

Correlation of Synesthesia and Common Recognition Concerning Music and Color

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Abstract - This paper discusses that a common recognition concerning music and color from a report on the synesthesia, especially color-heard-persons. They have the interminglement phenomenon of the sense that recognizes the image of music and color in the brain. Concretely, we did the questionnaire survey that listens to music and answered the color image. From the analysis of the questionnaire survey, two results are shown. It is suggested that the human beings have the synesthesia subconsciously. It is shown that the synesthesia is caused by an influence on the common recognition of music and color.

Keywords: Tracking, filtering, estimation, information fusion, resource management.

1 Introduction

Synesthesia is a phenomenon that two senses resonate such as hearing and vision, sense of touch and vision[1]. Many researchers are thinking that the synesthesia occurs by the sensory interminglement inside the brain. Especially, the persons who have the special ability with regard to the relation of sound and color are called the color-heard-person. This paper discusses color-heard-sense and common recognition between music and color.

1.1 Former works

Cytowic explained that ability of the color-heard is very rare [1]. He thought that the color-heard-person will exist one person in 25,000 people. However, it is reported by N.Nagata et al. [2] that color-heard sense is a general sense that everyone has. Cytowic is the well-known researcher who has an useful result concerning the synesthesia in the followin [1].

(a). Color-heard-sense is caused by the combining and the confusion of the information that occurs with recognition area inside the brain.

(b). At a part with impression, sensivity(Kansei) recognition in the brain exists two stages. The combining and confusion of the information break out in the first stage of the simple judgment area. Therefore, the

synesthesia is a very simple reaction. However, his report contradicts the result Messiaen, Scriabin who are very famous composers with color-hearing sense.[3],[4]. Because, we can read that the Scriabin was feeling the nuance of a very delicate color, from the his musical pieces. In the Messiaen's report of own color-heard-sense, we can find the description like the following. He said , I feel that the color is changed largely, when a chord changes a little.

Also, Cytowic insists that the synesthesia and common recognition are the judgment in different phase entirely. He explains it as follows.

(a). The synesthesia occurs with the part that does the simple judgment of the first stage. When simple judgment finished , we judge more detail in the common recognition field of the second stage.

(b). The combining of information is impossible in the common recognition part of the second stage. Therefore the color-heard-sense should be a very simple reaction.

Now, let's think about the 5th symphony "the Prometheus" that are composed by Scriabin with using the own color-heard-sense. This piece is the sensible work that we can understand . Namely, his color-heard-sense is not a personal sense. Thus, we can say that his sense is not differnt from the common recognition in music. That is ,it is difficult to think that his color-heard-sense differs entirely with the sensible sense as a musician. Therefore, it is difficult to say that the color-heard-sense is a very simple reaction. We can predict that the color-heard-sense is the reaction within the common recognition as a musician. The various discussions have been done about the synesthesia and also color-heard-sense in representative precedence researches. However, though researches do not yet the conclusion. The research that clarifies the mechanism about the synesthesia and common recognition is hardly carried out.

From the above discussions, we show the difference of the synesthesia and common recognition, and also the new view with regard to the synesthesia.

1.2 Preparation of the questionnaire survey

We do the survey with regard to the color-heard-sense and common recognition. For doing that questionnaire survey to the music major student and the general subject student about the relation of sound and color are executed. Why do we do questionnaire to two groups of different ability in music recognition? It is because that questionnaire is able to examine the relation between the solfege ability, synesthesia and common recognition. From the report of the musicians that has the color-heard-sense, we think that there is a closely relation between the ability of the color-heard-sense and solfege. Because, the ability that receives many information from sound is necessary to obtain a sensitive image. Generally, it is called the solfege ability. A music specialist with high solfege ability has higher recognition of color-heard-sense than general people. It is very interesting problem to compare the two groups about the possibility that discovers the color-heard-person.

We prepared three sample tunes that only tonality changes. Needless to say, three sample tunes are fixed without any changes for the height of note and rhythm. We composed new sample tunes to avoid the preconceived idea.

The color-heard-person said that a color can be imaged by the sound of the chord. Therefore, when we decide the sample tune, we paid attention to the tonality that has an influence to the sound of the chord.

In, Section-2, details of questionnaire survey are described. In Section-3, the recognition of tonality and the analysis result of the music image are described by using feature recognition method [5] by the adjective image chart that we developed. In Section-4, we explain the color-heard-sense and common sense that were obtained from the result of the questionnaire. Also, three sample tunes used for the questionnaire survey are given in the appendix.

2 Details of Questionnaire

2.1 Process of questionnaire

We executed the questionnaire survey twice.

The 1st questionnaire

(1) The object of the 1st questionnaire survey is as follows.

- Group- 1 a (general students)

15 students in the fostering and welfare specialized schools (women)

- Group-2a (music major students)

8 students at Kunitachi Music College (women)

(2) Contents of the questionnaire survey are as follows.

- Three sample tunes are used for the questionnaire which are given in the Appendix, composed by one of the authors.

- All the registers of the sample tunes are got within one octave.

Sample tune-1 : C Major / C dur.

Sample tune-2 : D Major / Des dur.

Sample tune-3 : E minor / es moll.

We play Sample tune-1 (Fig.1) , Sample tune-2 that is transposed from Sample tune-1, and Sample tune-3 (Fig.2).Detailed contents of the questionnaire are given in Section-2. When the questionnaire survey was actually done, the followings were noted.

(a) One of the authors performs the sample tunes that are recorded under the same condition.

(b) The questionnaire survey does in each group of 3-4 people. The order of reproducing the sample tune is changed by the group.

The 2nd questionnaire

(1) The object of the 2nd questionnaire survey is as follows.

- Group- 1 b (general students)

33 students in the fostering and welfare specialized schools (women)

- Group-2b (music major students)

10 students at Kunitachi Music College (women)

(2) Contents of the questionnaire survey are as follows.

- Three sample tunes are used just like the questionnaire survey of the 1st, and other conditions are all the same as the questionnaire survey of the 1st.

- The member of the G1a and G1b does not overlap. The member of the G2a and G2b overlap 7women.



Fig.1 Sample tune-1 in C Major/Cdur.



Fig.2 Sample tune-3 in E minor/es moll.

2.2 Question items of questionnaire survey

In the questionnaire survey, the following three methods were done.

(A) Free adjective selection: The image of the corresponding sample tune is filled in by a free selection of the adjective.

(B) Free color selection: The imagined color is freely described, when the person for the questionnaire listens to the sample tune.

(C) The person for the questionnaire describes tonality of the performed sample tune.

Method-A : The feature extraction method of the music developed by the authors is used[5]. In this method, the feature can be extracted by a free selection of the adjective. Here, 56 adjectives are used as choices.

Method-B : The color imaged is freely described, when the object person listens to the sample tune. This means that it is a method of replacing the image of tonality by the color. In addition, it can have the advantage that can be compared with method-A by such a method.

Method-C : This is a method for the check on object person's musical sensitivity (solfege). In this time questionnaire , we would call the absolute pitch holder person who correctly answered the tonality of all the sample tunes[6].

As a result of the questionnaire survey, the object person of the G1 group had neither the absolute pitch holder nor the relative pitch holder in both the first time and the second times questionnaire surveys. As a result, it was clarified that the absolute pitch holder had six people in the G2 group, and two people existed the relative pitch holder.

3 Analysis of the questionnaire result

3.1 Characteristic extraction system

The characteristic extraction system [5] has the following two stages.

1st stage : We extract a representative adjective from the adjective that is used to the color image chart [7] and prepared as the choice. As a result, 56 adjectives are selected for choices of the questionnaire survey.

2nd stage : In the next stage, (x,y) coordinates are given to 56 extracted adjectives. In each coordinates point, the selection frequency of the adjective is shown with a balloon. We do analysis by using this plot figure. It is able to express the approximation of the image of the adjective. Therefore, it is possible that the chart figure grasps the characteristic of music. The chart figure is possible that it grasps the image roughly.

This chart figure is conforming to the adjective image chart. We set up the axis of chart figure as follows. X-axis and Y-axis correspond to Warm-Cool and Soft-Hard, respectively.

3.2 Plot of the result of Method-A

Each figure of the adjective images that was processed by our system is shown as Fig.3 to Fig.10. The size of the balloon of the adjective image chart is showing the relative size in each chart. Accordingly, the size of the balloon is not showing the absolute value of each adjective.

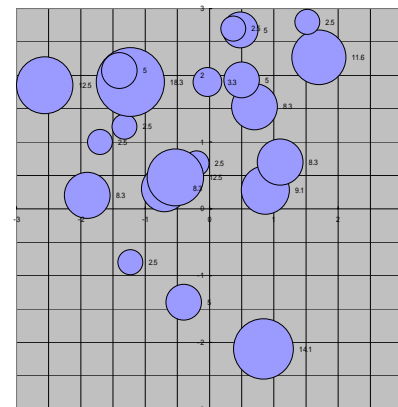


Fig.3 1st questionnaire in C major for the genral student.

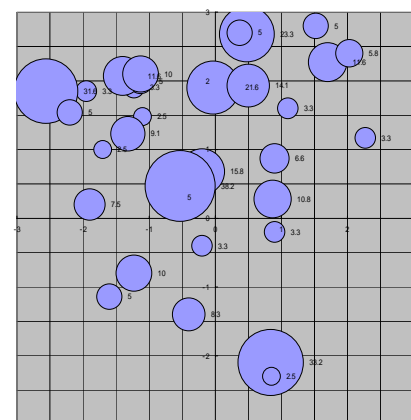


Fig.4 2nd questionnaire in C major for the genral studens.

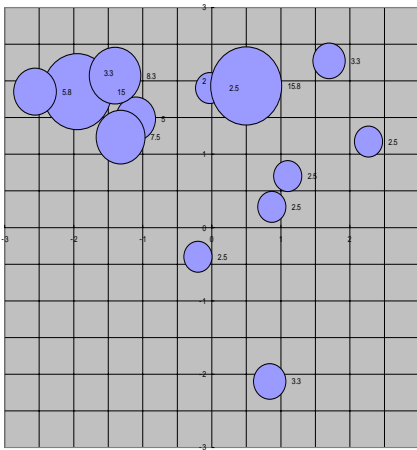


Fig.5 1st questionnaire in C major for the music major student

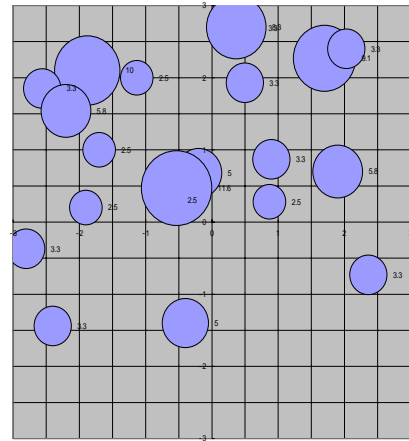


Fig.8 2nd questionnaire in D major for the music major student.

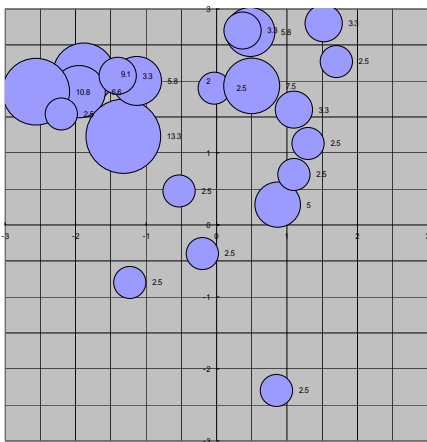


Fig.6 2nd questionnaire in C major for the music major student.

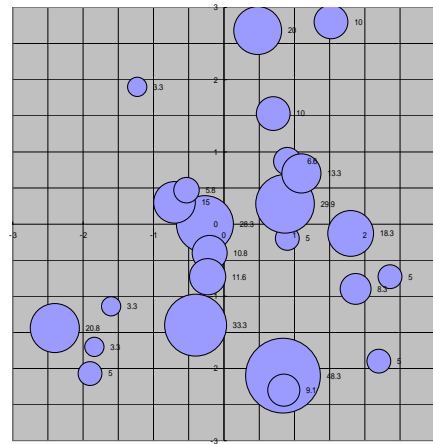


Fig.9 2nd questionnaire in E minor for the general student.

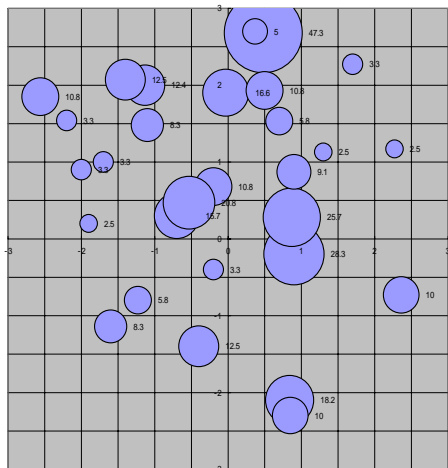


Fig.7 2nd questionnaire in D major for the general student.

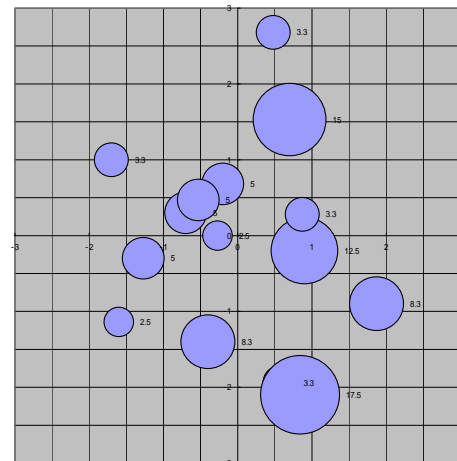


Fig.10 2nd questionnaire in E minor for music major student.

3.3 Analysis as a result of method-A

Trend analysis for the group of general students

(1) Because the object people of the general student are all student at the same school, the recognition level and solfege ability of music are almost thought to be the same. Because object person's of questionnaire survey of the first time and the second times school year is different, the situation is quite different. It is about twice that the number of object people is the second times when Figure 1 and Figure 2 are compared compared with the first time, so that the number of balloons or more increases. That is to say, the tendency to which the image diffuses is seen. However, the entire tendency does not turn. As a result, it turned out to show a certain constant tendency.

(2) Figure 4 and Figure 7 are the data of the same person for the questionnaire. The difference of the 1st (Cdur) and the 2nd (Des dur) tonality is clearly shown. Of course, the 3rd tune (E minor) shown in Figure 9 has the great divergence compared with other cases (tendency to concentrate on the 3rd and 4th areas). They understand the difference between major key and the minor key well. However, none of judgments of tonality were answered for Method-C. It was a situation in which even the meaning of the question was not able to be understood. That is, they did not become G2 groups like that though it, the solfege ability was high and listened to the difference of the interval.

(3) It is influenced by a personal preference as for the adjective selection rate in the questionnaire survey when the object person is not a music specialist [8]. The general student's diffusion of the image is more remarkable than the music major student.

Trend analysis for the group of music major students

(1) Because the first tune (Cdur) shown in Fig. 5 and Fig. 6 are the C major key (C dur) with an easy judgment of tonality, all members are answering method-C correctly. Their images have concentrated as understood from this fact.

(2) The diffusion of the image has occurred about the D major (Des dur) as shown in Fig. 8. When we determine the tonality of the 2nd tune without the score, there is a possibility that the confusion of the C major and D major. Because, C major and D major are the same tone in a different name. It is called at enharmonic tonality that is same tonality in different name. In the enharmonic tonality, there is an image diffuses. It may be a natural case that the dispersion of the image breaks out there.

(3) There is remarkable difference in the image of the 1st tune/C major and 3rd tune/es minor. It is an area in Fig. 3 in the adjective image chart corresponding to "Romantic",

"Pretty", and "Natural". As for the plot data of Fig.6, "Gorgeousness", "Dandy", and the classified area are centered in the adjective image chart. Thus, a constant tendency was often found to the selection of the adjective.

Table1.Result of the 2nd tune tonality determination

Tonality	Selection
D Major (Des dur)	10
C major (Cis dur)	7
Other (Mistake)	1 (D Major)

Table2. Result of color evaluation for the general students (G1 1st and 2 nd time).

Sample	Color evaluation (18 person)
1st Tune (C Major)	White-5, Lightblue-5, Pink-3, Red-2, Yellow -2 Other (1 person selection) Black Yellowish Green
2nd Tune (C Major / D Major)	Pink -5, Yellow -2, Red-2, Orange-2 Other (1 person selection) Brown Gold Light blue Yellowish Green Blue
3rdTune (E Minor)	Gray-5,Blue-2,Light blue -2,Flesh Color -2 Green-2 Other (1 person selection) Brown Gold Black

Table3. Result of color evaluation for the music major students G2(1st and 2 nd time).

Sample	Color evaluation (48 person)
1st Tune (C Major)	White-9, Pink-8, Yellow-8, Light blue 7 Green-4, Red-3, Yellowish-2, Green-2, Silver-2 Other (1 person selection) Sanguine Purple Blue Flesh Color
2nd Tune (C Major / D Major)	Light blue-12, Pink-7, White-6, Yellow-6, Yellowish Green-4, Green-4, Blue-3, Gray-2 Other (1 person selection) Brown Gold
3rdTune (E Minor)	Grat-20, Blue-8, Black-5, White-4, Dark Red-3, Yellowish Green-3 Other (1 person selection) Silver Brown Green Light Blue

3.4 Result of Method-B

The result of the general student group are shown in Table 2. The result of the group for the music major students are shown in Table 3, There is a person who has written the subtle change in the color. As for them, the image is

integrated and evaluated basically. For instance, as follows. "Thick green" is "Green" and " Beautiful red" is "Red. "

Members of the 1st questionnaire and the 2nd questionnaire are overlapping. Seven persons who are overlapping select the same color even in the questionnaire that takes an interval of four months or more. However, the data of seven people was added to the evaluation table of the color.

3.5 Analysis for the result of Method-B

(A) There is strong correlation in the result of Method-A and Method-B. The result of Method-A of the 1st tune for the music major student is focusing on "Romantic", "Pretty" and "Natural" areas. Also the result of question A of the 1st tune of the music major student is focusing on "Gorgeous", "Gallant" areas. Moreover, the third has concentrated on "Gorgeousness" and "Dandy" areas. However, Both groups of the general students and the music major students of the color selected by Method-B most is very near the image of the arrangement of color pattern of three colors provided in each area in the color image scale. Here, because a color and slight nuance is not expressible by the print, the color image scale is shown next for deep understanding. The followings will be appeared in the color image chart.

「 Romantic 」

It is soft, the dream of it is and a gentle image. Summarizing light soft color and white subtly the atmosphere of the fairy tale is created.

「 Dandy 」

There is style high atmosphere. We feel composure. The masculine refinement is the image of a basis. The cold color system of a hard sense is being centered around. There is the coloring that is with lively. In the plot (Fig. 3, Fig.4) of the G1, the image of the adjective diffuses and unable to find out the trend. However, between the color of method B of G1 and result of Method-A of G2 have many relation.

(B) When we try to examine it about all the Sample tunes. Many similarities exist in G1 and G2 in the color selection of Method-B. There is a difference in the ability of solfege to it is not related. The selection trend of the color is resembling.

(C) Table 4 shows the comparison of selections for the object, which is common to the 1st and 2nd questionnaire in the G2 group. In the case that the object chooses the entirely same color in the 1st and 2nd questionnaire, we entered with bold-faced type. In the case that the object chooses the approximation color in the 1st and 2nd questionnaire, we entered with Italics bold-faced type. These result are shown in Table 5.

Five in Seven people are choosing the same color or approximation color entirely about 2 tunes during 3 tunes.

Namely, it becomes 71%. We are doing a lot of setting questions besides the simple tune used to research this time. It answered without thinking about questionnaire survey at all when they received the questionnaire survey of 2nd times. It is the result that selected it with complete spontaneity. This phenomenon looks like color-heard-sense. Therefore, this result contradicts with the insistence of a current researchers.

Table4. G2 group color selection comparative

	1st/C Major	2nd/C Major	1st/D flat/C sharp Major	2nd/D flat/C sharp Major	1st/E flat Minor	2nd/E flat Minor
1	Red	Red	Green/Des	Green/Des	Beige	Gold
2	Light Blue	Light Blue	Yellow/?	White/Cis	Purple	Black
3	Light Blue	White	Purple/Des	Pink/Des	Purple	Blue
4	White	White	<i>Pink/Cis</i>	<i>Red/Cis</i>	Brown	Light Blue
5	Pink	Yellow	<i>Yellow/Des</i>	<i>Orange/Cis</i>	Gray	Gray
6	Light Blue	Light Blue	<i>Red/Des</i>	<i>Orange/Des</i>	Gray	Gray
7	White	White	<i>Sanguine/Cis</i>	<i>Dark Red/Cis</i>	Deep Green	Deep Green

Table5. Total table of color selection

Selection situation	Number
2same color and 1 approximation color	2
2same color	1
1same color and 1 approximation color	2
1same color	1
No Trend	1

4 Conclusions

4.1 Reaction of the G 1 group

G1 group (the general students) understands the image of tonality accurately, although the tonality judgment of Method-C is not understood at all. However, a more evident trend is not able to find out it to the image in comparison with G2(the music major students)group.It is shown that the person who is not a musician has the individual difference and rare reactions. Accordingly it is guessed that it is difficult to feel the same image of G2, when the G1 group listens to the musical piece that is simple and the no change of the rhythm. In the G1group , there is no absolute pitch hold person. Also, there is no relative pitch hold person.and their solfege ability is low.However, a regular trend is able to find out it in the selection of color in Method-B.In the reaction of G1 and G2 groups in the Method-B, we can find the same trend of the color selection. We are surprised at this result. How do they(G1) find the difference of tonality? The group of G1 has a regular trend in terms of the color. Although the

recognition level to tonality is low. They hardly have solfège ability, because they are not receiving musical training. However, they have the image of tonality. Moreover, a particular trend can be found out to the image. Namely, It is considered that they are holding the common recognition to music, which their image is very rough.

It can be imaged easily that the music specialist has the common recognition with regard to music. Actually, not only music specialist but also every one has the common recognition with regard to music. It is concluded that the selection of colors is influenced by the common recognition with regard to music. It will be considered that the field where decides the sensory image of the music and the field where decides the sensory image of the color are overlapping inside the brain.

4.2 Reaction of the G2 group

The G2 group is the persons who are holding absolute pitch and also relative sound impression. Even if it is the questionnaire with regard to a very simple musical piece (cadenza: the repetition of the chord called - - -), it became clear that G2 can extract a musical image accurately. Also, we can see the trend of music. It is conjectured that the image to the tonality is established.

The results of Method-B of the G2 group are more diffusing from the G1 group. However, the almost selection of the G2 are not differ from the image of the category in the color image chart. Their results of data for Method-B are not deviating from general trend. We can think that the differences of a personal delicate sense are appearing in their selection.

4.3 Common recognition and synesthesia

It defines that the part of common recognition with the sense of hearing is a field where decides the image of the music in the brain. It defines that the part of common recognition with the sense of vision is a field where decides the image of the color in the brain. It is clearly that the common recognition with the sense of hearing and the common recognition with the sense of the vision exist in the brain as the field which everyone can hold. The field of the hearing common sense and the field of the vision common sense are not separate in the brain. It is conceivable that the field of the hearing common sense and the field of the vision common sense are organized in the brain. We think that the personal sense range is gradually being produced, when the experience of a music and vision have become deeper.

It is shown that the selection trends of the color in G2 are more reflecting in a personal design than the G1 group. Also, it is shown that the personal image of G2 are very firm and not change trend even if the time changes. The image of the color to the music of G2 are not influenced by the mood.

From the fact, we can set up one prediction. When the image is becoming firm to more, everyone will have the color-heard-sense. Especially, the color-heard-sense of the musician is the gradual personal sense that does not miss from musical common recognition. There is the possibility that the musician who has the color-heard ability exists a lot more than the color-heard-person who is investigated by Cytowic. We are thinking that musician who has the color-heard ability and the color-heard-person who is investigated by Cytowic might be the different dimension. However, both color-heard-person can image of the color when they hear the sound. Also, both color-heard-person are able to image color without being influenced temporal progress and any situation.

4.4 Color-heard-person

We call the color-heard-person who has the reaction of physiology with PCHP (Physiological Color-Heard-Person = PCHP). We call the color-heard-person whose individual image is established from common recognition with ACHP (Acquired Color-Heard-Person = ACHP).

The following prediction results from our research result. The person that has normal sense and normal intelligence is possible to have the common recognition concerning the sense of hearing and vision. Furthermore, everyone who is given the stimulation concerning music and vision will become ACHP. However, when they have the ability, they do not consider it. The discussion above is not being investigated by the psychologist. It was led from the result by our questionnaire survey. This research will be appeared in the future for clarifying the mechanisms of synesthesia.

References

- [1] R.E.Cytowic, "The man who tasted shapes," Soushisya, Tokyo, 2002
- [2] N.Nagata and S.Inokuchi, "Mapping extraction of Color-heard-person," Japan, pp.97-104, 2002 MUS 47 17, 2002
- [3] O. Messiaen, "Lecture in Kyoto" Alphonse Leduc & Cie p.24-25, 1988
- [4] M.Shibata and Tohyama, "The new glove world music large dictionary volume 7th" Bunkensya, Tokyo, p.509, 1994
- [5] Kazuhiro Yamawaki and Hisao Shiizuka, "Feature Extraction of Music with Adjective Image Chart, the data processing academy research report" Japan, 2002-MUS-47-17, pp. 105 ~ 109, 2002
- [6] H.Saisou, "Absolute pitch", Syougakukan, Tokyo. Japan, 2002
- [7] Japanese color design research institute Co. Ltd., "Color image dictionaries", Kodansha Ltd. Publishers, Tokyo, Japan, p. 96, 1993
- [8] Kazuhiro Yamawaki and Hisao Shiizuka "Individual Differences on Feature Recognition of Music", 6th Asian Design Conference, Japan, E-47, 2002