Shadow Colours for Painters

Paul Centore

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Abstract

This article presents a simple, practical method for painting realistic shadow colours. The method involves the Munsell colour system. A straight line is drawn on the Munsell hue leaf, whose hue is that of the object being painted. The line starts at the Munsell specification of the object's colour (when viewed in full light), and ends one value step below N0, on the neutral axis. The colours on this line are the colours of the object in various degrees of shadow. The Reilly paint mixing approach is presented as an intuitive way for a painter to mix these colours. A step-by-step shadow painting demonstration is given, using readily available materials. Although presented non-technically here, the method has a technical basis, which has been published previously.

Introduction

A realistic painting depicts scenes or objects by reproducing the visual stimuli they would present to a viewer. In any ordinary setting, some parts of an object will receive more light than other, more shaded parts, so a realist painter cannot avoid considering shadows. In a black and white painting or drawing, the shadowed parts of an object are a darker grey than the more strongly lit parts. In a realistic painting in colour, there is also a relationship between the shadowed and lit parts. This article will use the Munsell system to describe that relationship, and suggest a practical paint mixing method to produce shadow colours.

Like many artists' working methods, the procedure starts with some idealizations and assumptions, which the artist then refines. For example, a sculptor might conceive of a human neck as a cylinder [1], and attach a roughly cylindrical chunk of clay to an armature. Later, he will refine the cylinder by adding bulges for the sterno-mastoid muscles and the Adam's apple, hollowing out the pit of the throat,

and so on. Similar simplifying assumptions were made in deriving the shadow colour procedure [2,3].

One assumption is that the local colour of an object being represented does not vary. Like the cylindrical approximation, this assumption is not an exact statement. An object such as an apple might be predominantly red, but likely has many flecks or areas of other colours. A painter would first paint the entire apple loosely with the light and shadow colours (to be described in this article) corresponding to the dominant red. Then he would work back into the wet layer of paint, mixing in bits of purple or brown, or other local colours that occur on the apple, taking account of their differences in light and shadow, too. Progressively finer distinctions would be made until the desired detail and finish were reached.

Artists usually divide shadows into *form* shadows, which occur because the shadowed part faces away from the light source, and *cast* shadows, which occur when another object blocks light from reaching the shadowed part. The colorimetric analysis of form and cast shadows is identical, and the method in this article applies equally well to both kinds.

The procedure discussed in this article usually produces adequate results, but some technical limitations should be kept in mind. First, the method assumes a neutral, approximately white, light source, such as indirect daylight. Strongly tinted light sources can cause noticeable changes in the hues of shadows. At sunset, for example, sunlight is much redder than it is during most of the day. The shadows on a white object, such as the pages of a book, can actually look blue at sunset, rather than the grey that would be expected. Second, the method assumes that the object to be painted has a matte finish. If the object has a glossy surface, then light from some directions might be reflected as off a mirror, which will affect colours. A third factor is light that is reflected off nearby objects of different colour. If a red cube were placed near the shadowed side of a blue cube, for example, then some red light could reflect into the blue shadow, lightening it and altering its hue. In practice, it will be found that most of these exceptions are easily recognized and adjusted for. Furthermore, even in a realistic painting, there is some latitude when painting shadow colours. And, of course, a painter is free to bend rules for expressive effect. The method of painting described in this article is a general-purpose approach, that, in most cases, quickly and easily produces acceptably realistic shadow colours.

1 The Munsell System

The Munsell colour system is a colour classification and specification system that is tailored for painting and the visual arts. It was developed by the American painter

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and teacher Albert Munsell, at the start of the 20th century, as an educational tool. Early versions of the system were collections of hand-painted swatches, which were used as physical standards for judging other colours. A major advance was the 1943 Munsell renotation [4], which superseded previous versions, and is the standard today. The renotation used thousands of visual assessments of paint samples, by 41 human observers, to provide a firm empirical basis for the system. In addition, the renotation specified a set of 2,745 Munsell colours scientifically. A paint swatch can be measured with a spectrophotometer, and its colour can be specified objectively, in terms of three coordinates. Any two swatches with the same three coordinates, even if they are made from different paint mixtures, will have identical colours. By interpolating between the 2,745 specified colours, any surface colour can be located. The Munsell renotation extends to theoretical limits, providing specifications for colours, such as very intense reds, that have never been produced in paints or inks. The scientific specification is an important factor for us, because it allows shadow colours to be calculated.

Even without understanding the science behind the Munsell system, painters can still use it profitably, because it is based on natural colour perception. The Munsell colour system classifies surface colours by three perceptual attributes that are basic to painting: hue, value and chroma.

Hue is universally understood. It says whether a colour is red, yellow, purple, etc. Munsell designates 10 basic hues: R (red), YR (yellow-red, or orange), Y (yellow), GY (green-yellow), G (green), BG (blue-green), B (blue), PB (purple-blue), P (purple), and RP (red-purple). Each basic hue is further subdivided into 4 steps, denoted with a prefix. For example, the four greens are denoted 2.5G, 5G, 7.5G, and 10G. 2.5G is a yellower green, that is closer to GY than it is to BG. 10G is a bluer green, that is closer to BG than it is to GY. A prefix of 10 is sometimes replaced with a prefix of 0 and the next hue. For example, 10G is sometimes written 0BG. In all, then, the Munsell system specifies 40 hues (4 steps for each of the 10 basic hues). These 40 hues are equally spaced perceptually. For example, the hue difference between 2.5G and 5G is the same size as the hue difference between 5G and 7.5G. The 40 hues are discrete stopping points on a continuous hue circle. One could interpolate any desired amount between two adjacent hues. For example, the hue 6GY is a yellowish green that is between 5GY and 7.5GY, but closer to 5GY. White, black, and greys are not considered hues in the Munsell system. An N, for "neutral," is used to designate them.

Many different colours can have the same hue. Figure 1, for example, shows the "hue leaf" for 6GY, a set of colours all of which have hue 6GY. The different colours within a hue leaf are specified further by value and chroma. The empty boxes

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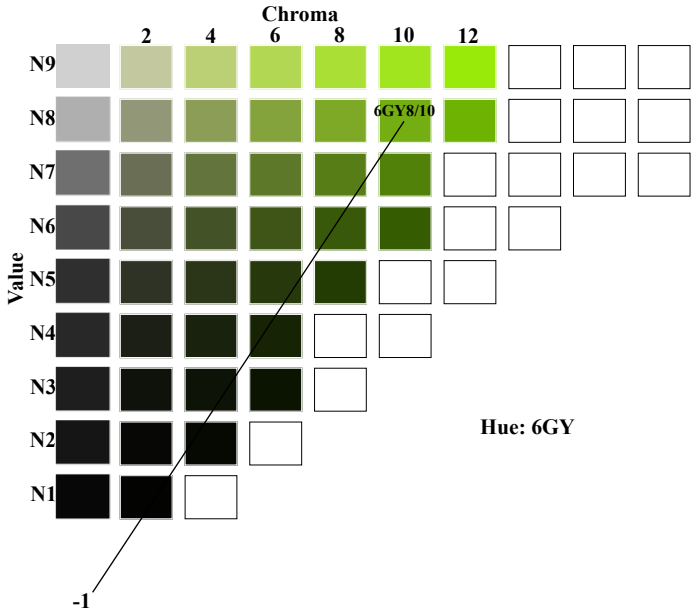


Figure 1: The Hue Leaf for 6GY in the Munsell System

indicate colours that are in the Munsell system, but that are beyond the gamut of the printing process used to produce the figure.

Munsell value designates how light or dark a colour is. The theoretically darkest black has a value of 0, and is denoted N0. The theoretically lightest white has a value of 10, and is denoted N10. N0 and N10 are theoretical ideals, that actual paints approach, but have so far not reached. Most artists' blacks, such as carbon black, are about N1, rather than N0. Similarly, titanium white is just below N10. Between N0 and N10 are 9 progressively lighter greys, denoted N1, N2, and so on up to N9. The spacing between the greys is perceptually equal. All colours have a Munsell value, not just the neutrals. For example, there are light blues and dark blues. A blue with value 8.5 has the same lightness as N8.5.

Munsell chroma refers to how intense, or saturated, a colour is. For example, a lemon is an intense yellow, while masking tape is a dull yellow. A dull colour is closer to a neutral grey than an intense colour. The Munsell system denotes chroma numerically. Greys have chroma 0. A colour with a chroma of 10 is generally perceived as saturated, and it is rare for paints to have chromas greater than about 16. Colours of low chroma, say 4 or less, are perceived as subdued, with a high grey content. It is often difficult to distinguish the hue of low-chroma colours. For example, one cannot say readily whether masking tape is more yellow or more orange.

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The hue of high-chroma colours, by contrast, can easily be identified.

The Munsell notation for a colour takes the form H V/C, where H stands for hue, V stands for value, and C stands for chroma. For example, the colour 10R 9/6 would be a very light (V is 9), moderately intense (C is 6), orangish red (H is 10R). A colour with chroma 0 is a neutral grey, which is denoted NV, where V stands for value. For example, N5 is a grey that is midway between white and black. Liquitex acrylic paints typically give Munsell notations directly on their tubes, at least on some lines. Other manufacturers, such as Golden, list Munsell notations on their websites.

The Munsell system is important to painters for several reasons. First, the attributes it identifies (hue, value, and chroma) are all vital to art. A painter should see his paintings in those terms. Value is the most important. A black and white reproduction of an image retains the Munsell values, but discards all hues and chromas, yet there is no trouble "reading" the black and white reproduction. A painter should similarly learn to look at paintings solely in terms of lights and darks. Classically, a tonal underpainting served to make sure the light and dark structure was sound. Chroma is also important. Colours whose chromas are too high (in the context of a painting) tend to be "loud" and jarring, calling undue attention to themselves. Colours whose chromas are too low will not provide sufficient emphasis. Secondly, the Munsell system provides a way to communicate about colour. A language is needed, for example, for this article to explain how colours in shadow relate to colours in light. The Munsell system provides that language. Thirdly, the Munsell system, as we shall see, suggests a simple yet flexible procedure, the Reilly method, for mixing paints, that a painter can easily control.

2 Shadow Colours in the Munsell System

Suppose that a painter is painting an object, some parts of which are in light, and other parts of which are in varying degrees of shadow. Assume for now that the object's local colour is the same everywhere, and that its surface is matte rather than glossy or reflective. Assume also that the object is lit solely by indirect daylight, and that no other objects are providing reflected light.

One challenge for a painter in this situation is to find shadow colours that have the correct relationship to the colours in the lit parts. A technical approach to the challenge is suggested here. The colour stimuli from the lit and shadowed parts have a simple spectrophotometric relationship. Although spectrophotometry is not intuitive to painters, the renotation allows the shadow relationship to be expressed in terms of the Munsell system, which is intuitive. A recent technical article [3] used

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the renotation for a set of shadow calculations, from which derives the following rule of thumb for painters:

Suppose that the colour when lit has Munsell coordinates H V/C. For example, H V/C could be 6GY 8/10. Locate the lit colour in the Munsell section of constant hue H, as shown in Figure 1. The left axis is a vertical line of neutral greys, numbered from N1 through N9. Continue the neutral axis downward, to where the value would be -1. Draw a line from the value -1 on the neutral axis, to the center of the square containing 6GY 8/10. The shadow colours of 6GY 8/10 fall on this line.

As an object colour in a scene being painted becomes progressively darker, its Munsell value, not surprisingly, decreases. The rule of thumb says that the chroma also decreases, by about the same proportion. A realistic painter should therefore insure that a shadow colour is not only darker, but also duller, than that same colour seen in more light. An object is often seen in several degrees of shadow, so the colours of the darker shadows should be progressively duller than the colours of the lighter shadows.

In general, the Munsell hue does not change much in shadow, although the calculations showed that there was a slight, consistent shift towards the warmer, yellow part of the spectrum. A reddish colour seen in shadow would shift towards orange, which becomes brown when viewed as a darker colour. Similarly, orange seen in shadow would shift towards a yellowish brown. In painter's terms, these colours would be said to exhibit warm shadows. This observation is particularly relevant when painting flesh tones, which fall in the orange-red part of the spectrum. Similarly, hues in the sector from BG to PB also become warmer as they become darker, although the effect is not as pronounced as in the orange-red sector. As shadows become darker, and chroma decreases, hue becomes nearly indistinguishable. In a portrait, for example, nostrils are typically very dark, because very little light is reflected out of them. They are near the bottom of the line in Figure 1, so they are also very dull. It is nearly impossible for a painter to identify the hue of a nostril in shadow, even if he studies a model's face for a long time. For simplicity, then, and because calculated hue changes are small, the rule of thumb is to maintain a constant hue along the shadow series.

Informal experiments with Munsell chips provide an example of the rule of thumb. Figure 2 shows a Munsell hue sheet for 5R. The chip 5R 7/10 has been removed and placed on top of the chip 5R 5/8. A piece of opaque black cardboard has been positioned to cast a shadow on half of the chip 5R 7/10, but no shadow on 5R 5/8. The shadowed half of 5R 7/10 is now adjacent to the lit 5R 5/8, and the two colours

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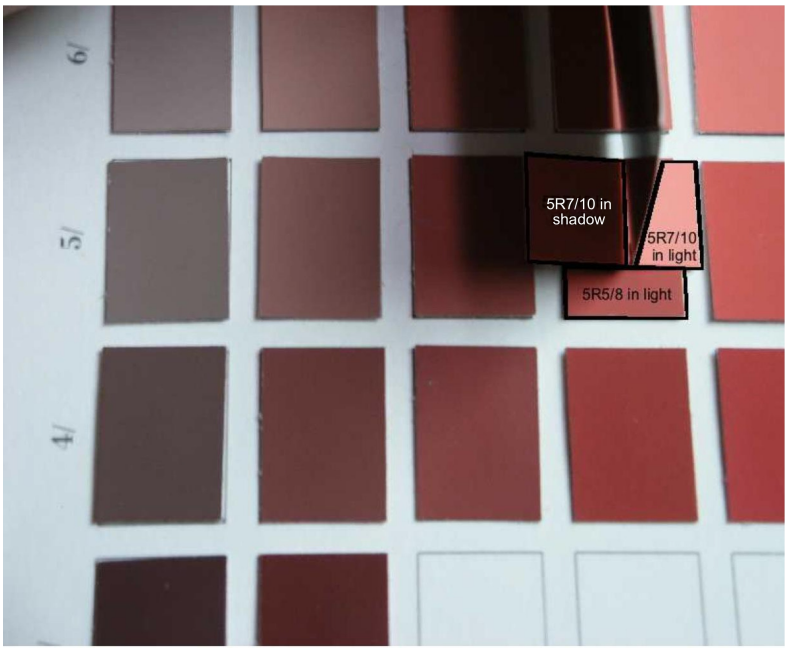


Figure 2: Studying Shadow Colours with Munsell Chips

appear similar. From this similarity it can be concluded that 5R 5/8 is nearly in the shadow series of 5R 7/10. We see the effect predicted by the rule of thumb: chroma and value both decrease in a shadow colour. Further experiments can be performed, with other colour chips, and varying kinds of lighting.

3 A Procedure for Painting Shadow Colours

This section presents a procedure for painting shadow colours, using the rule of thumb just presented. In addition, the Reilly paint mixing method [5] is presented; this method is based on the Munsell system, and is well-adapted for shadows. Initial attempts at applying the procedure will involve matching colour swatches against a Munsell colour chart, which can be artificial and time-consuming. After a few careful exercises, however, the reader will be able to dispense with the Munsell chart, and rely on his eye.

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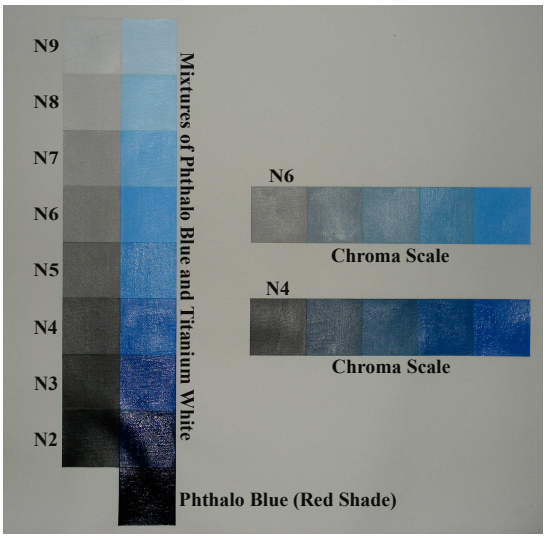


Figure 3: Mixing Paints to Control Hue, Value, and Chroma

3.1 The Reilly Paint Mixing Method

The Reilly paint mixing method is named for Frank Reilly, who developed it from the Munsell colour system. It allows the painter to control hue, value, and chroma, in isolation from each other. The one prerequisite that is hard to find, but necessary, is a Munsell colour chart. Though complete Munsell books are available, they typically cost upwards of $500. The company X-Rite has produced industry-standard Munsell books [6] for many decades. Munsell posters, which typically have smaller colour swatches than the books, are also hard to find. Until recently, BabelColor produced an excellent poster, with over 2000 swatches, for about $50. It might be possible to find one secondhand. A useful, easily accessible resource is the book *The New Munsell Student Color Set* [7], by Jim Long and Joy Luke, now in its third edition. This book contains a set of 250 Munsell swatches, which the reader sorts by eye and glues onto provided hue leaves. Figure 2 is a photograph from this book.

Figure 3 shows the first step in the Reilly system, making a grey value scale. The scale on the left goes from N9 down to N2. Golden Acrylics makes a set of neutral greys, spanning from N2 to N8, that are spectrophotometrically tested to conform to the Munsell standard, and are helpful in the first step. If needed, approximate greys can be mixed by combining burnt umber and titanium white, and matching to the grey values in a Munsell chart. While such mixtures are only approximate, they are adequate for underpaintings, and for reducing the chromas of other paints.

The second step is to mix a set of saturated colours, of a desired hue, whose

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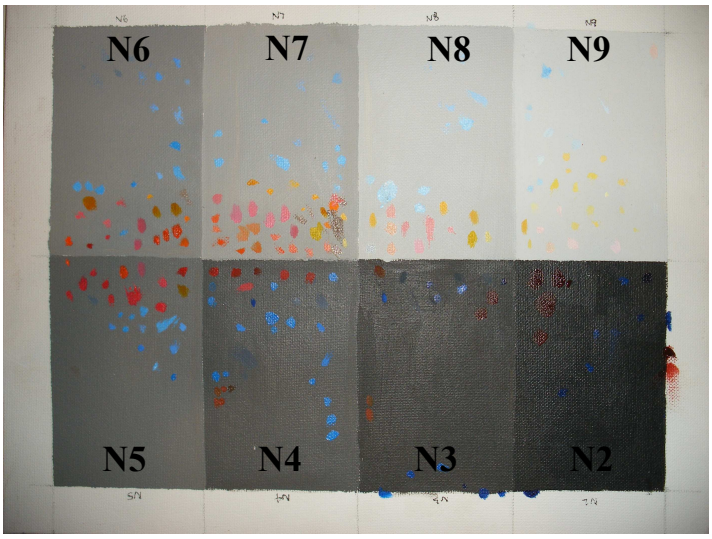


Figure 4: Matching Values

values agree with the value scale. In this case, Phthalo Blue (Red Shade), produced by Golden Acrylics, was used. Its Munsell hue, judging visually, is 10B. The column on the right was produced by mixing phthalo blue with various amounts of titanium white. Each blue square in the right column has the same Munsell value as the grey square beside it in the left column. Figure 4 shows a simple method for matching values. Eight large grey rectangles are painted, of colours N2 through N9. To test whether a paint has value, for example, 5, paint a small fleck on the rectangle for N5. If the paint seems to vibrate visually, then it has value 5. If it is too light or too dark, that difference will also become clearer, and it can be adjusted accordingly.

The third step is to adjust chroma. The upper horizontal bar in Figure 3 adjusts chroma by mixing the grey of value 6, and the saturated blue of value 6, in varying proportions. The more grey there is, the lower the chroma, and the more blue there is, the higher the chroma. The horizontal bar, or *chroma scale*, is bounded by the original grey and blue. A painter can choose the desired chroma from such a scale. In practice, difficulties can occur with the chroma step because of unexpected hue shifts (for example, mixing a yellow hue with a grey of the same value often produces an unwanted greenish tint), or because a sufficiently saturated paint for the non-neutral end of the chroma scale is hard to find. Some experimentation with pigments might be needed to overcome these difficulties.

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3.2 An Example of Painting Shadow Colours

Figures 5 through 8 show a simple example of the shadow colour procedure. The object to be painted is a blue cube, lit from above, sitting on a grey table. The top face is light, one side face is dark, and the third visible face is a midtone. Figure 5 shows the cube in shades of grey. As shown in the figure, the light has Munsell value 7, the dark has value 4, and the midtone has value 6. The table has values 3 and 5. The example was painted with neutral grey acrylic paints.

The grisaille shown in Figure 5 serves as an underpainting. The colours painted over it in the final painting should match the grisaille underpainting in value, but have different hues and chromas. An important, still unresolved question, is what Munsell values a surface representation should have, to correspond to an actual scene. Artists can "key" values to some extent, darkening or lightening a painting overall (much as a photographer can adjust exposure time), while still maintaining a realistic appearance, so there is no unique right answer. In practice, painters can usually find a convincing value scheme, so this article will assume that an initial choice of lights and darks has been made.

Figures 7 and 8 show two approaches to painting the cube. Figure 7 is a naïve approach. The colours in that figure were produced by mixing phthalo blue with titanium white. For each of the three colours, enough white was mixed into the blue, which is a very dark colour on its own, to produce the desired value. The hues of all mixtures were approximately 10B. Figure 6 shows a dotted line joining the three colours that resulted: 10B 7/12, 10B 6/16, and 10B 4/16. Although the values of the mixed colours are correct, their chromas prevent the colours from falling along a shadow series. The figure reads as a three-dimensional form because the lights and darks are right, but the shadows and midtones are too saturated.

Figure 8 shows the cube with the colours adjusted to fall in accordance with the rule of thumb. The light blue in Figure 8 is identical to the light blue in Figure 7; both are 10B 7/12. The other colours were calculated by drawing the line suggested by Figure 1. Figure 6 shows this line, which joins 10B 7/12 to an imaginary grey of value -1. Regardless of the hue and chroma, the values of the finished painting should match the values in the grisaille, so the midtone and shadow should have values 6 and 4, respectively. The colours in the shadow series that attain these values are 10B 6/10 and 10B 4/8. 10B 6/10 was obtained by adding N6 to 10B 6/16, until a chroma of 10 was reached. 10B 4/8 was obtained similarly, by adding N4 to 10B 4/16.

Figure 8 is more accurate than Figure 7, in the sense that it more closely matches the visual stimulus a shadow series would produce. The shadow and midtone are more subdued, and their chroma does not compete with the chroma of the cube's

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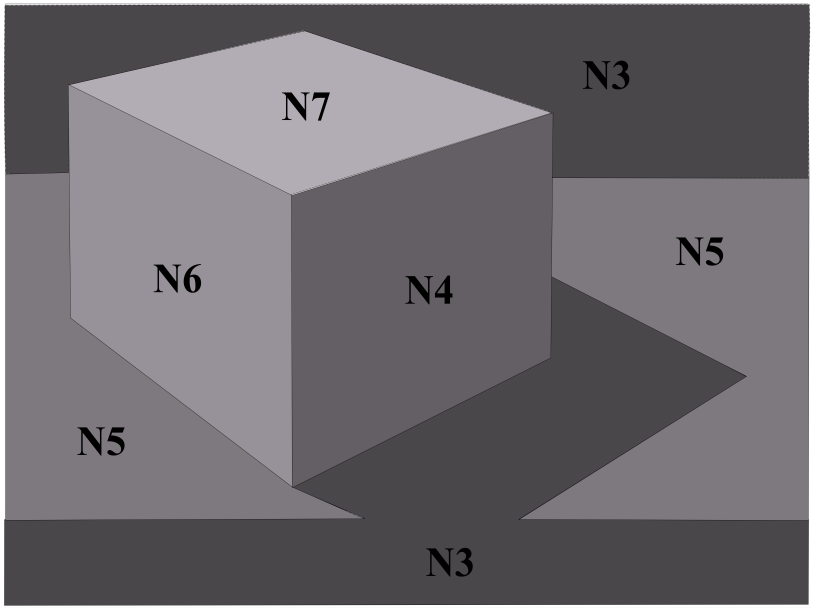


Figure 5: Cube Underpainted in Shades of Grey

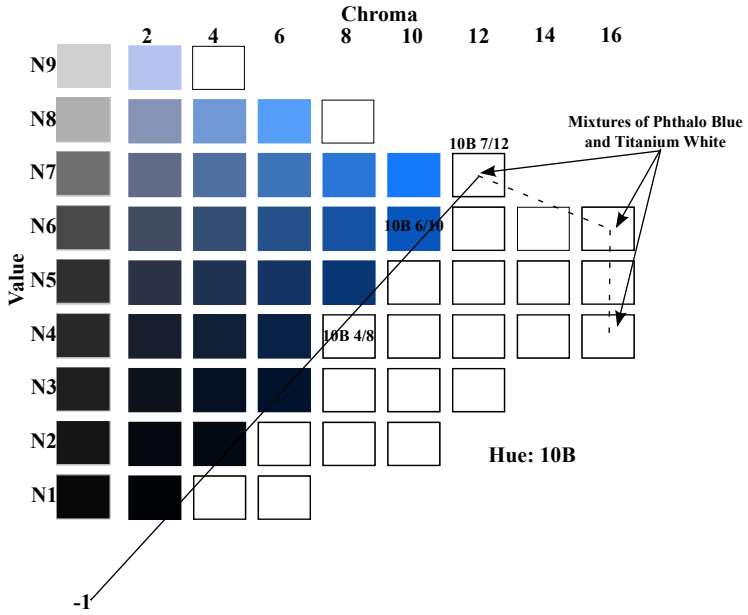


Figure 6: The Munsell Colours in the Hue Leaf 10B Used in Example

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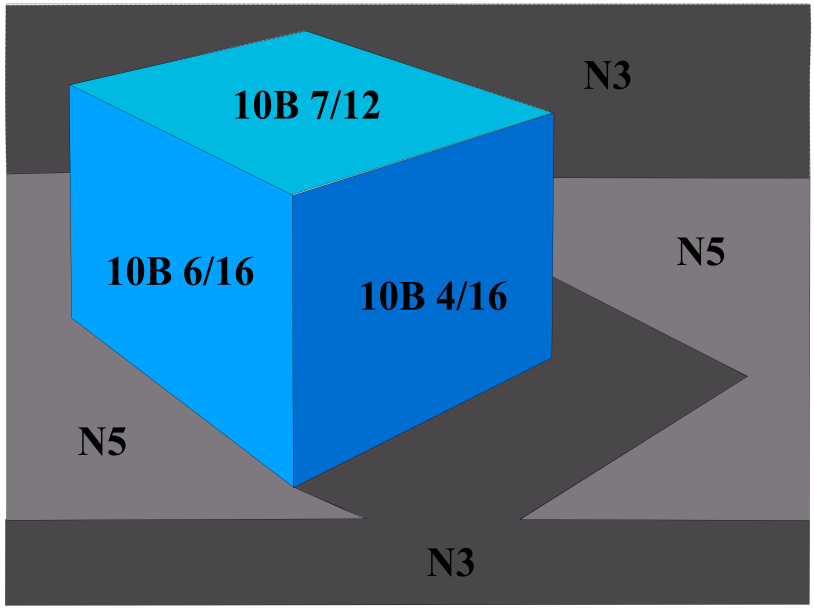


Figure 7: Cube Painted with Mixtures of Phthalo Blue and Titanium White

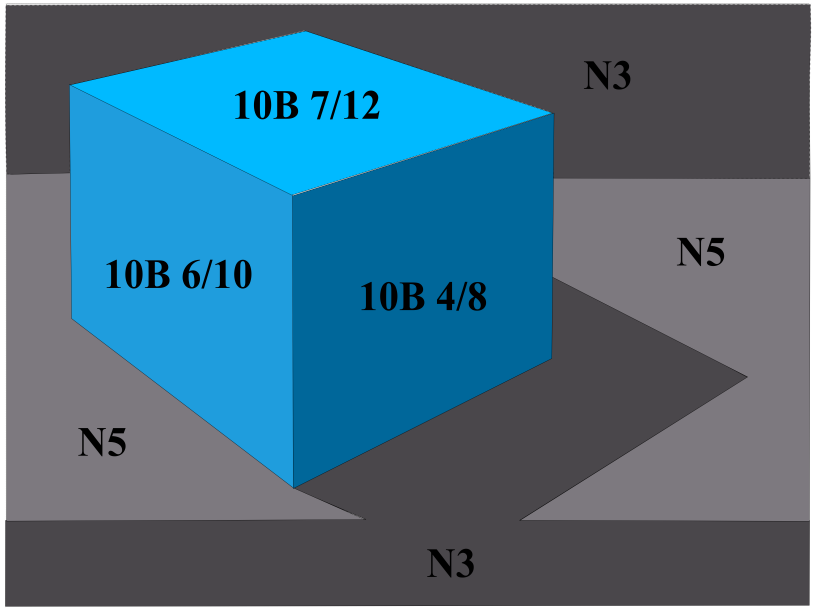


Figure 8: Cube Painted with Shadow Series

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brightly lit top face. In comparison with Figure 8, Figure 7 looks artificial. The loud shadow colours compete with the colour in light, producing a jarring effect. Figure 8 produces a subtler, more realistic effect.

3.3 Flesh Colours

A particularly difficult problem is mixing flesh colours. Figure 9 shows how the rule of thumb for shadow colours, combined with the Reilly method, can simplify this problem. The figure shows three levels of illumination for a Caucasian model. The highest level is the model in light, the middle level is the model in shadow, and the lowest level is the very dark shadows that occur in undercuts such as nostrils. The highest level, which is the large upper square in the figure, is all at Munsell value 7.5. The shadow level, which is the middle rectangle in the figure, is all at Munsell value 4, and the very dark shadow is value 2.

The first step in the Reilly method for the flesh tones in light is the mixture of a light grey, of about value 7.5. A mixture of Maimeri Puro Burnt Umber oil paint, and Maimeri Puro Titanium White, was used. Rather than being a true grey, this mixture has a bias towards the red-orange-yellow part of the spectrum, where most flesh tones are located. This grey occupies the entire left side of the upper part of the figure. The square on the upper right is a mixture of Gamblin Cadmium Orange oil paint and white. This mixture was chosen to have a Munsell value of 7.5. The lower right square is a mixture of Gamblin Perylene Red and white, also chosen to have a Munsell value of 7.5. The two intermediate squares are mixtures of the orange and red in the corners. These mixtures are made to provide a range of hues, because flesh tones show a lot of local variation. Although it is not done here, the hues could be extended by adding a yellow and a purple, and even greens and blues if desired. The saturated hues on the right are now mixed with the grey to produce chroma scales, containing duller versions. The result is a set of hues and chromas, all of the same value, that can be used to paint the more illuminated parts of the model.

The middle section of Figure 9 shows similar mixes for shadow colours. The left side is again a mixture of burnt umber and white. The upper and lower right squares are Maimeri Puro Golden Ochre and Mars Red. These two colours are considerably duller than the bright oranges and reds above them. The rule of thumb predicts, however, that shadows should be duller, so there is no need to search for more saturated colours. A consequence of the rule of thumb is that the range of chromas in shadow is narrower than the range of chromas in light. This narrow range is part of the reason that details tend to get lost in shadows. Finally, the square at the very bottom of Figure 9 is burnt umber with a slight amount of white and alizarin

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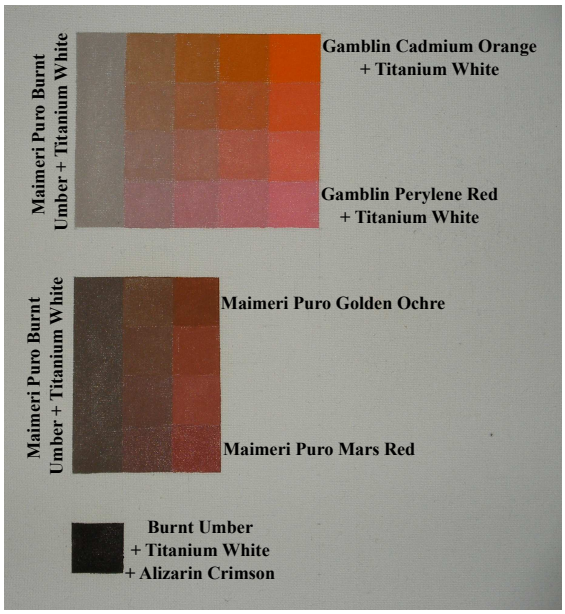


Figure 9: Suggestions for Flesh Colours

crimson. This colour would be used for the very dark shadows found in nostrils, or between folds of skin. The rule of thumb predicts very low chroma for such dark shadows. At low chromas, hue distinctions are hard to make, so almost any red or orange could be used to avoid a pure grey; alizarin crimson was used here.

The palette in Figure 9, derived from the shadow colour results and the Reilly method, is suggested as a helpful starting point for figure or portrait paintings. It can, and usually should be, extended at will to include midtones and highlights. There is also wide latitude in the choice of paints. For example, a cadmium or pyrrole red would serve just as well as a perylene red, and any brand could be used. The reader is encouraged to adopt the principles of the shadow colour method presented in this article, while varying the details.

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