Color Harmonies and Color Spaces Used by Olivier Messiaen in *Couleurs de la cité céleste*

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ABSTRACT

This paper explores the color spaces used by Oliver Messiaen in his orchestral composition *Couleurs de la cité céleste*. Messiaen discussed with Claude Samuel his experience of synesthesia, which is the ability of some persons to perceive colors when they hear sounds. In this work Messiaen identifies in the score the highly evocative colors and brilliance characteristics of gemstones suggested by scenes in the Book of Revelation, and he associates them with the voicing and instrumentation of the chords played by selected instruments from the orchestra that he uses in this work. Messiaen's colors exist in a color space that corresponds with the formant space of the sound of the chords that realize these colors. Just as color models such as CIE L*a*b* define hue, saturation and luminance in three dimensions, the F1 x F2 x F4 formant space of Messiaen's chords also locates the same color attributes within the three dimensions defined by these formants, with hue and saturation represented in the F1 x F2 plane, and luminance in the F4 dimension. The software application Speech Filing System is used to determine the formants of the digitized sound of the orchestral chords that are associated with the various colors that he specifies. The formant data are plotted in three dimensions with IDL Workbench visualization software, using three-dimensional polynomial regression. These plots identify the surfaces and their orientations within this space that correspond with colors and color combinations. These data confirm that Messiaen's colors are not merely symbolic associations, but represent his simultaneous perception of sound and color.

1. OBJECTIVE

Messiaen is somewhat unique among composers with synesthesia because he not only acknowledged possessing the ability but also used it explicitly to determine the harmonies and instrumental textures in several of his compositions. *Couleurs de la cité céleste* is Messiaen's setting of the *Book of Revelation*. The author of this book describes the new holy city of Jerusalem (Rev 21:18-21):

> The wall was constructed of jasper, while the city was pure gold, clear as glass. The foundations of the city wall were decorated with every precious stone; the first course of stones was jasper, the second sapphire, the third chalcedony . . . .

Messiaen sets these highly evocative colors and textures to chords played by selected instruments from the orchestra he uses in this work. His association between color and sound is not merely symbolic, but is instead his notation of the sounds that he experiences when imagining the colors of the scene from *Revelation*. In fact, he specifically identifies in the score the colors that he intends.

Previous research by Jonathan Bernard (1986) focused on associating interval complexes and the modes of limited transposition with the colors that Messiaen identifies in his scores. The present study will focus on analysis of the recorded sound of the chords that he associates with colors. It will also show that certain modes possess characteristic spectral components regardless of their voicing and instrumentation.

2. THE EXPERIENCE OF THE SYNESTHETE

Synesthesia is the capacity of some persons to be able to experience a phenomenon with more than one sense. In the case of music, a listener will both hear the music and perceive patterns of colors (photisms) that correspond with the sounds heard. Messiaen is, presumably, one of those synesthetes who can experience a bi-directional sensory association. In other words, he was able to hear the sound of colors and notate the orchestral chords that corresponded with them (Messiaen, 1993).

Some synesthetes perceive photisms as spatially extended. They often describe their perception as a set of patterns localized somewhere in space in front of them, with patterns that may move from left to right as the sound changes. Whether the patterns are perceived as external to the body or an internal phenomenon is irrelevant, however, because the perception is real. It also is involuntary, memorable, different for each synesthete, and persistent. Throughout a synesthete's life, his or her color association with a particular sound will not change (Roberston and Sagiv, 2009).

Synethetes report a variety of photisms: thin lines, thick lines, parallel lines, curves, circles, spirals, etc. More than one photism may occupy the visual scene. Scenes with multiple colors may occur in various parts of the visual scene and move or dance among the photisms, or different colors may dissolve into a white connection (Campien, 2008).

Messiaen specifies not only colors and color combinations, but also their texture and gem-like character (e. g. *topaze jaune, chrysoprase vert clair, et cristal).*

3. FORMANT ANALYSIS

This study is based on the assumption that synesthetes who associate colors with sounds may base their association on their formant analysis of the sound. A person's ability to understand the

meaning of a natural language is a skill that is more universal than the ability to comprehend the structure and harmonic organization of musical sounds. To understand language, a listener must be able to recognize vowels. A large literature describes how listeners identify vowels in any particular language based on their position in a two-dimensional formant space. Except in extreme registers, vowel perception is generally independent of the fundamental frequency produced by a speaker for any vowel, but the formant structure of vowels produced by men and women differ to a certain degree, as do the structure of vowels in different languages.

4. METHOD

Speech Filing System (SFS) is a speech analysis software application that includes routines for formant analysis. In this research study, SFS is being used to analyze digital recordings of the chords identified by Messiaen as associated with colors, and data representing the first five formants of these sounds are plotted. Figure 1 shows that, during the duration of a chord, the formants vary dynamically, but only within a range that corresponds with the color or color combination. The variation of each formant can be plotted in a multi-dimensional space to observe where in that space each color falls.

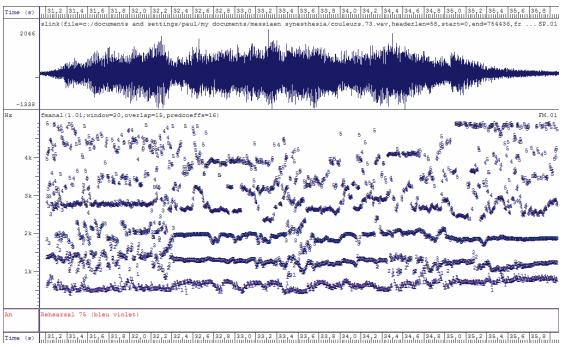


Figure 1: Formants at Rehearsal 75 for "*bleu violet*."

In Figure 2, the average value of each formant is plotted against its specified color or color combination. The colors are arranged by increasing values of F4, and the order is determined both by hue and by saturation. Although the order of the color combinations does not correspond with a spectral ordering, clusters of certain colors can be observed.

Figures 3 and 4 address Bernard's consideration of how the modes correspond with interval sets. Figure 3 consists of two voicings of the notes of mode 3, created with Sibelius. Figure 4 show the formant structure of the orchestral chords on the left, and of the synthesized chords on the right. With the exception of the lowest formant in the orchestra, some correspondence in the frequency of formants can be observed, but the strengths of formants varies with the voicings.

IDL Workbench Visualization Software was used to plot formants in three-dimensional space. Because the frequency interval or frequency ration of formants is somewhat unique for each color or color combination, plotting F1 x F2 x F4 is just as accurate as F1 x F2 x F3, but the former is used because it better separates colors in this three-dimensional space, and in many cases F4 varies less than the other formants, which establishes distinct planes for each color.

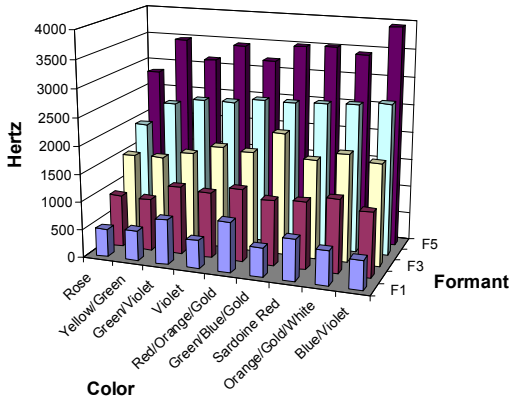


Figure 2: Messiaen's colors arrange by F4.

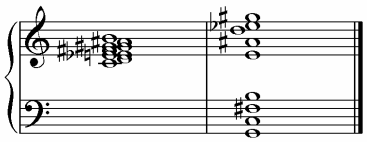


Figure 3: Notes of Mode 3 tightly packed and voiced in 4ths.

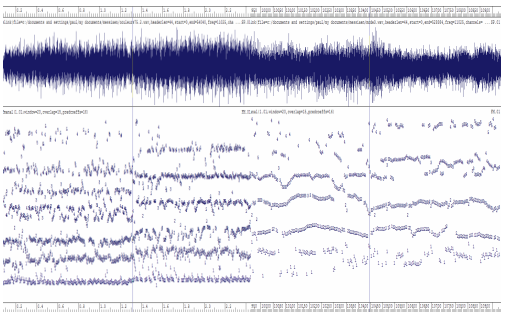


Figure 4: Orchestral chords using Mode 3 at Rehearsal 75+2, followed by the formants of the synthesized chords of Figure 2.

5. COLOR MODELS

Many color models have been developed to specify digital color production. One of these is the CIE L*a*b*, which specifies luminance values from black to white on the vertical axis, and two pairs of complementary colors, red and green on the a* axis, and blue and yellow on the b* axis.

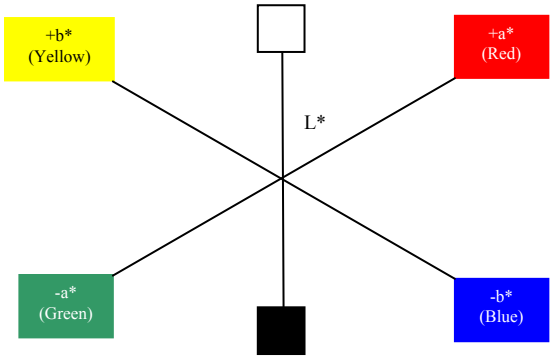


Figure 5: CIE L*a*b* color model.

Bruce MacEvoy (2008) describes how this and other models may be adapted to the artist's selection of pigments, and suggest the following artist's value wheel, which places specific pigments within the three-dimensional CIE L*a*b* color space.

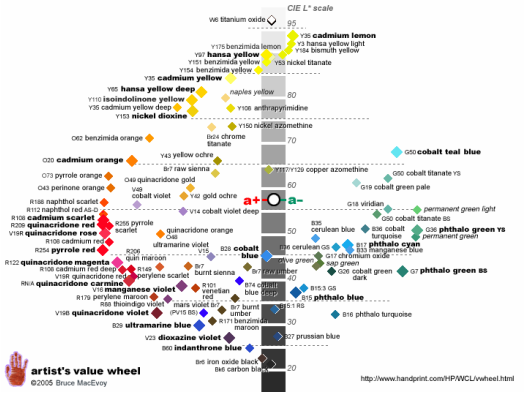


Figure 6: MacEvoy's artist's value wheel, ©2005 Bruce MacEvoy.

James Fulton (2001) proposed a model that describes visual perception, shown in Figure 7. The color plane in this diagram places perceived complementary colors equidistant from the origins of both primary axes. Consequently, the origin is not in the center of the color plane, and the color wavelengths that are paired on these axes are somewhat different from the CIE L*a*b* model.

In all of these models, saturation increases with distance from the origin. Chroma is related to the purity of the hue, which can be defined by the bandwidth of the color wavelength. On Fulton's diagram, e. g., a very small area of color would have a higher chroma value than a larger area that mixed hues and saturation values.

Both MacEvoy's and Fulton's models take into account the nonlinear aspects of visual perception.

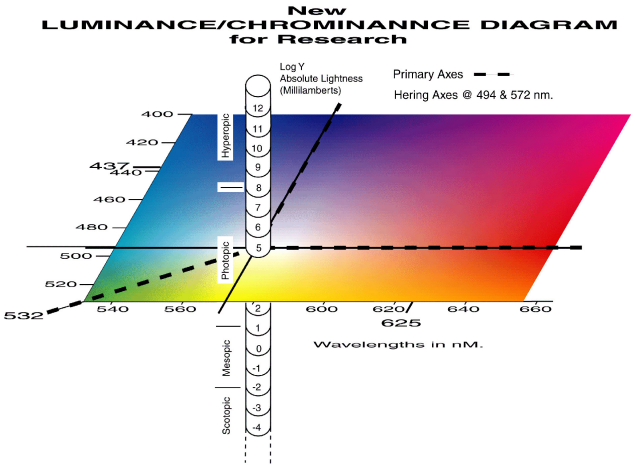


Figure 7: Fulton's Luminance/Chrominance Diagram for Research, ©2001 James Fulton.

6. MESSIAEN'S COLOR SPACE

The preceding color models were described to provide a context for the discussion of Messiaen's use of colors. In some cases, Messiaen specifies a single color (*sardoine rouge*), in other cases multiple colors (*topaze jaune* , *chrysoprase vert clair*). Some have greater luminance (*rose, mauve, et gris*), others less (*bleu saphir*). Of course, all of the color swatches are merely approximations of the gems and other textures that he specifies.

The following figures plot the F1 x F2 x F4 formant data for the orchestration corresponding to the specified color(s). The data forms a cluster of points that is plotted, for clarity, as the three-dimensional polynomial regression of the points. The data points fall within the rectangular surface and its degree of curvature.

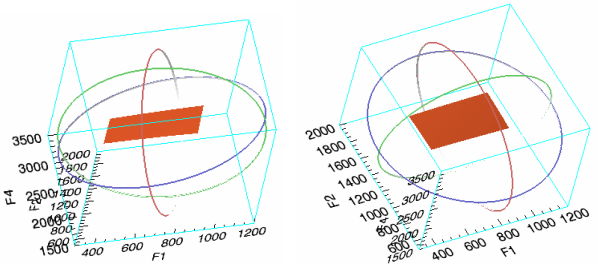


Figure 8: *Sardoine rouge.*

In Figure 8, the red color has a brownish tint. The perimeters for reds are oriented parallel to the F1 axis. Figure 9 shows the same red, as well as blue-violet. Note that the blue component is oriented parallel to the F2 axis, as suggested by Figure 5.

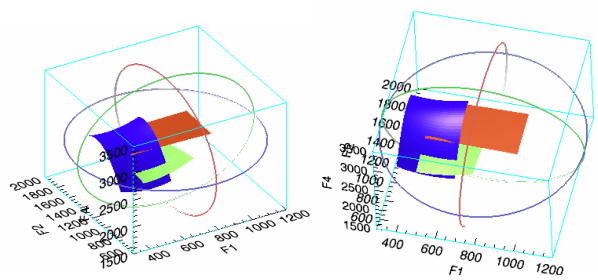


Figure 9: *Sardoine rouge, bleu-violet, jaune / vert.*

In Figure 10, the higher luminance of the rose and green/blue hues is reflected in the lower F4 values of these colors. Note that the green/violet hues show an orientation parallel to the F1 axis, which appears to correspond with the a* (red-green) axis of the CIE L*a*b* model. Both the green/violet and the green/blue/gold have smaller surface areas, which suggests a higher value of chroma.

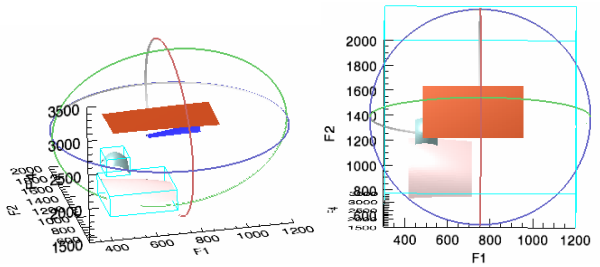


Figure 10: *Sardoine rouge, rose / mauve, vert / bleu / or, vert / violette.*

Figure 11 shows the orientation of related colors. *Rouge, taché de bleu*, the topmost surface, has orientations of both red and blue, and the curvature of blue-violet that was seen in Figure 9.

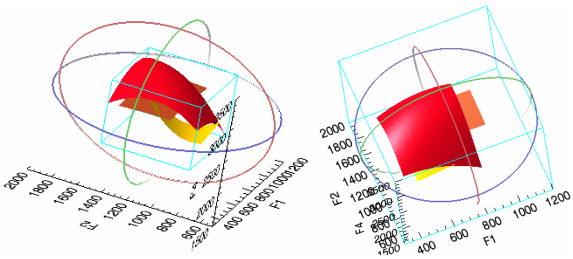


Figure 11: *Sardoine rouge, rouge / orange / or, rouge / bleu.*

7. CONCLUSIONS

The component pitch classes, interval spacing, and orchestration of each of the chords that Messiaen associates with a color generate a formant structure that defines a surface in F1 x F2 x F4 formant space. Examples of these surfaces are shown in Figures 8 through 11. Chords that might be considered “brilliant” in character correspond with higher F4 values. Those that have very stable formant structures over the duration of the chord have small surface areas in the F1 x F2 x F4 formant space. Chords that are more “dull” in character correspond with lower values of F4 and may also correspond with the higher luminance value of the specified color(s). Chords with more variable formant structures over the duration on the chord occupy larger surface areas in the formant space.

The current research is a first step toward better understanding Messiaen’s color space. It does not provide sufficient data to show direct correlations between the F1 x F2 x F4 formant space and a perceptual space such as Fulton’s, which attempts to model visual perception. It also does not explain the nonlinearities within Messiaen’s space. The fact that it is not possible to imagine the specific colors and the way that they blended in the photism’s in Messiaen’s experience of these colors makes it difficult to make direct colorations between the specified colors and the formant space. Nevertheless, this research demonstrates that the color / sound associations are not arbitrary, but do follow principles of color theory and are related to existing color models. Clearly, Messiaen’s ability to associates sounds with colors in a way that maps formant space with color space demonstrates that the unity of his perception with the two senses and the consistency of his sensory associations.

8. REFERENCES

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