Dice Design Respecting Player Preference for Colours and Contrast

ABSTRACT

Colours and contrast are significant for aesthetics and for readability reference leading to a need to identify the correlation between the player preference of colours in general and to game objects. The object chosen for the experiment is dice. Dice come in a variety of colours and designs and with its simple usability mechanics is a compelling object for investigation. These dice are examined for the correlation to players colour preferences and a set of contrasting dice are examined for their readability errors. It was found that the die with minimal contrast provides for more readability errors and greater time required to understand the roll. Furthermore, it has been identified that dice colour preference does not correlate with colour preference.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**; **Accessibility design and evaluation methods**; • **Software and its engineering** → Interactive games.

KEYWORDS

Dice fairness perception, Dice design preferences, Dice Design, Colour Preference

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1 INTRODUCTION

Colours are associated with perceptions, emotions, aesthetics, and usability. Colours have the power to introduce diversity in many shapes and forms. Colours invoke experience and emotion. A glorious day is a blue sky and an unfulfilled wish is a black hole. It is the millions of shades spread all over the sky, that make a sunset beautiful. Colours depict all moods and embrace emotion. Colours are joy and sadness, fantasy and reality, longings and achievements. Everything has colours: adventures, perceptions, hopes, failures, impressions, and experiences. Humans, by nature associate colours with life. Life, in brief, is a transition of colour.

Recognizing the enormous numbers of colours and their impact on our well being, this research is an effort towards understanding an individual's preference for game object colours. The question under investigation is, how much a player's preference of colours in general (such as in everyday life) is correlated to their preference for game object colours aesthetically. Though colours are also introduced to increase design clarity for users, our major focus is on identifying the preference correlation between general preferences and game object colour predilections.

Colours can speak for design usability as much as the designer wants them to illustrate. Cultural aspects must be taken into consideration while determining colours to represent a certain dimension of design usability. Games are artistic objects with aesthetic concerns which are best evaluated by human subjects testing. Anything can be a subject of aesthetics and colour is undoubtedly a significant component of art. Though colour preferences is a subjective matter, still research on colours and emotions have proved that common patterns exist between colour preferences and appreciation in particular contexts.

There has been enormous research on colour psychology and readers can find plenty of compelling investigations on this topic, a few examples are, Lee et al. [5] studies colour preferences among different age groups, Mohebbi [6] investigated colour preference in children based upon their gender, and Hanafy and Sanad [3] investigated colour preferences between groups of different educational backgrounds, and many more. Colour psychology is significant to dive into in order to find correlations among colour choices and human factors, affecting an individual's preference among colours. Though in-depth colour psychology, is beyond the scope of this research, we present a rather simple experiment that investigates if the individual's preference for certain colours also applies to a game object.

This study evaluates the colour roles in usability mechanics and aims to understand players' preferences of colours for game objects, aesthetically. The chosen object for this study is dice as they are familiar objects with clear usability and mechanics. Dice has been a significant element of games. The six-sided die has existed from antiquity and bone based pipped examples are seen dating from the Roman and Byzantine 1-3 Century, example in Figure 1, are little changed even in the 9-10 Century, an example in Figure 2. These dice could easily be used in the games of today, though would not be to the same levels of manufacturing quality to ensure the distribution.

Dice are manufactured in a variety of shapes, colours and sizes are fascinating for the game audience. Research on current trends of players' perception about the fairness of dice as they see dice of unusual shapes has been presented by Boschi et al. [1]. The results demonstrate that participants' preferences about dice usage are influenced by their past usability experience. The research participants considered those dice fair which they have seen or have interacted with previously. However, they also showed curiosity and interest in interacting with the dice, which appeared unusual in

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Figure 1: Bone Dice and Knuckle Bones from Byzantine Rome c. 1-3rd Century - Istanbul Archaeology Museums, Turkey - photo by authors

Figure 2: Dice from the Sarkel Fortress in Rostov Oblast c. 9-10th Century - State Hermitage Museum, St. Petersburg, Russia - photo by authors

design and aesthetics. Dice have also been examined in an academic context in regards to their usability for contrast and errors [7].

We aim to identify, how much an individual's choice for colours in daily life is inflicted upon, their choice for colours in-game objects. Furthermore, we also investigate colour contrast and die readability experience. In case if a player's preference for game object colours is synchronized with their colour preferences in general, game designers can utilize significant findings from colour psychology research to deduce their audiences' recent trends for colour predilections.

The experimental study elaborated in the following section examines the correlation of an individual's likeness pattern of colours in general with their selection of coloured dice to interact with.

2 EXPERIMENTS

The following sections describe the research methodology. All participants began by answering a short questionnaire about their age and gender.

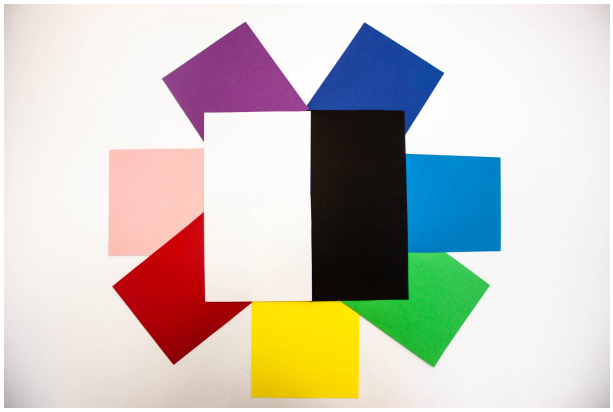


Figure 3: First phase - Papers for sorting in nine colours

Figure 4: First phase - The transparent dice in the same nine colours

2.1 Colour Blindness Test

The Ishihara colour blindness test has been chosen to identify visual impairment developed by Shinobu Ishihara [4]. The participants went through an online test "Ishihara colour blindness test" that contains 38 pseudo-isochromatic plates, each of them showing either a number or some lines [2]. According to what the individual can see and cannot, the test gives feedback on the degree of their red-green colour vision deficiency. The colour blind samples in the data are treated as outliers for this research.

2.2 Colour Preference

The participants were shown nine different colours on paper as shown in Figure 3. The colours include red, pink, yellow, white, green, light blue, dark blue, violet and black. The participants had to sort the papers from the most preferable colour to the least preferable in this set. Once the paper colours were sorted according

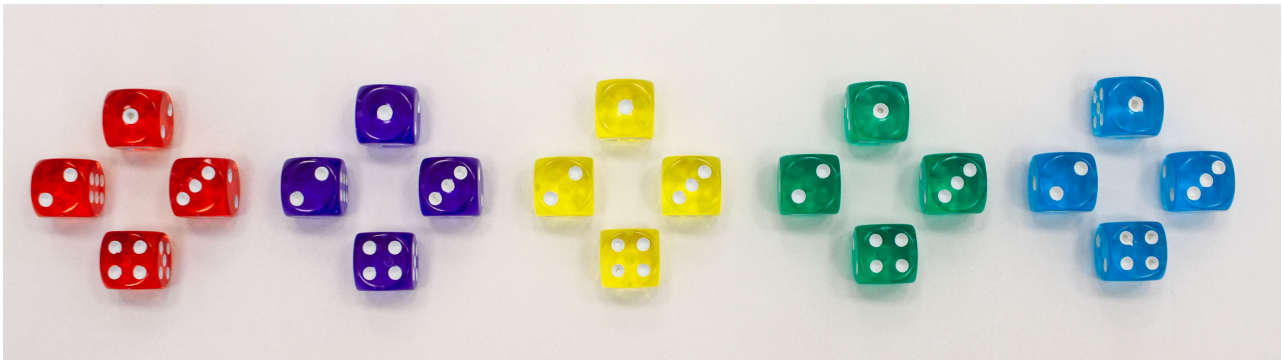


Figure 5: Second phase - sorting transparent dice in ascending/descending order

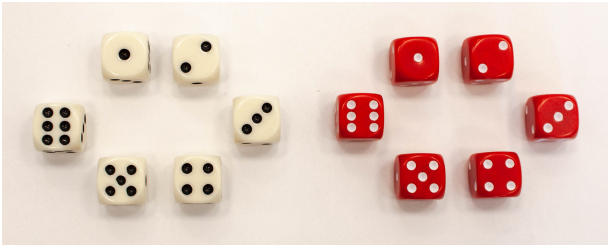


Figure 6: Second phase - sorting opaque dice in ascending/descending order

to the participant's preference, transparent dice of nine colours (same colours as shown with papers), Figure 4, were presented to the participant and were asked to sort them from the most preferable colour to the least preferable.

2.3 Colour Contrast and Dice Sorting

After identifying participants' preference of colours in general and to dice, the next step involves identifying, if different background colours of the dice with an apparently readable contrast affect the dice readability or not. For this, the participants were asked to sort four transparent dice of five colours including red, blue, purple, yellow and green in ascending order, see Figure 5. The sorting time was recorded by the timer and is done two times for each colour for more precision. Further, the participants were given opaque dice of two colours; red and white for sorting in ascending order, Figure 6.

2.4 Knockout Game and Die Readability

The third part of the study includes seven dice with unusual colour contrasts and a usual white six-sided die as shown in Figure 7 and Figure 8. Thirty participants with an average age of approximately twenty-one years were selected for the readability experiment. The participants were the students of Information Technology. The participants have spent approximately seven hours playing video games and three hours playing board games on average in the past thirty days. Furthermore, thirteen participants informed that they prefer video games over board games and seven participants prefer board games. Ten participants showed neutral response and like playing both digital and non-digital games. The experiment includes playing a knockout game with the observer with each die from the set in Figure 7. The observer selected a die, one by one, from eight dice and played the knockout game. The hypothesis under test is that contrast is the main reason that affects the readability of the die. The die in Figure 8 is the control die as it is commonly used and the most familiar one among all dice presented. The game starts with players choosing a number from one to six. The player rolls the die and *reads the outcome* once the die stops rolling. The one who rolls the opponents number first is the winner. During the game, the observer is counting as to how many times the participant got confused (such as, had to concentrate more while reading) and how many times they read the outcome incorrect.

3 EXPERIMENT RESULTS

We have the hypothesis that selections of colour preference of an individual should be linked to their colour preferences for dice. In order to examine this hypothesis in the study, we examine the colour arrangements for the number of differences. We will assume that given the extremely short period of time between the presentation of the slips of paper and of the dice, the emotional stability was not a factor which perturbed the ordering. In psychological tests such as Lüscher colour test, the participant, when presented with colours are asked to concentrate on colours in front of them and not think of colours that would suit them in dresses or they would like to see in other things. In our study, we asked participants to choose their preferred colours. The preference for a particular colour might result from their likeness of this colour because of other factors such as this is their favourite colour for clothes etc. The hypothesis under test is, how much an individual's choice of colours, in general, is reflected upon their choice for selecting dice from most favourite to least favourite colours.

For the difference calculation, we need to examine what is a difference in the arrangement so we can place a measure. We assume that people may forget a colour, add a new colour, substitute one colour for another. This is modelled well by the edit distance (also known as the Levenshtein distance) which looks at the minimal number of insertions, deletions, or substitutions to turn one string into another. We can also examine an extended version which allows for elements to be transposed or swapped. Now we have a measure on the difference, for each of the players, we find the difference between the string and produce a histogram. What we

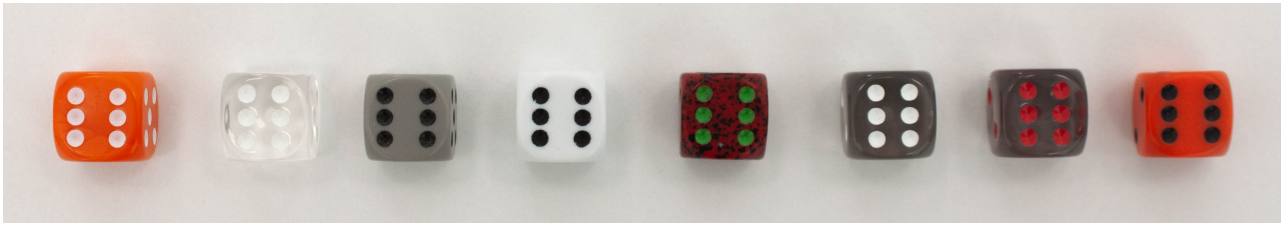


Figure 7: Unusual colour Contrast Dice for Playing Knockout

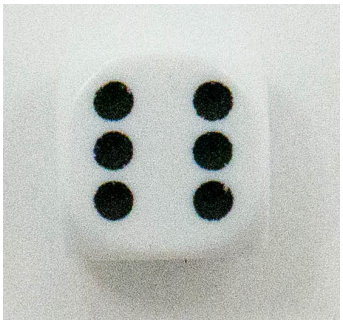


Figure 8: Control Die

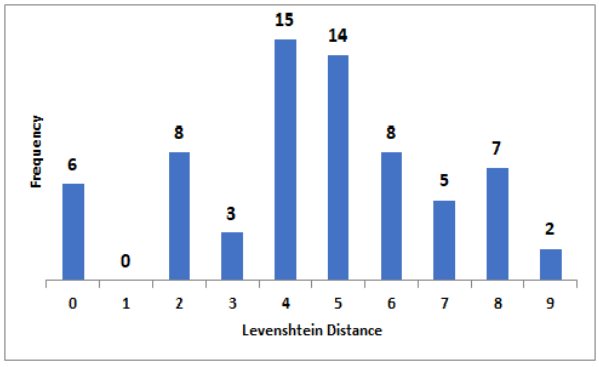


Figure 9: Levenshtein Distance calculated without Swapping

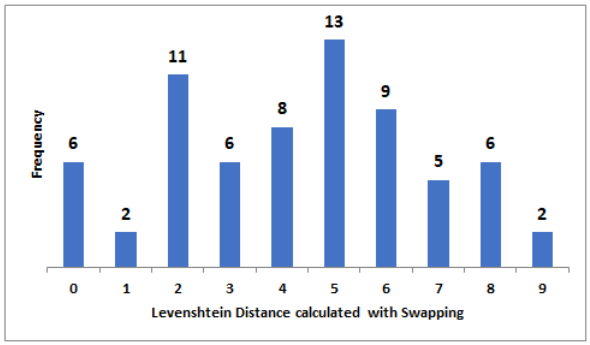


Figure 10: Levenshtein Distance calculated with Swapping

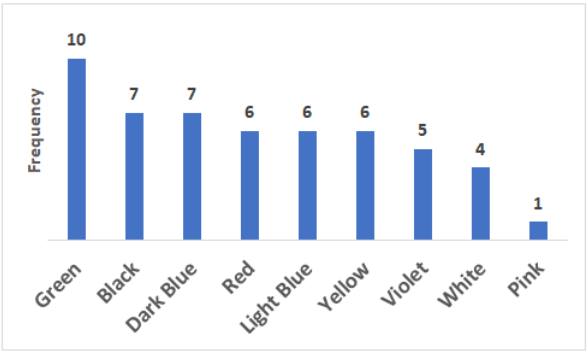


Figure 11: Replaced colours from first three preferences.

would expect to see if people's selection of colours, in general, is close to their selections on the dice is a histogram heavily weighted to low numbers of edits being required to turn one string into another, that disruption is very unlikely.

Examining the histograms in Figure 9 and Figure 10, we come to a result which violates our hypothesis, rather than seeing a high peak at the low end of perturbations, we see a peak at about the middle. Therefore, colour preference alone does not account for dice colour preference. But we should look at where the perturbation is happening in the string. Perhaps, it is that, people care more about their first choices of die colour being their favourite colour, or some early subset has importance.

However, examining the first choice of colour, only thirty-seven out of sixty-eight participants maintained their first colour choice between both paper and dice. The first three colour preferences both for paper and dice colours were examined and Figure 11 shows which colours were replaced from the first three while participants informed their preferences for dice colours. The new colours that were introduced in the first three colour set are shown in Figure 12. With the introduction of new colours, we could not see one dominant trend such as either moving to a darker colour from lighter ones or vice versa was significantly prominent than the other.

Based on these results, the colour preference seems to have a poor relation to dice colour preference. Given that these dice are of the same size, shape, weight, transparency, manufacturing company, etc. There is another factor in the minds of the participants rather than just enjoyment of colours. We believe it is, usability.

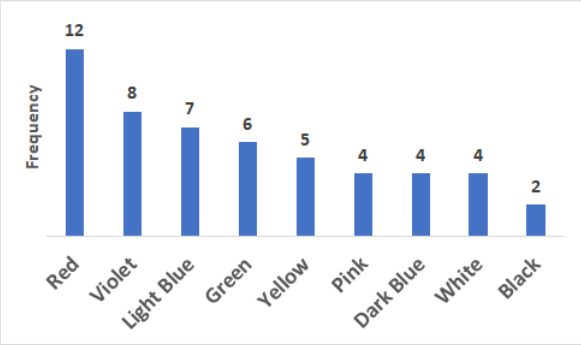


Figure 12: The new colours that are introduced while selecting favorite dice.

3.1 Results of the Sorting

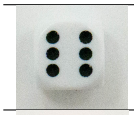
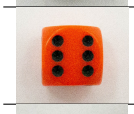
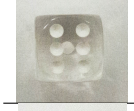
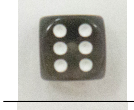
We took the average time of the sorting for all sixty-eight participants for each of the five types of dice and looked at a comparison via a one way repeated measures ANOVA, which found no statistically significant difference between the dice sorting times for the five transparent sets of dice or the opaque dice sets.

3.2 Knockout Game and Readability Errors

The results of the knockout game and dice readability experiment are demonstrated in Table 1. The maximum number of error, i.e. incorrect reading is two. The transparent die with white dots (3^{rd} row in Table 1) caused the most errors (two) and twenty-six times led participants to focus more on reading the outcome. The orange die with black dots caused one reading error. It is speculated to be because of the brightness of the orange shade.

The participants provided feedback on the ease of readability and informed that the control die, the usual white die with black dots, Figure 8, is the most comfortable to read in comparison to other dice presented. Participants considered transparent die with white dots (as shown in Table 1, 3^{rd} row), the most inconvenient to read. In context of colour desirability, transparent grey dice (both with white and red dots, 4^{th} and 8^{th} row in Table 1) were most fancied. The contrast of grey and white, as well as, grey and red, including the transparency of the dice appeared fashionable and neat to participants and therefore caught attention. Though the transparent white die with white dots was the most difficult to read, participants were enthusiastic about it and called it exotic and interesting.

The analysis needs extended testing to discern a particular colour contrast as providing a hindrance to smooth reading of die roll. The results obtained so far clarify the significance of colour contrast selection for game designs. Dice being a prominent article in games requires consideration upon design dimensions to avoid unnecessary complications with usability during gameplay.

Die	# of Errors	# of Confusions
	0	0
	1	0
	2	26
	0	0
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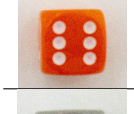	0	2
	0	0
	0	2

Table 1: Dice with Error and Confusion rate - Error refers to Incorrect Reading and Confusion refers to Correct Reading but Required more Concentration

4 CONCLUSIONS

The die has been selected for the investigation as it comes in a variety of colours and is easy to interact with. The study results do not demonstrate a similar pattern between the colour preference and the dice colour preference. The unusual dice contrast was pleasing for the players, they also informed on the inconvenience of reading with a die having minimal contrast.

The methodology presented in this paper is advantageous for the designers to identify colour impacts and associations with player experience and usability. A simple affair such as a colour contrast has the capacity to induce frustration into the player's interaction with the game design.

The results demonstrate a poor correlation between the player preference of colours to their favourite dice colours. This supports the understanding that players in gameplay are: 1) compelled towards different choices, 2) are impersonate to be risky, 3) and adventurous to be different from their personality traits. Games provide a stage to be diverse and our research work suggests future dimensions such as, to consider and investigate not just players' preferences but giving them the opportunity to be diverse in gameplay.

Colours are significant from both dimensions of *possible error introduction* and *making an interaction pleasant*. It is a trade-off as most aesthetically appealing design and colours might not give a

smooth usability interaction. The decision lies with a designer's priority and goals for the game and its players.

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