AIVP ADVANCES IN IMAGE AND VIDEO PROCESSING
SOCIETY FOR SCIENCE AND EDUCATION UNITED KINGDOM
VOLUME 3, ISSUE 3
ISSN 2054-7412

Psychological Interpretation of Drawings by Color Analysis for Mental Therapy

[1]Chieko Kato and [2]Tadahiko Kimoto
[1]Department of Information Sciences and Arts, Toyo University, Kawagoe, Japan;
[2] Department of Science and Engineering, Toyo University, Kawagoe, Japan;
[1]kato-c@toyo.jp; [2]kimoto@toyo.jp

ABSTRACT

In order to provide psychotherapists with an objective criterion for evaluating client's mental states, this paper proposes a method for analyzing a drawing that a client makes in drawing therapy for four psychological primary colors. The method consists of two steps: an image segmentation step and a color analysis step. In the first step, those areas which seem what the client intended to depict are extracted from the entire digitized image. The effective resolution in the extraction is made variable with the values of parameters in mathematically morphological processing. In the second step, the pixels of the extracted areas are classified into four categories, corresponding to the psychological primary colors, as determined by the dominant component of a pixel color.

A case study of employing the color analyses in drawing therapy was carried out with a series of drawings which were obtained in an actual clinical therapy. A comparison of the objective results of the analysis and subjective evaluations obtained in the process of cognitive behavioral therapy has demonstrated that the analyses are useful to describe a variation in a client's mental state in terms of psychological properties of colors. In conclusion, the color analysis method in drawing therapy works in cooperation with cognitive behavioral therapy.

Keywords: Drawing therapy; Cognitive behavioral therapy; Psychological primary colors; Mathematical morphology; Image segmentation; Color space division.

1 Introduction

Creative activities such as art making have therapeutic effects on mental clients. In drawing therapy, which is a practice of art therapy [1], a client is treated through the behavior of making drawings while they require no artistic talent or drawing skills. Deducing the client's mental state from the drawings enables a therapist to properly help them to improve in their therapeutic process. Thus, drawing therapy is currently recognized as an effective and proven way of treating clients for their mental problems [2].

Drawings that a client makes are supposed to contain psychological information about a wide variety of their emotions. Not only what is described in a drawing but also how it is made, for example, how it is composed on the drawing paper, how the drawing tools and materials are used to depict it, how it is made colored, and so on, can express different kinds of emotions. Observing the drawing, a therapist interprets it by describing the client's emotions in psychological terms and then, diagnoses their mental symptom.

DOI: 10.14738/aivp.34.1316
Publication Date: 17th July, 2015
URL: http://dx.doi.org/10.14738/aivp.34.1316

Different therapists often make different interpretations of the same drawing because pictures such as drawings are usually viewed from different viewpoints by different people. Besides, the personal experience of a therapist may affect their interpretation result. Thus, drawing therapy essentially involves subjective assessment by each therapist.

To reduce subjective views in the assessment of a drawing, employing its objective features is effective. A way to obtain such features is to analyze a drawing by techniques of image processing with a computer [3]. The analysis results are obtained in a numerical form and they can be used in further processing. For example, a change in client's feelings over a long period can be revealed by data sequence analysis. Consequently, computer-aided analysis of drawings is expected to help therapists to make treatments suitable for a client. It is also helpful for a therapist with a short-term experience. The effectiveness of such quantitative analysis has been recently reported in many researches for artistic paintings [4].

In the present study we consider a use of colors in drawing therapy. It is known in color psychology that some colors, which are called psychological primary colors, relate strongly to human mind. For each psychological primary color, those emotions which it generally symbolizes have been investigated [5]. Such psychological effects of colors indicate that which color is painted in a drawing expresses emotions, especially unconscious ones of a client who makes it. This paper proposes a method for analyzing a drawing for the psychological primary colors so that a therapist can assess the client's emotions from the analysis result.

The rest of this paper is organized as follows: Section 2 describes the significance of colors in drawing therapy. This section also includes an explanation of subjective assessment that is often performed in cognitive behavioral therapy, which will be used later for comparison. In Sect. 3, the method of color analysis for drawing images is explained in detail on the supposition of the image format same as that used in the next section. In Sect. 4, a case study of applying the color analysis method to drawing therapy is carried out with a series of drawings that a clinic patient made in their therapeutic process by one of the coauthors who is a qualified clinical psychotherapist. Section 5 concludes the paper.

2 Evaluation of Client's Emotions

2.1 Evaluation from colored drawings

In drawing therapy, a client is allowed to draw whatever comes into their mind in such a manner as they like with given drawing tools and materials. Then, various types of self-expression appear in such drawings while the client may have been unconscious of their own mental state in drawing. From visible features in the drawing, a therapist deduces the client's emotions with which the features are associated in psychology. Thus, the drawings can reveal the client's unconscious emotions and enable the transference between the therapist and the client.

As for color, a drawing is evaluated using the psychological properties of colors. The properties of a color are the emotions which it is usually associated with in psychology. A color has two mental aspects: a positive one and a negative one. In addition, a color provokes three kinds of mental responses. Combining these factors, each color has several psychological properties that affect human mental activities. In the psychological primary colors there are four foremost ones: red, green, blue and yellow. Main psychological properties of each of these colors are listed in Table 1.

In order to describe a drawing in terms of the psychological primary colors, it is necessary to analyze the drawing for the colors and then evaluate the amount of each color. For the implementation of

such evaluation, in the method which will be described later, the entire drawing is to be divided into those

Table 1. Psychological properties of four primary colors [6].

Color	Positive properties	Negative properties
Red	Physical courage, strength, warmth, energy, basic survival, fight or flight, stimulation, masculinity, excitement.	Defiance, aggression, visual impact, strain.
Green	Harmony, balance, refreshment, universal love, rest, restoration, reassurance, environmental awareness, equilibrium, peace.	Boredom, stagnation, blandness, enervation.
Blue	Intelligence, communication, trust, efficiency, serenity, duty, logic, coolness, reflection, calm.	Coldness, aloofness, lack of emotion, unfriendliness.
Yellow	Optimism, confidence, self-esteem, extraversion, emotional strength, friendliness, creativity.	Irrationality, fear, emotional fragility, depression, anxiety, suicide.

areas which can each be made colored approximately in any of the primary colors. Then, the amount of each color included in the drawing, for example, the area ratio can be measured.

2.2 Subjective evaluation in cognitive behavioral therapy

Psychological problems are considered as the result of a defective way of thinking. Cognitive behavioral therapy helps a client to change their wrong way of thinking to a healthy one, and this allows them to change their behavior as a result. Because the brain deals with information which is gathered by the senses, human behavior is analyzed by having a client perform various mental tasks in cognitive psychology. Through such a therapeutic process, the client can understand their feelings better and turn their way of thinking into useful behavior accordingly.

A cognitive behavioral therapist evaluates mental states of a client by discussing their psychological problems with them. A way of how to give scores to the mental state is as follows: Suppose that a client first thinks in a negative way and may be angry after they have been scolded by their boss, for example. At this point in time, they are considered to be 100 percent angry in a terrible feeling. Let us suppose next that they can later afford to think in a more rational way and their feelings of anger decrease accordingly. For example, realizing that their boss was only trying to help them, they change their way of thinking. By talking with the client, the therapist estimates the degree to which their feelings of anger have dropped to be, say, 50 percent. This estimate indicates that the client has made a 50-point improvement in their way of thinking. We refer to the score as the degree of improvement, which will be used later in the case study in the present paper.

3 Color Analysis of Drawing Images

3.1 Method for analyzing drawings

Drawings to be dealt with in the present study are those which are depicted on a blank sheet of paper with chromatic materials such as pastels, crayons and pencils. It is supposed that there are no restrictions on the contents or the composition of a drawing. Arbitrary use of color is also allowed in drawing. Here, let a drawing area mean the entire area depicted intentionally so as to express objects.

A drawing area is situated within the sheet in various ways. Some cover all over the sheet; others are located inside the sheet with the surrounding area left blank, and the boundary can be arbitrarily shaped.

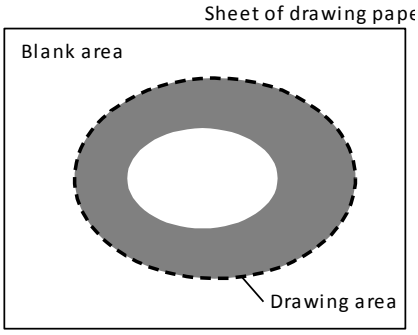


Figure 1. A drawing in a sheet of paper.

As shown in Fig. 1, the drawing area may also include that area looking like an internal hole inside which is either a part of sheet left blank or an area intentionally painted over in the same color as the ground color of the sheet.

A drawing area is painted and textured in various ways with painting materials and tools. Using lightly a crayon, for instance, perhaps also owing to the granularity of paper quality, can color in a mottled way. The mottled area which is depicted directly on the blank sheet in this way could include a lot of small unpainted holes.

The aim of analyzing a drawing with a computer is to investigate what colors are intentionally used there. To exclude the color of the blank area, first the drawing area is to be extracted from the entire digitized image of the drawing. Then, color analysis is carried out only in the drawing area. The details of each procedure are described below.

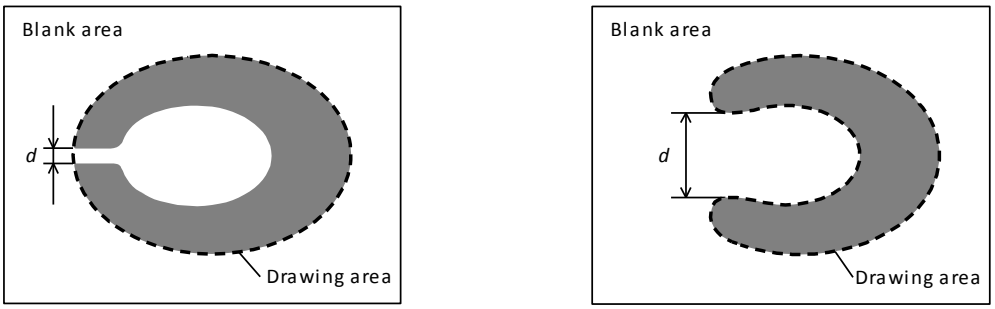
3.2 Extraction of a drawing area

A drawing area is defined in more detail in the following way. In the first place, it is reasonable to regard an area of different colors from the ground color of the sheet as a drawing area. As mentioned in 3.1, a blank area surrounded by the colored area is considered as a part of the object situated there, and hence, it should be included in the drawing area. As for an internal blank area connecting to the outside, if the connecting path is narrow as shown in Fig. 2(a) where d represents the path width, the internal area should be included in the drawing area. On the contrary, if the connecting path is wide and accordingly, the internal area looks like a "bay" rather than a hole as shown in Fig. 2(b) with a large value of d, it is reasonable that the blank area is no longer included in the object.

Suppose that concave parts of an object are expressed in the ground color while convex parts are depicted in the material colors. Then, small concave parts along the edge of the object are to be included in the drawing area as illustrated in Fig. 3(a). In other words, the ground color is assumed to be intentionally used there. On the contrary, on the assumption that relatively large concave parts are represented by the curvature of the object's contour, they are excluded from the drawing area as shown in Fig. 3(b).

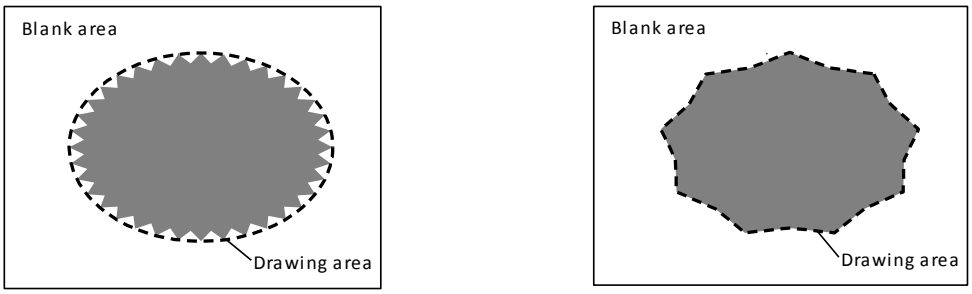
So as to achieve the above definition, the procedure for extracting drawing areas from a drawing image is composed of the following steps:

(1) Digitization: A digitized image of a drawing is obtained using an optical scanner. Let D denote the



(a) (b)

Figure 2. A drawing area with an internal blank area connecting to the outside.



(a) (b)

Figure 3. A drawing area with surrounding concave parts.

scanning resolution in both horizontal and vertical directions in units of dots per inch (dpi). Each pixel of the digitized image has three quantized values of the primary color components, red (R), green (G) and blue (B). Let IO represent the digitized image and a description of an image followed by (x, y), such as IO(x, y), denote a pixel of the image at spatial coordinates (x, y). The image IO will be also used in the later color analysis.

(2) Reduction: According to actual roughness of drawing, the image IO can be reduced to a coarse one. By replacing a square block of pixels with a pixel, the resultant resolution is equal to D/u. Let JO represent the resulting reduced image. Each pixel of JO still has three color components.

(3) Binarization: Pixels of the ground color of the sheet are distinguished in the image JO in the following way: Suppose that each color component has 8-bit levels in the range [0, 255], and that white is given by ; black is given by . Let us refer to a color composed of these three 8-bit color components as a 24-bit RGB color. Given the ground color of the sheet, for example, white, the color of each pixel is classified to two categories to produce a binary image, denoted by JB, by thresholding as follows:

$$J_B(x,y)=\begin{cases}0 & \text{if } j_R(x,y)>L_{\max}-a,\ j_G(x,y)>L_{\max}-a, \text{and } j_B(x,y)>L_{\max}-a\\ 1 & \text{otherwise,}\end{cases} \quad (1)$$

where jR(x, y), jG(x, y) and jB(x, y) are the red component, the green one and the blue one of a pixel JO(x, y), respectively, and a performs an allowable margin of level variation that is likely to occur in the digitization. Thus, pixels labeled 1 in the image JB correspond to objects, whereas pixels labeled 0 correspond to either the unpainted background or internal holes.

(4) Smoothing: Objects in the image JB are smoothed in the following two steps: First, gaps in the object are closed by morphological closing [7]. By using a square block of pixels whose origin is located at the center as a structuring element in the processing of closing, gaps of a width of less than or equal to 2p pixels are closed.

Next, the objects are smoothed by morphological opening. By using a square block of pixels whose origin is located at the center as a structuring element in the processing of opening, projections of a width of less than or equal to 2q pixels along the edge of the object are planed off. Also, being considered as noises, tiny isolated spots are removed. Let JS represent the resulting image of this step.

(5) Segmentation: To extract a drawing area with the internal holes included, a blank area that surrounds the drawing area is distinguished in the image JS as follows: Suppose that pixels labeled 1 have 8-connectivity in the image JS, whereas pixels labeled 0 have 4-connectivity. Then, a blank area is defined as a set of pixels that are 4-connected to the outside of the image. By labeling pixels of the blank area as 0 from the outside of the image to the inside according to the definition of 4-connectivity, the remaining pixels are labeled as 1 and regarded as the drawing area. Let us refer to the resulting binary image as a map image JM.

Through the above procedure, a map image JM produced from the original image IO of the resolution D is a function of the above parameters u, a, p, and q. Consequently, the drawing is to be effectively resolved with the spatial resolution of in mm. Parts smaller than a square block with one side w pixels are considered to be painted solid. Also, minimal parts of the drawing area are assumed to be in mm wide.

Figure 4 demonstrates the above segmentation. Figure 4(a) shows an example of a drawing image of 3294 2668 pixels with a 24-bit RGB color that was produced by digitizing a client's drawing with an optical scanner at D=300 dpi. Figures 4(b) and 4(c) show the results of segmentation with different values of the parameter p, where the drawing area is shown in black and the blank area in white. The evaluated w of Fig. 4(b) is 2 mm, and that of Fig. 4(c) is 3.4 mm. We observe that according to the spatial resolution, the white area on the right of "flower" is connected to the surrounding blank area in Fig. 4(b), whereas it is included in the drawing area in Fig. 4(c). Thus, values of the parameters can be determined so that desired parts can be included in the resultant area.

On the other hand, an extracted drawing area may include those parts which seem to result from something like stains on a sheet, that is, which seem unrelated to the intended contents, such as the fractions seen at the top and left sides of the images in Figs. 4(b) and 4(c). Such parts can be removed from the map image by manual operation with a kind of graphics application software.

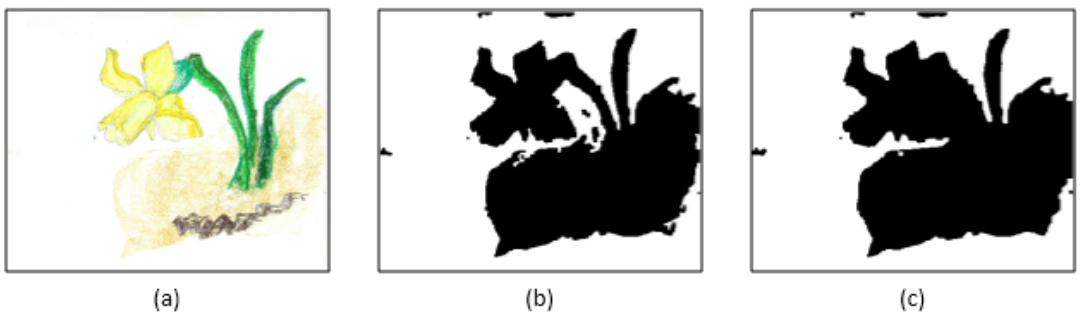


Figure 4. Example of segmentation: (a) an original image of *D*=300 dpi; (b) a map image obtained with *u*=8, *a*=8, *p*=1, *q*=1; (c) a map image obtained with *u*=8, *a*=8, *p*=2, *q*=1. Here (b) and (c) are shown by magnifying to the same size as (a).

original image I_O in the segmentation process, first, J_M is extended to the same size as I_O. A simple method for the extension is to replace each pixel with a value, t, which is either 1 or 0 in J_M, with $u \times u$ pixels with the same value of t. Let I_M represent the extended map image.

Consider classifying colors by dominant color components. The dominant component of a color is defined as that which has the largest or the smallest value among the three color components. We refer to a color whose dominant component is α as a α-class color. Let a color that has three color components r, g and b be represented by a point (r, g, b) in the three-dimensional RGB-coordinate space. Then, the set of red-class colors, denoted by P_R, is defined as

$$P_R = \{(r,g,b) \mid r > g \text{ and } r > b\}. \tag{1}$$

Similarly to P_R, the set P_G of green-class colors and the set P_B of blue-class colors are defined as

$$P_G = \{(r,g,b) \mid g > r \text{ and } g > b\} \tag{2}$$

and

$$P_B = \{(r,g,b) \mid b > r \text{ and } b > g\}, \tag{3}$$

respectively. The cubic space that represents all the 24-bit RGB colors is divided into three subspaces corresponding to P_R, P_G and P_B as shown in Fig. 5(a), where they are illustrated apart from each other for easiness to see. Note that the sets exclude the boundaries between the subspaces. Also, as for the CMY-color system using three color components cyan (C), magenta (M) and yellow (Y), the set of yellow-class colors, P_Y, is defined by using RGB-components as

$$P_Y = \{(r,g,b) \mid b < r \text{ and } b < g\}. \tag{4}$$

Figure 5(b) illustrates the subspace corresponding to P_Y located in the RGB-coordinate space together with the other two subspaces corresponding to cyan-class colors and magenta-class colors.

For an original image I_O of a drawing and the extended version I_M of a map image produced from I_O, pixels in the extracted drawing area, that is, those which satisfy $I_M(x, y)=1$ are classified according to the color classes. Let S_R be a set of those pixels in the drawing area of I_O whose colors belong to the red-class P_R, that is, expressed in the relation

$$S_R = \{I_O(x,y) \mid I_M(x,y) = 1, (i_R(x,y), i_G(x,y), i_B(x,y)) \in P_R\}, \tag{5}$$

where $i_R(x, y)$, $i_G(x, y)$ and $i_B(x, y)$ denote the respective components of red, green and blue of a pixel $I_O(x, y)$. We refer to S_R as the red-class area. Similarly to S_R, the green-class area S_G, the blue-class area S_B and the yellow-class area S_Y are defined and obtained from I_O for P_G, P_B and P_Y, respectively.

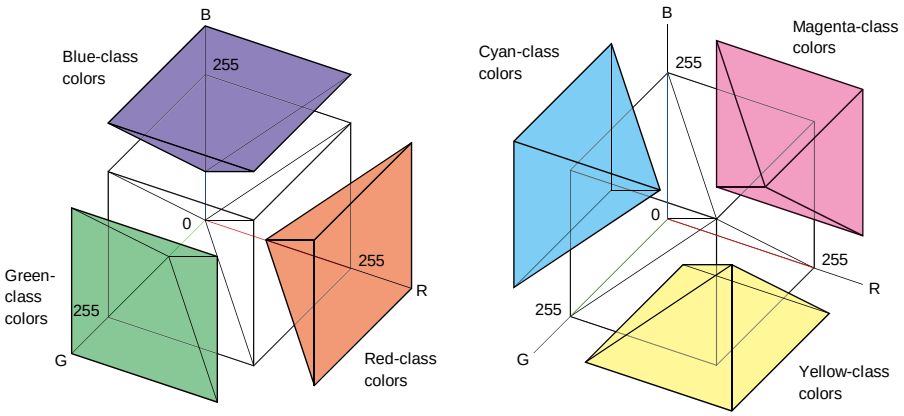
Figure 6 demonstrates the results of color analysis: Figure 6(a) shows an original image I_O, and the map image I_M in Fig. 6(b) was produced from I_O to represent the extracted drawing area. Figures 6(c), 6(d), 6(e) and 6(f) show the resulting red-, green-, blue- and yellow-class areas on a white ground, respectively. Figures 6(c)-(e) are three sets of pixels which are mathematically exclusive, in other

words, disjoint to each other. We observe from them that the drawing area is divided into three differently colored areas which look like the objects of respective colors, such as trees, the sky and the pond.

4 Case Study

4.1 Method of a case study

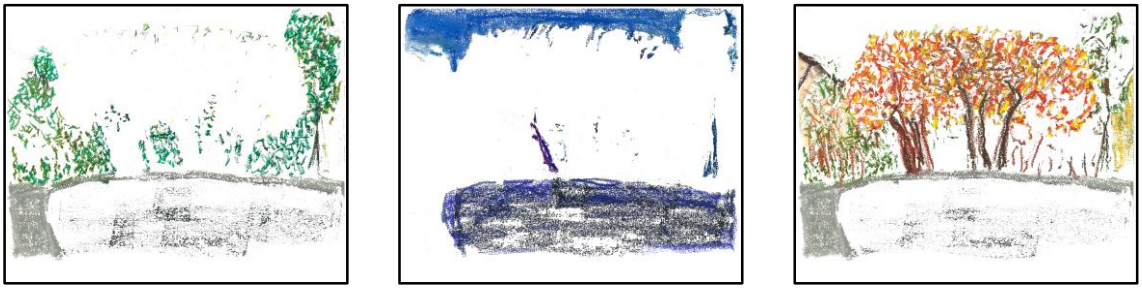
A case study of using the proposed color analysis method in drawing therapy is carried out in this section. Drawings, together with scores of the degree of improvement, which were obtained previously in the actual clinical therapy for a certain client are used as the experimental data. From the viewpoint of a qualified clinical psychotherapist, we examine how useful the objective analyses can be for assessing the client's mental state.



(a) (b)

Figure 5. Division of the 3-d color space.

(a) (b) (c)



(d) (e) (f)

Figure 6. Example of color analysis: (a) an original image; (b) the map image; (c) the red-class area; (d) the green-class area; (e) the blue-class area; (f) the yellow-class area.

The client and the therapy are described in brief below. The client was a male in his 50's. He was experiencing some difficulties at work, and was feeling pretty depressed. He had held a will to live and more importantly, he wanted to be cured of his mental problems. In general, cognitive behavioral therapy works well with intelligent and serious clients, because they are required to write in their diaries and also to work on correcting their negative behavior. The client concerned in the case study was well-educated and serious-minded, so he had well adapted to this kind of therapy. He also liked the fine arts, so he had selected art therapy as a form of treatment included in cognitive behavioral therapy. He had been treated once a month between 2007 and 2011 at a mental health clinic.

The drawings were obtained in the following way: The client made a drawing as he pleased in every month during his therapeutic process. He came for counseling once a month with not only his diary but also the drawing. Thus, a sequence of the monthly drawings by the same client were obtained.

Each drawing was analyzed by the method described in Sect. 3. Here we use the same notation as in Sect. 3. Before analysis, each drawing was scanned at a resolution of 300 dpi (i.e. D=300) and quantized to a 24-bit RGB color image, denoted by I_O. The images previously shown in Figs. 4(a) and 6(a) are samples of these digitized drawings. The drawing area was extracted from I_O by the method stated in Sect. 3.2, and also the map image J_M was generated so as to specify the drawing area. In the segmentation procedure, values of the parameters u, a, p and q were determined for each drawing so that the resultant area could look like what the client wanted to depict.

For each I_O, the color analysis was carried out to obtain the red-class area S_R, the green-class area S_G, the blue-class area S_B and the yellow-class area S_Y by the method described in Sect. 3.3. Now we are ready to evaluate the amount of each psychological primary color in each drawing. Let N be the number of pixels in the segmented drawing area; that is, N is defined in the relation

$$N = \left| \left\{ I_M(x,y) \,\middle|\, I_M(x,y) = 1 \right\} \right|, \tag{6}$$

where $|s|$ denotes the number of elements in a set s. In addition, let N_R, N_G, N_B and N_Y be the respective numbers of pixels in S_R, S_G, S_B and S_Y; that is,

$$N_R = |S_R|, \quad N_G = |S_G|, \quad N_B = |S_B| \quad \text{and} \quad N_Y = |S_Y|. \tag{7}$$

Then, we define the respective area ratios of S_R, S_G, S_B and S_Y by

$$\rho_R = \frac{N_R}{N}, \quad \rho_G = \frac{N_G}{N}, \quad \rho_B = \frac{N_B}{N} \quad \text{and} \quad \rho_Y = \frac{N_Y}{N}. \tag{8}$$

Thus, the respective sequences of the area ratios have been obtained from the sequence of the drawings.

On the other hand, the scores of the degree of improvement were obtained in the following way: In the cognitive behavioral therapy, the client had written down his feelings in his diary at any time, when he felt stress or got upset about something, for instance. From the monthly records of his feelings, his therapist assessed how his mental state had changed in that period and estimated the degree of improvement. Thus, a sequence of the degrees of improvement of the client has been obtained, each of which accompanies his monthly drawing.

4.2 Result and discussion

Figure 7 shows the degrees of improvement in the order of the sequence, or equivalently, with time in months by taking a moving average of three consecutive values. From this figure it is observed that soon after the client started his therapy, the degree of improvement dropped somewhat and then remained low until around 14th month; after that, he improved to some extent, but he got worse again. The change in the degrees of improvement after the 37th month indicates that he was gradually getting better.

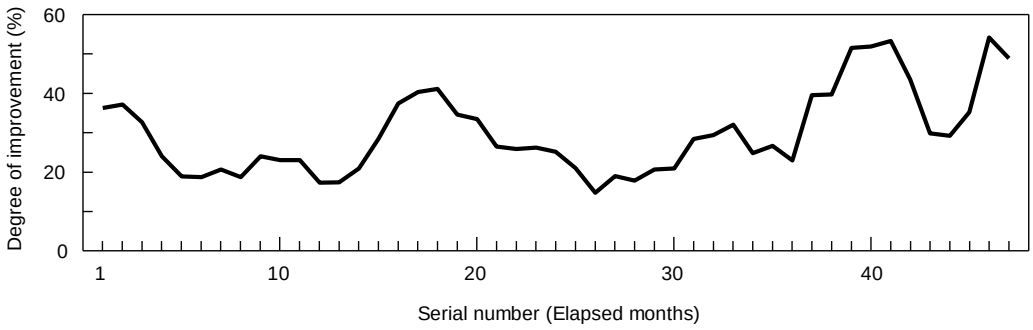


Figure 7. Degrees of improvement in the therapy period.

Figure 8 shows the respective sequences of the area ratio ρ_R, ρ_G, ρ_B and ρ_Y by taking a moving average of three consecutive values. From this figure, together with Fig. 7, the client's mental state is assessed in terms of the four colors as below.

The variation of ρ_R looks roughly coincident with that of ρ_Y in Fig. 8, and also, both the variations look roughly coincident with the variation of the degree of improvement in Fig. 7 while changes seem occurring in the degrees of improvement somewhat later than in the two area ratios. This observation indicates a probability that a diagnosis that the client is getting better can be made in drawing therapy before an improvement in his feelings is recognized in cognitive behavioral therapy.

The relationship between variations in the usage of the above two colors and improvements in cognitive behavior is explained from the viewpoint of consciousness and unconsciousness in mind as follows: Yellow in drawing therapy represents positive mental states such as optimism, extraversion and so on in an unconscious mind. If these feelings are getting strong and appear in the client's conscious mind, he improves accordingly. As for red, it represents stimulation, excitement, aggression

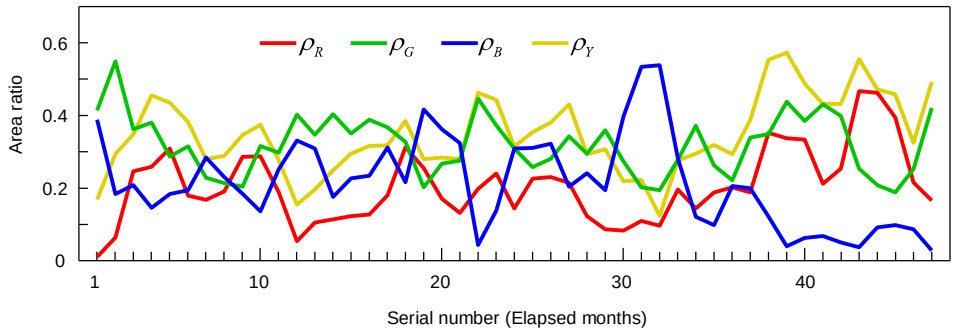


Figure 8. Area ratios of psychological primary colors in the therapy period.

and so on. It is observed from Figs. 7 and 8 that at first, the client got a sharp increase in these feelings, and later, as an improvement occurred in his unconscious mind, the feelings were subsiding accordingly. Generally, in drawing therapy a client improves unconsciously; on the contrary in

cognitive behavioral therapy a client is aware of their improvement. Because colors are easy to observe, a therapist can find changes in a client's mental state immediately although the client may be unaware of their improvement in drawing therapy.

On the other hand, a variation in the blue-area ratio ΔB indicates a time when there was a reversal in the client's improvement. It is observed that the curve of ΔB was trailing away while an improvement was occurring in his mental state, and his behavior such as unfriendly one seems to have been mitigated accordingly.

5 Conclusions

Because each color expresses both positive emotions and negative ones, it is difficult to judge if a client's mental state is getting better or worse from a variation in the usage of a single color. Hence, it is necessary to combine analysis results for several colors.

In the above case study by comparing the amounts of the primary colors and the degree of improvement, we have investigated which colors can be associated with the client's improvement and also how they can be associated. The result indicates that the colors can describe how a client is improving, more specifically speaking, which sort of emotions the client is improving in. Hence, if this type of therapy goes smoothly, a therapist can realize a client's mental condition without missing important signs or details regarding a client's behavior and feelings, by using objective and quantitative analyses.

In the present paper, we have concentrated on the four psychological primary colors. The study will be extended to the eleven psychological basic colors including these four colors. The main subjects are not only the analysis of drawing images for those colors but also the application of the analyses to cognitive behavioral therapy.

REFERENCES

[1]. Malchiodi, C.A. ed., Handbook of art therapy, 2nd ed. 2011, Guilford Press (USA).

[2]. Beck, J.S., Cognitive behavior therapy: basics and beyond, 2nd ed. 2011, Guilford Press (USA).

[3]. Thyme, K.E., Wiberg, B., Lundman, B., Graneheim, U.H., Qualitative content analysis in art psychotherapy research: Concepts, procedures, and measures to reveal the latent meaning in pictures and the words attached to the pictures. The Arts in Psychotherapy, 2013, 40: p. 101-107.

[4]. Kim, D., Son, S.W., Jeong, H., Large-scale quantitative analysis of painting arts. Scientific Reports, 2014, DOI: 10.1038, p. 1-7.

[5]. Nijdam, N.A., Mapping emotion to color. 2005,http://hmi.ewi.utwente.nl/verslagen/capita-selecta/CS-Nijdam-Niels.pdf.

[6]. Color psychology http://micco.se/wp-content/uploads/2010/05/Micco-Groenholm-on-Color-Affects-System.pdf

[7]. Giardina, C.R., Dougherty, E.R., Morphological method in image and signal processing. 1988, Printice Hall, Inc. (NJ, USA).

