THE VISUALIZATION OF TONALITY THROUGH COLOR IN THE ANIMATIONS OF STEPHEN MALINOWKSI

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Introduction

Generations of composers, artists, and even scientists have been fascinated by a potential link between color and music. Though only a small portion of the population actually experiences color and music as a single sense, the prevalence of the color/music metaphor suggests that the association of these two media does speak in some way to our collective experience. In particular, there appears to be a desire to directly associate color and pitch through some one-to-one mapping between the two media. Such a mapping from color to pitch (or vice versa) has the interesting byproduct—whether intentional or not—of allowing us to visualize the interaction of pitch hierarchy, which I am defining broadly as tonality. Tonality is perhaps the most ineffable quality of music and yet also one of its most important organizational principals. By allowing us to "see" tonality, color/music mappings reveal a whole new world of musical structure hidden just beneath the surface of what we normally hear. Unfortunately, few color/music theories have actually been realized in the production of multimedia artwork and even fewer exists in a format that is readily accessible today. The work of Stephen Malinowski represents a significant exception in both its abundance and availability. Furthermore, Malinowski has often used color explicitly for the visualization of tonality and has been very self-conscious about his methods for doing so. For this reason, his work is an excellent case study in the possibilities, limitations, and benefits of using color as a means of visualizing tonality.

An Overview of "Harmonic Coloring"

Stephen Malinowski uses a system he calls "harmonic coloring" to visualize tonality. In this system, the twelve scale degrees of the chromatic scale, arranged in a circle of fifths, are mapped to twelve equally-distant colors on an additive or RGB color wheel (See figure 1 below). In the additive color system, which is used for digital color, the "primary colors" (colors that "cannot be broken down any further and are the principal ingredients that make up all other colors") are red, blue, and green.[1] By mixing these three primary colors in equal amounts, three "secondary colors" are created.[2] Mixing each primary color in turn with the two secondary colors on either side of it makes six "intermediate or tertiary colors.[3] Each pair of adjacent and almost adjacent colors (colors separated by no more than one color) on the wheel are thus directly related to one another. Colors on opposite side of the wheel from one another are maximally contrasting and are known as "compliments."[4]

Many of these color relationships do not have exact analogs on the circle of fifths, but similar concepts do exist. Any two adjacent pitches on the circle of fifths are related by the interval of a perfect fifth or perfect fourth. Keys in this relationship share the maximum number of common tones and are usually termed "closely related," which is somewhat analogous to the relation between adjacent colors on the color wheel. Also like the color wheel, pitches across from one another on the circle of fifths are related by tritone. Keys that are related this way share the smallest number of common tones possible (2). There are no direct analogies in the pitch world to primary, secondary, and tertiary colors however.

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[1] Steven Bleicher, *Contemporary Color: Theory and Use*, 2nd ed. (Clifton Park: Cengage Learning, 2012), 66 & 107.

[2] Bleicher, *Contemporary Color*, 66.

[3] Bleicher, *Contemporary Color*, 66.

[4] Bleicher, *Contemporary Color*, 72.

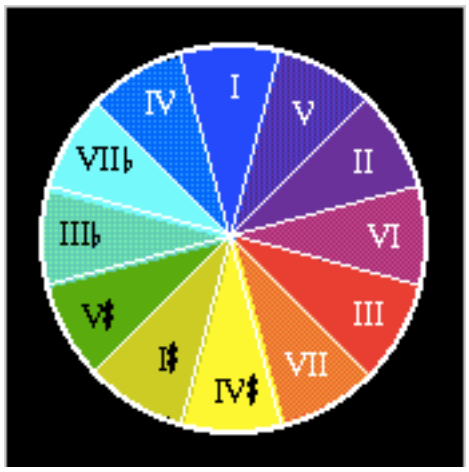

Figure 1. Malinowski's harmonic coloring wheel[5]

Malinowski chooses to align the color and pitch wheels in a very specific way for psychological reasons: "I've assigned blue to be the 'home pitch' (the ***tonic***, notated Roman numeral 'I') because that seemed the most 'settled,' and chosen the blue-toward-red direction as the I-toward-V direction because motion toward the ***dominant*** ('V') seems more 'active' compared with motion toward the ***subdominant*** ('IV')."[6] Note that closely-related and complementary colors retain their spatial orientation to one another (adjacent and directly across respectively) regardless of which color is placed at the "12 o'clock position" or the direction in which the colors proceed. Thus, a clockwise progression from blue to yellow produces the same color *relationships* (meaning the same colors remain adjacent to, and across from one another), but not color successions, as a counterclockwise progression from green to violet.

Malinowski's use of scale degrees rather than pitch classes in his harmonic coloring system is especially noteworthy. Using scale degrees requires the designation of a single pitch class as a reference point. All other pitch classes then receive their color assignments based upon their respective distances from this reference pitch class on the circle of fifths. As demonstrated

[5] Stephen Malinowski, "Harmonic Coloring: A Method for Assigning Colors to Musical Pitches" http://www.musanim.com/HarmonicColoring/

[6] Malinowski, "Harmonic Coloring," (bold in original).

by the Roman numerals in figure 1, this reference pitch class is the global tonal center of the entire piece of music being visualized. This means that the reference pitch class, and thus the specific pitch class to color mapping, varies from piece to piece. But because this mapping is based upon scale degrees, the relationships among these pitch classes *always* remains the same. That is to say that, whether C, $F^{\#}$, or B is assigned to I/blue, the pitch classes C and G (and any other pitch classes related by perfect fourth or perfect fifth) will always occupy adjacent spaces on the color/pitch wheel.[7]

Malinowski's system could thus be thought of as a visual analogue to the movable-do solfege system of solmization in which the tonic is always assigned the syllable *do*, regardless of what pitch class that tonic is. Unlike the movable-do system, however, Malinowski keeps this referential pitch class constant throughout the entirety of each piece, *even when modulations to other keys occur*. By so doing, Malinowski makes possible the visualization of large-scale tonal movements within a piece of music. And yet, by mapping from scale degrees (rather than pitch classes) to colors, Malinowski allows this relationship between color and tonal function to remain consistent from one piece to another.

The consistency of Malinowski's harmonic coloring from piece to piece resembles the way we hear and theorize about music. Let us consider the song *Happy Birthday* as an example. Since this song is often performed without instrumental accompaniment, its tonal center varies more from performance to performance than perhaps any other tune. In fact, it is quite often sung in the "cracks" between the frequencies defined for each pitch, meaning that it is technically not in any "key" at all. Yet I would argue that no matter how out of tune with A 440 the performance might be, or how sharp or flat we might drift over the course of the song (possibly even ending in

[7] Both the twelve pitch classes and the twelve equally-distant colors associate with themselves and each other in this way because they can both be mapped to the same geometrical shape (a twelve-hour clock) and thus behave in the same way.

a different "key" than we began), no one would ever claim that we did not sing *Happy Birthday*. This is because the identity of a piece of music lies not in the actual pitches themselves, but rather in the *relationships* (or intervals) between them. As long as these relationships between pitches are preserved, a piece of music may be transposed to any key and still be considered (for all intents and purposes) the same piece.

Similarly, (in equal tempered tuning), a V-I cadence contains the same intervallic relationships regardless of the key it is played in.[8] It is only because of this fact that we are able to generalize harmonic function with Roman numerals and directly compare harmonic successions in various keys. Otherwise, we would have to classify each harmonic progression in terms of the key in which it occurs.

Malinowski's system of harmonic coloring allows for this same generalizability across pieces. In a color system where *pitch classes* are mapped to specific colors, we would be forced to "transpose" the color successions of one piece into the color of another in order to compare them. In such a system, red and orange might represent C and G (for example), regardless of those pitches' relation to the global tonic. The viewer or analyst would thus have to track the color changes and then relate them back to the key of the piece. For a piece in F major, red and orange would represent dominant and supertonic. For a piece in G major, however, these same colors would represent subdominant and tonic. And so on. This might result in a mental process something along the lines of: orange = G, G = some relation to the tonic *for that specific piece*. Malinowski's system, in contrast, eliminates a step in this process: orange = the seventh scale degree in relation to the tonic *for any piece*. This system is thus much like a kind of color Roman numeral analysis, which makes it a valuable analytical and pedagogical tool.

[8] This would not be the case on an instrument tuned with "meantone temperament," in which case a V-I cadence in C major and $F^{\#}$ major would sound drastically different.

I am not suggesting, however, that one should be able, or even try, to use harmonic coloring to perform harmonic analysis in real time simply by identifying the colors. This would likely be far more difficult than simply identifying harmonies by following along in the score and would be of little benefit since color seems a rather poor way of communicating much of the other information provided by standard notation. What I am suggesting is that harmonic coloring's great strength lies in its generalizability, which allows us to take what we learn from one piece and apply it to another.

An Analysis of the First Movement of Prokofiev's *Classical Symphony*

To see how Malinowski's harmonic coloring system works, we turn now to the first movement of Sergei Prokofiev's *Classical Symphony*, visualized by Malinowski on April 2, 2017.[9] As would be expected given the title of the symphony, the first movement fits well within the sonata form paradigm established by the music of Mozart and Haydn. Part of what makes the piece so charming, however, is the way in which Prokofiev plays with the implications and expectations that come along with the classical tradition. One of Prokofiev's most significant modifications of the sonata paradigm is in regard to tonality. Over the course of the movement as a whole, Prokofiev conforms to the expected I-V-I tonal motion, reaching the dominant by the second theme of the exposition and resolving it to the tonic in the recapitulation. In between these harmonic checkpoints, however, Prokofiev takes the listener on a wild journey of unprepared modulations through distant keys, often slipping into the "correct" key at the last possible moment. These tonal motions are a very important facet of the piece, and much of the subtlety of the movement as a whole is lost on the listener who is unable to track the shifts in tonal center. Malinowski's system makes such tonal awareness possible.

[9] Stephen Malinowski, "Prokofiev Classical Symphony, 1st Mvt.," *YouTube* video, 4:40 posted by "Smalin," April 2, 2017, https://www.youtube.com/watch?v=6Z7HsXOW6Zw

By "stacking thirds" using the scale degree to color mappings shown in figure 1, we construct the twenty-four consonant "color triads" that may function as tonal centers in common-practice tonal harmony. These color triads are depicted in figure 2. The roots of triads that belong to the same major key occupy six hours of contiguous space on the clock face (see figure 3). Thus, while it is difficult to identify specific triads or keys as they flow by in real time, it is still quite possible to notice when these harmonies or keys change simply by noticing the changes in the types of colors that are present. Note also that, while sometimes cumbersome, Malinowski's assignment of color to individual notes (rather than chords or key centers) allows for the differentiation of both parallel and relative major and minor triads and keys.

Major Triad	Color			Minor Triad	Color		
I				i			
I#				i#			
II				ii			
IIIb				iiib			
III				iii			
IV				iv			
IV#				iv#			
V				v			
V#				v#			
VI				vi			
VIIb				viib			
VII				vii			

Figure 2. The 24 consonant "color triads"

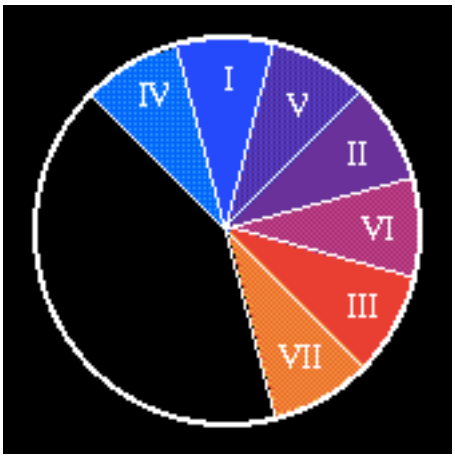

Figure 3. The seven notes of a single major key on Malinowski's harmonic coloring wheel[10]

The first movement of Prokofiev's symphony begins with a rapid flourish of arpeggios outlining the tonic triad (D major). This event is visualized from 0:04-0:07. It is not imperative that we recognize that these colors correspond to scale degrees I, III, and V and thus belong to the I color triad. Instead, we should use this passage as an opportunity to establish a "visual tonal center" from which we can compare all other triads and key centers. The large tutti chords played fortissimo help to hammer home the key center. Prokofiev uses gestures like this several times as a means of establishing a new key center, and this makes these modulations particularly noticeable when visualized with harmonic coloring.

The expected modulation to the dominant for the second theme group occurs at rehearsal 6, corresponding to 1:01 in the video. Visually, we can notice this modulation by the increased presence of orange and yellow at this point, corresponding the mediant and leading tone respectively of this new key. With this in mind, we can look backward and see the beginnings of this modulation at rehearsal 4 (0:48 in the video). We attain closure on the dominant with a PAC at rehearsal 10 (1:39) and remain there until the end of the exposition just before rehearsal 12 (1:55).

[10] Malinowski, "Harmonic Coloring."

The development spans rehearsals 12-19 (1:56-3:06). During this time, modulations occur frequently and rapidly, often to very distantly-related keys. The harmonic instability is visualized by the rapid shifts of color, and tonal dissonance is visualized by the close proximity of contrasting colors (colors opposite each other on the color wheel). We can also sense our "distance" from the tonic during this time by the frequent presence of colors on the yellow, green, and cyan end of the color spectrum.

One particularly clever moment occurs at the beginning of the recapitulation. As expected, the primary theme, complete with its introductory triadic flourish, returns at the beginning of the recapitulation (rehearsal 20, 3:07), but the thematic return is not accompanied by a concomitant tonal return. Instead, as the visualization makes clear at 3:07, we find that we are still in a distantly-related key. The "real" tonic does not return until the second phrase of the primary theme at rehearsal 21 (3:19). This actually recalls a very curious moment from the exposition (rehearsal 1, 0:17) when an abrupt modulation to C major (VIIb) is wedged between the first and second phrases of the primary theme. This chromatic parenthesis repeats the primary theme's first phrase before modulating back to the tonic to continue with the second phrase. By comparing the colors found at 0:17 and 3:09, it becomes clear that the recapitulation actually begins from this chromatic diversion rather than from the beginning of the exposition. But because of the tonal motion built into this passage as it appears in the exposition, Prokofiev is able to use it here as a very natural transition back to the tonic.

Without the visualization, it is very unlikely that a listener without absolute pitch would notice that the recapitulation begins in the "wrong key." In fact, it is likely that we would actually perceive the "wrong key" as tonic, and thus understand the modulation to the tonic as a modulation to a new key. I myself find that I am still fooled by Prokofiev's trick even though I

am fully aware of what is happening! With Malinowski's harmonic coloring, however, the colors provide me with a point of reference that allows me to actually perceive that this is not the correct key. And this is why I believe harmonic coloring is such a valuable pedagogical tool.

Some Drawbacks to the Harmonic Coloring System

While I find Malinowski's harmonic coloring system to be very effective in many ways, there are still some significant deficiencies and drawbacks. The first and probably most apparent difficulty is that—for the vast majority of Malinowski's visualizations—every single pitch is visualized. In his most traditional "scrolling piano roll" style of notation, this results in an enormous amount of color that often moves by quite rapidly (especially for an orchestral score like the Prokofiev symphony). This can be very overwhelming for the viewer. I find that multiple viewings of the same work can be very helpful in combatting this problem. Another strategy is to listen for points of structural articulation (like cadences) and note the colors that appear and these points. The large tutti chords that occur often in the Prokofiev are good examples of this. No matter what techniques we might use, however, there is still a lot of information to take in. Much of it, in fact, is redundant for the visualization of tonality; less information could provide us with the same tonal picture. But we must remember that Malinowski is after more than just the visualization of tonality. He wants us to see tonality as it interacts with many other musical parameters.

A related problem is that it can often be quite difficult to identify the exact colors being presented. This results largely from the fact that many of the colors are so similar to one another. Furthermore, the pitches are usually oriented in vertical space relative to their register, meaning that pitches in different octaves will often be quite far apart on the screen. This distance can often make different colors appear the same or vice versa. The viewer may also have difficulty

determining if two colors would be adjacent on the wheel or if there would actually be another, more closely-related color in between. I-II and I-V are often nearly impossible to distinguish.

To combat these two problems, Malinowski has created a visualization in which the music is presented on the harmonic coloring wheel rather than in registral space.[11] This drastically reduces the number of colors that appear in the visualization because it causes doubled notes to be mapped to the same triangle on the circle. The problem of color identification is eliminated by adding a spatial dimension to the visualization. In fact, this effectively eliminates the need for the color altogether since the spatial relationships convey the same information. Because the "musical past" continues to be visible as it gradually fades into the background of this visualization, we are also able to track tonal changes over the course of the whole movement. This technique does not show register, however, and thus completely obliterates any concept of musical line. While potentially useful for visualizing tonality and form, this visualization does not convey much else.

Another issue with the harmonic coloring system in general is that fifth relationships are not quite as significant for pitch as they are for chords or key centers. It thus seems a bit arbitrary and even misleading to say that the root and fifth of a triad are more closely-related than the root and third. This problem becomes compounded when we construct the color triads seen in figure 2. In every case, the third of the triad is a substantially different color than the root and fifth. While not necessarily a problem, this does create an unintended visual accent on the third of the triad. One potential solution for this problem would be to map the color wheel to the "key spanning circle of thirds," which places all the members of a triad

[11] See Stephen Malinowski, "Kodály, String Quartet No. 1, 3rd Movement," *YouTube* video, 4:23, posted by "musanim," March 18, 2016. https://www.youtube.com/watch?v=-lNhkEgdrmo&index=62&list=UUszyXm5HcAwxVSGeeHQscQg

adjacent to one another.[12] This system was intended for use with triads or key centers rather than individual pitches, however, which would make it nearly impossible to differentiate pitches belonging to the same triad and also create the peculiar problem of having two locations for each pitch. Visualizing whole triads or key centers is arguably a much more effective way to visualize tonality, but it loses much of the detail provided by Malinowski's visualizations in the process. While Malinowski's harmonic coloring is arbitrary in many ways, as any visualization of tonality is bound to be, I do think that it offers a working compromise. Perhaps it is not the most effective visualization of tonality in isolation, but it does allow us to see tonality along with many other musical parameters like texture, melody, register, etc. Rather than abstracting a single parameter for closer inspection, then, I believe Malinowski's visualizations allow us to see the *music as a whole,* to understand the way that many different parameters all work together to create an aural experience.

Conclusion

Every visualization is a metaphor in action. What a musical visualization shows us, then, is the arbitrarity and often ineffectiveness of many of our musical metaphors. We have seen for ourselves that space and distance are actually rather poor metaphors for music. No matter how far "apart" two pitches or key centers might be registrally or tonally, there is never actually any movement in physical space unless the location of the sound source changes.[13] The "distance" between two tonal centers is really a matter of the number of common tones shared between the two keys. Harmonic coloring actually provides a rather strong metaphor for tonality in this sense by allowing us to see the number of tones (colors) that are shared by two keys.

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[12] See Peter Ciuha, Bojan Klemenc, and Franc Solina, "Visualization of Concurrent Tones in Music with Colours," https://pdfs.semanticscholar.org/2918/6e8b06573e1b3cb23be51d01b29ca734ac8f.pdf.

[13] See Lawrence M. Zbikowski, "Metaphor and Music Theory: Reflections from Cognitive Science," *Music Theory Online* 4, no. 1 (1998) http://www.mtosmt.org/issues/mto.98.4.1/mto.98.4.1.zbikowski.html.

Closely-related keys will share all but one of their colors, while distantly related keys might not have any colors in common.

I believe that this allows us to perceive tonal motion across large spans of music. Speaking for myself (as someone without absolute pitch), I find that I have very little trouble identifying aurally *when* a modulation takes place. But what I cannot hear is *how* this new key relates to the previous one, much less the "global tonic" of the whole piece. It seems that my ear adapts to the new key almost as soon as the old one disappears. I can hear the new key, but my ear is missing the reference point of an absolute pitch with which to compare the new key. This means that most, if not all, of the large-scale tonal relations that make up the structure of tonal music are *totally* lost on listeners like me.[14] As I noted earlier, I find that even my analytical knowledge that the recapitulation of Prokofiev's *Classical Symphony* begins in the "wrong" key does not alter my experience of this key as tonic. No matter how hard I might try, I cannot keep my ear from being fooled because I am missing a piece of experiential information. By associating the music with a visual element that is (at least relatively) easy to identify, Malinowski provides us with this missing piece of information; he essentially allows us (if only for that piece of music) to have an approximate experience of absolute pitch, and, by so doing, finally allows us to experience for ourselves the tonal relationships that are so important for the structure and organization of tonal music.

[14] See Morwaread M. Farbood, "Memory of a Tonal Center After Modulation," *Music Perception* 34 no. 1 (2016): 71-93, Doi: 10.1525/m.p.2016.34.1.71; Elizabeth West Marvin and Alexander Brinkman, "The Effect of Modulation and Formal Manipulation on Perception of Tonic Closure by Expert Listeners," *Music Perception* 16, no. 4 (Summer, 1999): 389-407, http://www.jstor.org/stable/40285801

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