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Four Cases of Pitch-Specific Chromesthesia in Trained Musicians with Absolute Pitch

GEORGE L. ROGERS

School of Music, Louisiana State University, Baton Rouge, Louisiana 70803, U.S.A.

Subjects underwent a structured interview and aural testing. Aural testing revealed idiosyncratic but consistent color associations for specific pitches and confirmed the subjects' reported absolute pitch. Higher octaves of a note were described as being lighter shades of the basic color for that pitch. Chords were perceived as combinations of the colors of the individual notes in the chord. Subjects generally were not able to divorce their absolute pitch ability from the color associations, and reported that their chromesthesia helped them to identify pitches, take dictation, play by ear, and memorize music. All subjects were formally trained musicians who had begun piano study at about age five. All were actively involved in the visual arts or reported considerable arts training. Two subjects reported childhood pairings of colors and pitches in books where notes or pitch letter names were colored.

Chromesthesia, the eliciting of visual images (colors) by aural stimuli, is the most common form of synesthesia, in which a stimulus in one sensory mode results in a clear and consistent perception in another sensory mode. A summary of evidence suggests that 5 to 15% of the adult population experiences some form of synesthesia (Marks, 1975).

Among the theories attempting to explain chromesthesia is one proposing that cross-modal associations are learned early in life, perhaps by repeated pairings of pitches and colors (Binet, 1892, 1893–reported in Marks, 1975; Howells, 1944; Shindell, 1983). This might occur, for example, if a child had experience with a toy xylophone with colored bars or used a piano or organ method that associated pitches with colors. Such a theory of early associations seems consistent with the fact that chromesthesia is more prevalent in children than in adults, suggesting that associations may be learned early and gradually replaced by "another, more flexible mode of cognition," abstract language (Marks, 1975, p. 324).

Another possible learning explanation for chromesthesia is that it is the result of cultural and linguistic associations in which "auditory-color associations are established more or less uniformly within a given culture" (Hall, 1968, p. 5). Examples of common cross-modal language include "singing the blues" and "loud colors." Adjectives such as "dark," "bright," or "muted" are commonly used to describe both musical tones and colors. In one study of 995 elementary school children (Simpson, Quinn, & Ausubel, 1956), high tones of 8000 and 12000 Hz were paired with green and yellow more often than with other colors, possibly because of a cultural convention that the high pitches and colors were both considered "bright" or "happy." Omwake (1940) found similar results with elementary school students: black and blue were associated with low pitches and red and

yellow with high pitches. Such results are consistent with Marks' doctrine of analogous sensory attributes (1978), with both pitches and colors being arranged by convention along a "brightness" continuum.

Such a theory of cultural and linguistic convention, however, does not serve well to explain a highly specific type of chromesthesia in which musical pitch or keys elicit particular colors, as reported by Carroll and Greenberg (1961), Haack and Radocy (1981), and by numerous composers, notably Scriabin, Schoenberg, and Rimsky-Korsakov. Such a specific form of chromesthesia is typically accompanied by absolute pitch ability. In order for an individual to identify a specific pitch with a certain color, it seems logical that the person would need to be able to recognize the pitch when they heard it. (The exception to this would be a person who has associations between colors and written music.) This linking of absolute pitch and the ability to make color-pitch associations is supported by a recent experimental study by Block (1983), who reported more consistent pairings of colors and pitches among college music majors with absolute pitch than among similar students with good relative pitch. She concluded that persons with absolute pitch have the potential to develop color-pitch associations.

The present descriptive study gathered specific details of the subjects' chromesthetic experiences as well as investigating the subjects' training and history. The infrequent occurrence of pitch-specific chromesthesia and the relatively few subjects available for study limit the generalizability of any such investigation. The present study is intended to be interpreted as a multiple case study which adds four cases to the existing body of information.

Subjects

Each of the four subjects reported consistent color associations with most of the 12 tones of the chromatic scale and each reported having absolute pitch. All had begun piano study in early childhood at about age 5. Subject 1 is a woman, age 45, who is a violinist and college teacher. Subject 2 is also a woman, age 38, who taught both music and French in the public schools. Both subjects 1 and 2 have earned a master's degree in music. Subject 3 is a man, age 37, who is a choral conductor and college teacher and has earned a doctorate in music. Subject 4 is a man, age 29, who is an undergraduate music major in piano performance and a church organist.

Materials and Procedures

Subjects underwent an aural test and a structured interview. The author-designed aural test employed sine tones generated by a Synclavier synthesizer calibrated to A = 440 Hz. The test was tape recorded and the recording checked for pitch accuracy with a Korg Auto Chromatic electronic tuner, model AT–12. All pitches as reproduced were within three cents of the standard. Details of the aural test are described below in the results and discussion section. The aural tests and interviews were recorded on audio tape and subsequently analyzed, along with the researcher's written notes.

The subjects were also questioned from 6 to 12 months after the initial interviews to determine the consistency of their color associations over time.

Results and Discussion

Aural testing

Subjects' reported sense of absolute pitch was confirmed by the aural testing. Ten pitches of 4 seconds duration were played for each subject: E_4, Bb_3, A_5, C_4, Gb_3, G_5, $C\#_5$, $F\#_4$, D_3, F_3.

The subject was asked to identify each pitch as it was played and give the color association for the pitch. When identifying the 10 pitches, subjects were 60%, 80%, 90%, and 100% accurate ($M = 82.5\%$). For the four subjects, errors in pitch discrimination consisted of five semitone errors and two errors of a whole step. Although there is no general agreement in the literature on a quantitative definition of absolute pitch, it is generally acknowledged to be neither absolute nor "perfect." In any case, the subjects' responses were accurate beyond any chance occurrence and above the 50% level.

Four *a*'s of 4 seconds duration were played for each subject in different octaves: A_3, A_4, A_5 and A_6. Three of the four subjects described the octave *a*'s as being darker shades of the basic color for *a* in the lower octaves, with the higher pitches being lighter or brighter shades of the same color. Subject 1 stated that there was no real difference in the color of the octave *a*'s.

Three chords, also of 4 seconds duration, were played for each subject:

Subjects 2, 3, and 4 perceived the chords as combinations of the colors of the individual notes in the chord, with the root of the chord supplying the dominant color. Subject 1 stated that the chords did not evoke clear color associations in the same way that the individual pitches did. The responses of subjects 2, 3, and 4 to both the octave changes and the chords parallel the descriptions given in Haack and Radocy (1981).

The subjects tended to volunteer character associations with the three chords heard on the aural test, in addition to the color associations. The C major chord was described as "open and honest" (*S*1), "bright and happy" (*S*2), and "bright" (*S*4). The Ab major chord was described as "dark but rich" (*S*2), "warm" (*S*3), and "rusty" (*S*4). A total of 11 non-color adjectives were used in describing the three chords. Similarly, many non-color adjectives were used by subjects when describing pitches and keys during the interview (see Table 1).

In response to the glissando or "siren" tone ($C_4 \rightarrow C_5 \rightarrow C_4$) of 10 seconds duration, subjects 2 and 3 saw the distinct colors of each pitch emerge throughout the octave "gradually blending from one to another" (*S*2), as the tone reached each of the standard pitch levels for each note. This description also is similar to that reported in Haack and Radocy (1981), although the gradual blending of colors differs from the "bright white interference" (1981, p. 88) described by Haack and Radocy. For the other two subjects in the present study (*S*1 & 4), the glissando elicited no distinct colors.

Listening to timbral changes resulted in a variety of visual images for the four subjects. The timbre of a middle *c* (C_4) was altered by gradually increasing and then decreasing the second partial over a 25 second period. The same procedure was used with the third partial of the middle *c*, varying the partial gradually from 0% to 100% to 0% of the amplitude of the first partial. Subject 1 described the addition of the second partial to the fundamental as a "broad swatch of red" that got thinner as the partial was added and became broader again as the partial faded. Subject 2 also stated that the addition of the second partial made the visual image "thinner in the middle." Three subjects saw the combination of the first and third partials as being images of the color for *c* and *g* "with a hollow space in between" (*S*1), apparently perceiving the addition of the partial as a separate pitch, rather than as a change in timbre.

Finally, a crescendo-diminuendo of 15 seconds duration on middle *c* was played for each subject, beginning at an inaudible level. In response to this gradual increase and decrease in loudness, subjects 1 and 4 described a small or distant circle of color that approached and receded with the change in loudness, with no reported change in color. For subject 2, the *c* changed in color as the loudness changed, moving from gray (its usual color for her), to purple and then to "somewhat brown" as the loudness increased.

Color associations

Table 1 lists the color and character associations for each subject. The associations are for the octave beginning on middle *c*. All subjects stated that the colors for individual pitches and for keys (tonalities) were the same, with some differences in character associations between parallel major and minor keys (see Table 1). As reported in the literature, the colors are idiosyncratic for each individual. Some agreement, however, can be noted on the pitches *c*, *d*, and *g*. When questioned 6 to 12 months after the initial interview, subjects varied on only 3 of 47 colors given originally (94% consistent). Although such color perceptions are quite consistent, the pairings are not totally constant over time as described by Haack and Radocy (1981) and Shindell (1983). The present results are more in agreement with Carroll and Greenberg (1961) in which slight color variations were noted over a period of 11 months.

Although the four subjects' color associations were idiosyncratic, a comparison with other sources (Gay, 1972; Carroll & Greenberg, 1961; Haack and Radocy, 1981; Shindell, 1983) reveals a tendency for the note *c* to be linked with either white or red. Of 17 available sources listing specific color associations, 14 list *c* as being either red (9) or white (5). No similar consensus can be found for any other pitch, although there is some tendency

TABLE 1
Pitch-Color and Pitch-Character Associations

Pitch (Key)	Subject 1		Subject 2		Subject 3		Subject 4	
	Color	*Character*	*Color*	*Character**	*Color**	*Character*	*Color*	*Character*
C	red	C major: straightforward	light bluish gray	clear	white	contrived	white	plain statement C minor:brooding
C#/Db	maroon		C#: purple Db: dark brown	C# minor: nocturnal	Db: golden brown	Db: brooding	black velvet pearls	Db: pleasant
D	brown		brown	bright, happy	yellow	regal	yellow	bright
D#/Eb	purple		D#: brown & purple Eb: purple	Eb: heroic & rich	earth color	Eb: pompous		pious & pastoral
E	blue	E major: bright & aggressive	beige		red		green	proud, individual
F			bright green	pleasant, comfortable	gold	pastoral	tan or grayish	simple nostalgia
F#/Gb	blue-green lilac		F#: green w/ orange outline Gb: orange w/ green outline				black velvet	F#: weird
G	green	G major: optimistic G minor: tragic	red	bright & happy	green	academic	light red	"I don't like G"
G#/Ab	maroon		G#: reddish purple Ab: purple w/ gray outline	Ab: dark but rich	Ab: brown		red against velvet	Ab: smooth
A	white	A major: bright & aggressive A minor: noble	dark green w/ purple outline	clear, precise, energetic	purple	majestic	orange	comfortable
A#/Bb			Bb: beige w/ gray				light brown	Bb: soft
B	gray		light tan		"bright"		purple/ violet	secretive

*Subject 2 grouped the keys of Eb, Bb, and B major together as warm, optimistic, and joyful. She grouped the keys of C#, C, A, and Ab major together as cool, reserved, and pensive. Minor keys were generally dark and cool in character.

among the subjects in the present study to list "white key" pitches as primary or simpler colors (see Table 1).

Subject 2 was the only subject who listed separate colors for enharmonic notes (e.g., *d#/eb*). Her visual images also tended to be the most complex, as in describing *f#* as "green with an orange outline." When asked how she could distinguish between enharmonic tones and associate a color with the sound, she replied that she tended to "think in flats" when hearing isolated notes, except for *f#*, which she usually heard as *f#* rather than *gb*. When reading music or hearing a familiar piece where the key was known, the colors would match the particular notes as written. Subject 2 also commented that atonal music was confusing and less appealing to her than tonal music because of the lack of a key center and the resulting ambiguity of the color associations for the "black notes." The perceptions of subject 2 were similar to the case in Haack and Radocy (1981) in that both women saw several "black key" pitches (e.f., *f#*) as combinations of the colors of the two adjacent diatonic pitches (see Table 1).

Other details of the chromesthetic experience varied with each individual. Two subjects (*S*1 & 4) stated that the colors were elicited by the actual sound of the pitches, while subject 2 and 3 said that the colors were brought on both by the sounds and by reading music silently. All subjects stated that the color associations could occur with their eyes either open or shut, although subject 2 commented that "it would be a little easier not to be looking at something." All subjects also agreed that the colors were fixed rather than moving, and that the experience occurred in the "mind's eye" and not as an outward vision or hallucination. Three subjects described the color associations as constant: present whenever hearing music. Subject 4 said the colors were intermittent when hearing music and also indicated that he could voluntarily "turn off" the chromesthesia. Subject 1 stated that colors for some pitches would change according to the context or function of the note: *b*, for example, would be yellow in a G major triad, but would be gray when heard alone.

Subject 4 saw flatted (out-of-tune) pitches as darker in color and sharp pitches as lighter. Subjects 1 and 3 saw out-of-tune notes as "less intense" and "veiled," respectively. Subject 2 saw colors from adjacent pitches "edging in" over the real color when hearing two pitches that were not in tune. She likened this to a "clash" of colors.

In general, subjects were not able to divorce their absolute pitch from the color associations. Subject 4, however, was more confident and precise in identifying pitches than in giving the corresponding colors, suggesting that the color associations were not so strong for him as for the other subjects. (The other subjects sometimes gave the color first when identifying pitches during the aural test.) All subjects reported that they felt that the color associations helped in identifying pitches, taking dictation, playing by ear, and memorizing music.

Disadvantages of chromesthesia as described by the subjects centered around difficulties of transposition. Two subjects stated that they made a conscious effort to disengage color associations when transposing music.

Subject 3 stated that hearing a piece transposed from the original key was "wrong," because the mood and the color of the music were changed along with the pitch level.

History and experience

As mentioned, all subjects were pianists who had begun piano study in early childhood. This is consistent with some other case studies of chromesthesia (Haack & Radocy, 1981; Carroll & Greenberg, 1961) but is also typical of persons with absolute pitch, in general, many of whom are not chromesthetic. Subjects reported extensive musical involvement through elementary and high school, including private instruction, band, orchestra, and church choir.

Subjects 2 and 4 reported some memory of early color associations. Subject 2 remembered an alphabet book with colored letters and stated that, for her, the letters of the alphabet and the pitch letter names are the same color. Subject 4 recalled *a* being "marked with orange" by his teacher in a beginning piano method book.

The reports of childhood pairings of colors and pitches (or letters in the case of *S*2) lends some support to an explanation of chromesthesia as a learned phenomenon. Although the pairings that were recalled explain some of the subjects' associations, they are not adequate to explain all the associations listed in Table 1.

The two women (subjects 1 & 2) stated that the color associations had always been the same for them. (Some variations in their associations over time, however, was noted above.) Subjects 3 and 4 reported some variations over time in their color associations. The subjects' awareness of their chromesthesia occurred during their high school years for *S*3 and *S*4, and during college for *S*1. Only *S*2 reported being aware of color associations in childhood, at about age 5.

All subjects were actively involved in the visual arts or had training in the visual arts beyond the usual elementary and secondary school requirements. Subject 2, for example, had taken elective art courses in high school, two drawing classes at the college level, and reported a life-long interest in drawing and painting. Subject 3 had taken art, drawing, and lithographic design classes and stated that he regularly attended art exhibits and museums. Subject 4 had taken art history courses and also attended exhibits and museums "whenever possible." Subject 1 had no special training in the visual arts, but reported owning a large collection of etchings and prints.

Subjects 2 and 3 shared some of their own theories as to why they had pitch-specific chromesthesia. Subject 3 felt it might be the result of a tendency to categorize all music by key and mood: the associated colors were an extension of the mood of the specific pieces he heard or performed. Subject 2 thought her chromesthesia may have developed because of listening and experimenting at the piano in childhood, at the same time she was learning the alphabet out of an "ABC" book in which the letters were colored.

This association of letters of the alphabet with colors reported by subject

2 was the only additional synesthetic occurrence reported by any subject. Although many sources state that synesthesia may be at least partially hereditary (e.g., Marks, 1978), no subjects were aware of any family members or relatives who were synesthetic in any way.

Conclusions

Early piano training and an active interest in the visual arts are common characteristics of the four subjects, and these traits are found in other cases in the literature. Although great caution should be used in interpreting results based on only four subjects, the evidence of early childhood color-pitch pairings suggests that for certain individuals chromesthesia may be related to early experience.

Although the color associations of the four subjects were idiosyncratic, some details of the chromesthetic experience were quite similar across subjects. Higher octaves of a note were perceived as lighter shades of the basic color for that pitch, and chords were generally perceived as combinations of the colors of the individual notes involved. As reported in the literature, the color associations of the four subjects were quite consistent over time. A comparison with other recent studies also revealed that the note *c* was listed as either red or white in 14 of 17 cases. No similar consensus was found for any other note.

All subjects volunteered character-pitch associations in addition to the color associations. For these persons, the color and character of a pitch seemed to be an integral part of the identity of that pitch or tonality. The four subjects stated that their chromesthesia helped them to identify pitches, play by ear, and memorize music.

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