-temporal patterns that afford segregations in the musical texture. This exploratory study allows us to envisage the creation of tools to generate and classify musical textures. Additional analyses combined with sound synthesis and listening tests might also provide new intuitive controls of fusion between sound sources and textures, which is not only of interest for musical composition, but also for sound design and other related areas.

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