

Use of Color in Sports Activities: Contrast and Visual Perception in Tennis Courts

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ABSTRACT

Effective visual perception and visual acuity are the key factors for a tennis player, who has to relate the target object (the tennis ball) with the boundary lines, play area and the net. To make accurate decisions in milliseconds of time, referees and players are in need of effective color contrast ratios, besides sufficient illumination levels. The aim of this study is to discuss court surface color combinations in terms of visual performance, and to make recommendations on operative combination schemes that would enhance visual perception. The experimental survey involved in the study was designed to examine the perception of tennis ball on different ground colors. The pilot survey demonstrated that subjects perceive balls better on blue-purple combinations, followed by red color combinations.

1. INTRODUCTION

The technological advancement and progression in construction techniques and material assembly systems propose several new materials and application methods everyday. From many reflections of this technologically defined development, sports activities can be discussed as one predominant example of change in human lifestyle. Increased interaction of technology with human body has altered both the activity and competitors' characteristics.

Tennis, one discrete example of these sports, became more popular in the 60s with television broadcasting¹. There is a remarkable revolution and change in tennis, in terms of game play, style and game duration. Textiles and materials, designed to decrease friction boost human potential to the extremes in athletics, and in tennis, players' hitting techniques are analyzed using computer software. Racket manufacturing firms use polymer matrix composites to produce lighter and stronger rackets with more power control. That's why we observe an increased game pace, in which it became more difficult to follow the ball, reaching extreme velocities of 200 km/h. The increase in game pace with faster strikes has reduced game durations compared to past years. One preventive action, currently discussed by International Tennis Federation (ITF) is making use of bigger balls in order to slow game speed by air friction and help players and referees to perceive the ball more accurately².

2. SCOPE OF THE STUDY

Approaches to enhance game duration and increase spectators' enjoyment will probably be favoured by line judges. Although there are some technical solutions and apparatus for tracking the ball during the game, it is still the referees who have to decide whether the ball is in or just out of the bounds, and the players who have to set eyes on the ball to react and run after it. Effective visual perception and visual acuity are the key factors for tennis players and referees who have to relate the target object (the ball) with the boundary lines, play area and the net.

Among several variables affecting visual performance³, light source characteristics (in terms of spectral distribution quality- color rendering and color temperature- and quantity), dimensions and colors of the target object and its surroundings and their relative luminance levels, the position and movement of the target object within the visual field can be considered as the key factors in tennis play.

For great tournaments like grand slams, lighting requirements are prepared, calculated and designed by using computer software. Besides provision of lighting uniformity on court surface and avoidance of glare, modelling is very important for players' visual performance. Modelling is also

vital for the quality of television broadcasting⁴. With the increase in court color variety, color rendering properties of light sources became more and more significant. Today metal halide sources with 83-90 CRI values are preferred.

Lighting characteristics for tennis were grouped in four categories regarding the capacity of courts and arenas. Table 1 describes the minimum required illumination levels in current applications in comparison with previous standards⁵.

Table 1: Illumination Requirements for Tennis

Game Classes	Current standards		Previous Standards	
	Horizontal		Average	Minimum
	Lx	Fc	Fc	Fc
I	1500	150	125	100
II	1000	100	60	40
III	750	75	40	30
IV	500	50	30	20

When compared with old standards, it can clearly be observed that for each class there is an increase between 250 and 400 lx. This can be considered as another parameter and effect on the changing character of tennis play. Increasing game pace necessitates more light on the target object as visual acuity is dependent on the speed of the target (Figure 1). Visual acuity can be improved by considering contrast ratios within the perceptual field. Illuminating Engineering Society studies the factors that are needed to distinguish objects from their backgrounds in two headings namely: brightness contrast and color contrast⁷. This study deals with color contrast issue so as to make recommendations on the court surface colors.

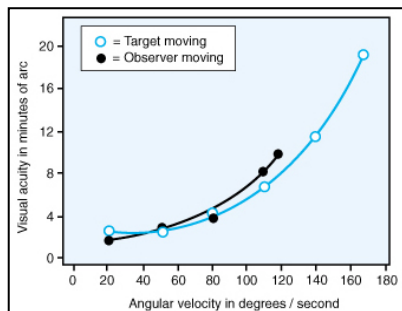


Figure 1: Visual Acuity⁶

Along with new court surface materials and development in dye production techniques, there are tens of color alternatives for tennis courts. Figure 2 and 3 illustrate just two examples of this occurrence. From the discussions made with National and International Tennis Federations, federation approved tennis ball production firms and, court surface covering material manufacturers, it has been found out that there is neither a standard nor a norm in the selection and application of colors on tennis courts. The underlined selection criteria were visual attractiveness and the success of selected dye in hiding scratches or defects. Moreover the color(s) of the sponsor firms are mostly applied especially in the tournaments named after their sponsors.



Figure 2: Sample court color



Figure 3: Sample court color

On the other hand the color of a tennis ball has been standardized disregarding surface pace ratings and court surface colors. Therefore, this study is an attempt to suggest color combinations for tennis play by investigating ball-surface color relationships.

3. METHOD

The discussions and suggestions on the selection of tennis court colors are formulated in light of a survey being conducted within a laboratory setting. The setting was designed to make comparisons among the perceptions of two standard tennis balls placed in two identical spaces, which allows the manipulation of ground color while the other conditions are being kept constant. Therefore, it is possible to observe the perceptual differences between identical objects illuminated under same sources of artificial lighting (Figure 4).



Figure 4: Experimental Setting

In the study, colored cardboards are laid on the base of each cabinet to represent court surfaces. To the center of the cardboards International Tennis Federation Approved tennis balls are placed. In order to simulate the lighting conditions in tennis tournaments in terms of light source type, color rendering index and color temperature, metal halide lamps were used. The chosen type is Powerstar HQI-TS 70w/NDL, manufactured by OSRAM. The lateral surfaces of the cabinet spaces are covered with gray cardboards with 0,5 reflective coefficient. Current study is the first phase of the research and is limited in color palette. Cardboard and ball colors were detected using a chroma-meter and the findings were converted to RGB based values⁸. RGB values were utilized in discussing contrasting schemes and in preparing computer simulation.

Complementary colors on the color wheel propose more visual contrast when used together⁹. Hypothetically, the tennis ball having yellow color, can be best perceived when it is seen within a complementary color scheme. The survey was utilized to experiment this issue by examining and comparing the ball perception between different color schemes. The most contrasting cardboard color (with respect to the ball color) was determined using Color Wheel Program. It was a blue (R:71, G:105 B:147) and was compared with 5 other colors (Table 2 and 3).

Table 2: Cardboard color values (Yxy - D65)

Color	Y	x	y
Blue	16,2	0,234	0,248
Green	27,0	0,342	0,400
Purple	16,7	0,255	0,389
Red	15,8	0,473	0,308
Pink	42,6	0,356	0,318
Brown	19,0	0,440	0,336
Yellow (ball)	75,8	0,409	0,489

Table 3: Cardboard color values- RGB

R	G	B
71	105	147
126	137	96
150	89	142
178	65	80
209	152	161
171	88	84
231	230	55

In the survey, the subjects were taken into the room, housing the experimental setup instrument, one by one and took colorblindness test to detect possible color perception problems. Then, each subject was shown five color schemes (firstly, within the experimental setting, and then, on the computer), and were asked to choose the side in which the ball is perceived better.

4. FINDINGS

Preliminary findings show a preference tendency towards contrasting color schemes (blue-yellow). Red (R:178, G:65, B:80) and purple (R:150, G:89, B:142) colors are mostly preferred following blue-yellow scheme. Therefore, instead of direct complementary ones, split complementary schemes may be used in the applications. When exposed to similar schemes on computer, most of the subjects encountered the problem of simultaneous contrast and could not differentiate some of the

colors. Same situation is evident on courts with two colors (when the color of outside area is different than inside of boundary lines). If it is not the intention of the designer to make a differentiation between outside and inside area of a court, i.e. making the inner court color visually more saturated or dull, then the interaction of the used colors may create visual fatigue during long run matches¹⁰. This can be prevented by using tones of the same color, however, tints and shades may again lead to visual fatigue as a result of visual adaptation problem. Westervelt states that green-red and green-beige schemes are the worst color combinations in terms of visual accuracy although they are most widely used court colors¹⁰. During the survey, some subjects stated that they perceive the balls differently in terms of size and sharpness. Although the ball is mostly perceived better on blue background, red and purple colors were regarded as taking the most attraction. This phenomenon will be discussed in the latter phases regarding television broadcasting issues and the camera filters used to balance perceptual components.

5. CONCLUSION

The aim in this study is to propose colors for hard surface tennis courts, which are exposed to a variety of colors with no reference to a color standard and devoid of game pace categories. Considering light source characteristics the purpose is to enhance visual accuracy and perceptual performance of the players and referees in today's tennis play. The results in the pilot study underlined the significance of using contrasting colors. Highly saturated contrast color combinations maintain clear evidence for visual performance, though they may lead to visual fatigue in long-term encounters.

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