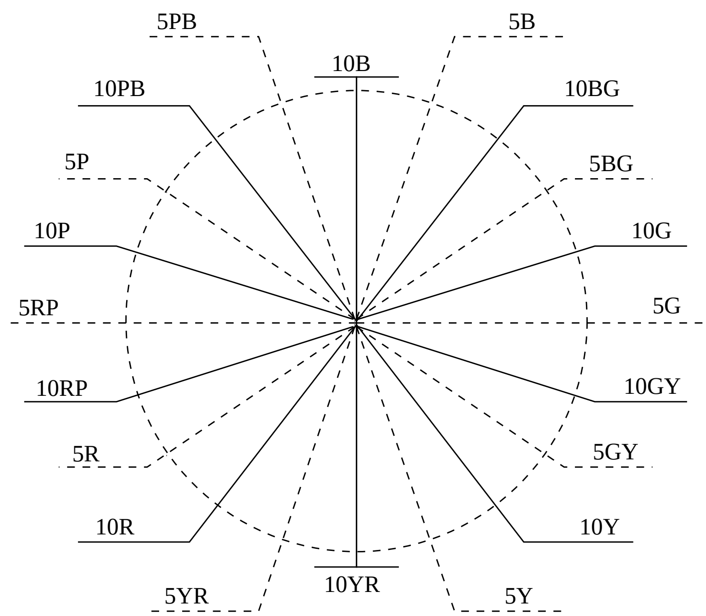

Figure 1: The Munsell Circle of Hues

Φ and Color

The discovery of musical consonances is generally, in the west at least, attributed to Pythagoras who observed that the division of a stretched string, according to simple integer ratios, gave rise to the musical intervals of an octave, perfect fourth, and perfect fifth. Though this notion of consonance is supported by what we know about the physical nature of sound (overtones etc.) it is not self evident that what the mind perceives as consonant be directly related to a physical description of the medium in question and there is no reason to assume that consonance, when it comes to color, will be describable by direct analogy to a physical description of light.

Complimentary colors

Unlike sound, the perception of color can not be simply defined in terms of wavelengths. In an experiment first performed by Edward Land[1], he demon-

[1]a dual camera was loaded with black and white film and a long and short wavelength record was made by using a long wavelength filter on one lens and a short wavelength filter on the other. The transparencies were then superimposed on a screen using two projectors, also outfitted with filters, so that the long wavelength record was illuminated with a slightly longer wavelength of yellow light then the short wavelength record. The result, the projected image was seen in approximately all its' original colors, though the

strated that the world of color exists not only within the bounds of the visual spectrum as discovered by Newton, but within any part of it. The same cannot be said of music. While one could certainly construct a microtonal scale, such that the relative spacing of its' notes was the same as that for a scale which spanned an octave, to do so would alter the relation that the notes of such a scale have with the tonic and thus affect their consonance.

In what is primarily an extension of Edward Lands' work, McCann,McKee, and Taylor performed a experiments, using the Munsell System(see Figure 1), which clearly showed the relation between compliments in terms of equal perceptual intervals. To eliminate the chance of a preconceived notion of color being associated with a known object an abstract patchwork of colors called a Color Mondrian was used. In each experiment the illumination on the Color Mondrian was adjusted so that the triplet of radiances that came from the grey area in the grey experiment came from the blue area in the blue experiment, the red area in the red experiment etc. Their results (Table 1), like Land's, show that color cannot soley be described on the basis of a physical description of light. For example, in the red experiment the perception of red remains essentially the same for different triplets of radiances (2.5R in the grey experiment, 5.0R in the red experiment). An interesting aspect of these experiments, not commented on in their paper, is the changing perception of the grey area where the compliments seem to appear. The relation between a color and its' compliment is represented, in Table 2 by the degrees of seperation between them on the Munsell Circle of hues and follows directly from Table 1. In the red experiment, for example, the red area appears as 5.0R and the grey area is perceived as 10.0G and the degress of seperation between them is 198^{o}[2]. The first 13 intersections that result when when $\sin\theta$ and $\sin\Phi\theta$ are graphed together and when $\sin\theta$ and $\sin\Phi^{-1}\theta$ are graphed together are given in Table 3 and Table 4, respectively. A quick inspection of both tables indicates that the results comes close to those in Table 2 when the adjusted values for the 3rd and 4th intersections in each table are considered.

light reflected from the screen was only yellow and a color photograph of it failed to show any color.

[2]counter-clockwise seperations are also given in the last column, eg. $360^o - 198^o = 162^o$

The enumeration of the integers is at the heart of musical consonance and is based upon the addition of things of like kind, whereas an enumeration based on Φ can be thought of as involving things which differ with respect to each other but which are related with respect to some whole. Of the two, the latter is closer, in spirit at least, to the observation that the world of color can exist within any portion of the visual spectrum. The fact that Φ can be used to describe the relationship between compliments suggests that it might make a good candidate upon which to base a language that encompasses both music and color.

area in mondrian	*experiment*				
	grey	red	blue	green	yellow
N 1.25/	N 1.5/	N 1.75/	N 1.75/	N 1.75/	N 1.75/
N 5.75/	10.0YR 6/1	7.5G 6/2 (207)	5.0YR 6/1 (207)	5.0RP 5/2 (162)	10.0PB 5/4 (153)
N 6.75/[a]	5.0YR 6/1	10.0G 7/1 (198)	5.0YR 6/1 (207)	7.5RP 6/2 (153)	10.0PB 6/4 (162)
N 9.6/	10.0R 9/2	5.0G 9/1 (216)	2.5YR 9/2 (216)	7.5RP 8/4 (153)	2.5P 8/4 (162)
10.0RP 6/10 (red area)	2.5R 6/10	5.0R 6/6			
2.5PB 6/8 (blue area)	2.5PB 6/8		2.5PB 6/4		
2.5G 7/6 (green area)	10.0GY 7/6			10.0GY 7/4	
5.0Y 8.5/10 (yellow area)	5.0Y 8.5/12				5.0Y 8/8

[a] this is the grey area used in the grey experiment

Table 1: summary of results as reported by McCann,McKee,and Taylor.

experiment (area examined)	*perceived color* in grey experiment	in current experiment	perceived compliment	degrees of seperation clockwise/counter
red	2.5R	5.0R	10.0G	198/162
blue	2.5PB	2.5PB	5.0YR	207/153
green	10.0GY	10.GY	7.5RP	153/207
yellow	5.0Y	5.0Y	10.0PB	162/198

Table 2: relation of compliments

intersect number	degrees of intersection	adjusted degrees of intersection	difference[3]
1	0	0	-
2	68.75388	68.75388	68.75388
3	206.26164	206.26164	
4	343.76941	343.76941	
5	481.27717	121.27717	
6	582.49223	222.49223	101.21506
7	618.78493	258.78493	36.2927
8	756.29270	36.2927	
9	893.80046	173.80046	
10	1031.30823	311.30823	
11	1164.98447	84.98447	133.67624
12	1168.81599	88.81599	3.83152
13	1306.32375	226.32375	

Table 3: intersects from $\sin\theta$ and $\sin\Phi\theta$

intersect number	degrees of intersection	adjusted degrees of intersection	difference[4]
1	0	0	-
2	111.24611	111.24611	111.24611
3	333.73835	333.73835	
4	556.23058	196.23058	
5	778.72282	58.72282	
6	942.49223	222.49224	163.76941
7	1001.21506	281.21506	58.72283
8	1223.70729	143.70729	
9	1446.19953	6.19953	
10	1668.69177	228.69177	
11	1884.98447	84.98447	216.2927
12	1891.18400	91.18400	6.19953
13	2113.67624	313.67624	

Table 4: intersects of $\sin\theta$ and $\sin\Phi^{-1}\theta$