Player Perceptions of Fairness in Oddly Shaped Dice

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ABSTRACT

Dice since the classical era have been some of the most popular object in games, with examples of six sized dice as we know them found in Egyptian grave goods and Roman burials. Over more than a millennium they have seen diversification. How people have adjusted to, affected by, or embraced these modifications is a subject of this paper. The study presented investigates people's perception of fairness in a pair of dice with a 2D6 distribution. Three pair of dice were presented, each modeling the distribution and proven mathematically to be fair, to the participants and they were asked about their opinion regarding the fairness of these dice. Participants were then able to use the dice via playing the game snakes and ladders. The results so far suggests variety of opinions regarding people's perception of fairness. The study also revealed that participants sometimes preferred to play with the dice they did not consider fair because of the unusual design of the dice or because in the dice rolls, they were getting higher numbers as outcomes.

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

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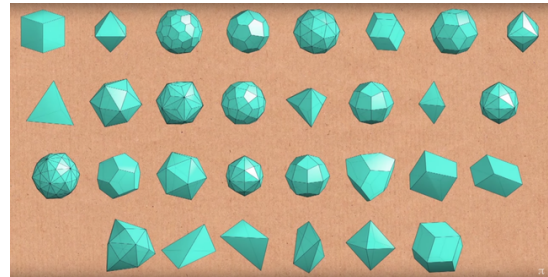[†]
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Figure 1: Thirty Euclidean shapes, symmetric both by faces and edges[8].

1 INTRODUCTION

Dice with pips and symbols made from different materials such as bones, ivory, and stones, close to the ones seen today, have been found in Egyptian burial tombs [9], remains from native American tribes, and in artifacts of the Greek and Roman antiquity [10]. Fairness in a game can be defined as equality of opportunity to win as well as to make a mistake or the right move. A dice is fair if each face has the same probability to outcome. As Diaconis and Keller [4] explain, a die to be fair must have symmetry. It needs to be symmetrical both by faces and edges. This means that with a reflection or a rotation, any face can be transformed into another one. There are thirty shapes discovered by Euclid with these characteristics as shown in Figure 1.

A die can be fair and unfair and consequently, players have a perception of fairness in a die. Perception is a word that derives from the Latin 'perceptio', and it refers to the organization and interpretation of all the information provided by our senses in order to understand and predict the presented information or environment [14] [12]. This process is directed by the nervous system and divided into two parts: first, the data from our senses is processed by the brain, and then it is altered by our knowledge, past experience and expectations [1] [14]. The Perception of fairness in a dice is broadly affected by six factors. These are shape, color, size, manufacturing quality, symbol on a die and past experience. Yermolaieva and Brown [16] demonstrate that majority of participants in their experiment think that a die with a different size than the usual is harder to control. In the content of dice control, John G. Brokopp [3] discusses, people think that they can control the dice toss just by setting the dice before tossing them and limit the rotational characteristic. For this reason, casino tables have a side textured

with rubber pyramids, and dice need to hit this wall that change direction and strength to be valid [3]. One of the most famous term to describe this technique is "slider". Focusing on symbol, Watson et al. [13] discovered that most of the people declared a die unfair just because it had unusual combination of numbers on its faces (in that experiment it had only the numbers 1, 2 and 3 repeated twice).

It can be generalized that people' s perception is influenced if a die is different from the usual, and as Yermolaieva and Brown [16] elaborate, most of the participants in their experiment had problems reading the result of die if it had different symbols. Isaksen et al. [6] presents a detailed analysis of dice rolls and its relation to a balanced game. The authors have presented a new attribute, *closeness* that indicates how far or near the game result was from the tie situation. Various experiments have been conducted to demonstrate which situations and rule change with a dice roll game can result in a more or less win bias. Considering perception and past experience, from Watson et al. study [13] it emerges that most people believe, some numbers have less probability of outcome, mostly 5 or 6, because these are the numbers usually needed in games to win. Consequently, we speculate that anyone with some basic knowledge about dice, can think a die is unfair if its shape is not symmetrical. On the contrary, even people with no knowledge about dice fairness might declare a die unfair just because its shape is different from the usual one.

The study presented in this paper brings into discussion the most profound object in games, Dice, and advance our understanding of how much player's perception and opinions have been changed or adjusted regarding the characteristics and usability preferences of this object. The following sections details experimental setup, analysis of outcomes and finally the last section concludes the paper with the future work outline.

2 EXPERIMENT

The following sections elaborate on each step of the experiment.

2.1 Initial Survey

The study start by a general questionnaire about participant's profession, age, gender, and their interest in video games and board games. For this the participants were asked about their gaming hours in the past thirty days and which kind of games they prefer to play or have played. The last question of this first part is: "What is fairness of die in your opinion in general?"

2.2 A Priori Questions on Fairness

The second part of the study includes putting three pairs of dice, see figure 2, 3 and 4 (all three pair of dice are fair but participants were not informed in the beginning of the experiment) on the table in-front of the participant, all of the same color but with different shapes, each time in a different order in order to avoid bias.

The participants informed which dice they think are fair and which are unfair and why they consider them to be fair or unfair. The participants were free to select more than one type of dice for this question. The responses from the participants were being recorded by the observer. The last question for this step was, which type of dice from the presented set, would they prefer to use if they

Figure 2: Normal dice used in the experiment. Photo by authors.

Figure 3: Skewed dice used in the experiment. Photo by authors.

Figure 4: Unusual dice used in the experiment. Photo by authors.

had to play a game requiring a dice roll? For this question, participant had to pick one type of dice from the three types presented.

2.3 Dice Usability

As depicted by a recent research, most of our neurons are multisensory [7] and in our study, we provided participants, a possibility to use as many sensors as possible via playing a game. The participant's perception of the fairness of die might change depending on, what they see, if they touch the die, form the sound and any other factor felt by the brain. Each participant is asked to play the famous board game "Snakes and Ladders", three times, each time with a different pair of dice in the order they were presented by the observer. Before playing the game each participant was given

the option to use a cup to roll dice. The game rules were modified to reduce play time such as in order to end the game the player can go over the final square if the dice roll shows bigger number than required to be on the final square. This also prevents fatigue on part of the participant. The game, "Snakes and Ladders" has been chosen because it is well known among people and it does not require equipments other than dice and board. Snakes and Ladders originated in ancient India, and it was known with the name of Moksha Patamu. The game reached Europe in the last years of the 19th century [2] [5] [11] [15]. Factors such as game's popularity, ease of play, and a lot of interaction with dice via rolling and reading outcomes makes it a suitable option for our research.

2.4 Re-evaluation of Fairness Opinion after Dice Usage

Participants are again asked about their perception of fairness in dice, if it has been changed after playing with all the dice. The last question is, which pair would they prefer to use in the play. Again (as in second part of the experiment) they had to pick one type from the three dice pairs presented. There was no restriction imposed on selecting a dice based upon their opinions of fairness, the preference could be related to fairness or just the liking of the design of the dice.

3 EXPERIMENT RESULTS

The study includes sixty-five participants, forty-eight males and seventeen females between eighteen and fifty-seven years old. In terms of game play, participants have spent approximately five hours on average playing board games and thirteen hours on average playing video games. The most preferred board games are chess and group game, while the preferred video games are Shooters, MOBA and simulation. We received permission from the ethics board of Innopolis for this experiment, all responses were anonymous and taken in accordance with local privacy laws and ethical standards.

3.1 Analysis

The majority of the participants consider a die to be fair if there is an equal probability of the occurrence of all faces of the die. Others mentioned symmetry of shape and made some considerations about weight and emotions, that could afflict the perception of a die being fair or not.

Some participants mentioned, they never thought an unfair dice could exist, and declared all the dice fair. Some participants rolled the dice to inquire which are fair and unfair. From the first phase(section 2.2) of the experiment, 96.9 percent of the people declared normal die as fair, 45.3 percent considered skewed die fair and 40.6 percent, the unusual. The main reason of the choice about normal dice was, all people were already familiar of it.

The decision about the unusual die (figure 4) was mostly unfair because of the repeated numbers on the die. For both unusual and skewed dice, majority of participants declared them unfair because of the shape that did not seem symmetric. There were also some considerations about the weight of the die. The response from the last question of the first part of the experiment (discussed in section 2.2), where people had to choose a single pair of dice, they would

prefer playing with, are the following: 23.1 percent selected the unusual, 20.0 percent the skewed and 56.9 percent, the normal dice.

After playing the game, Snakes and Ladders, with all three pairs of dice, participants responses yield that 96.9 percent claim normal dice to be fair, 64.6 percent considered skewed dice are fair and 52.3 percent of people thought unusual dice are fair. The number of participants along with their responses are shown in Table 1. The opinion about normal dice is almost the same, while for unusual and skewed the amount of people who consider them fair is much higher. The main reason of the difference in opinion after trying the dice are the numbers that came up as outcomes of the dice roll. The average number of throws to finish the game is 7 with normal and skewed dice, and 8 with unusual dice. Dice rolls that gave high or especially low number many times were considered unfair, while dice with variety of outcomes were considered fair.

Some participants also did not change their opinion about dice fairness as they thought it requires high number of dice rolls to verify the fairness of a die. Few participants also tried to control the roll, and after not succeeding, they considered the dice fair. Regarding participant's preferences about using a cup for a roll or rolling with hand, 89.2 percent of people used hands to roll the dice, 7.7 percent used the cup and only two people used a box.

From the last part of the experiment (subsection, 2.4), where participants again had to select one type from the three types of dice to play a game with, the results show that 38.5 percent of people preferred the skewed dice, 38.5 percent the normal dice and 23.1 percent the unusual dice.

The primary reason for the selection of normal dice is because they are the most familiar ones and are easy to understand. The main reason about choosing the unusual and skewed dice is the curiosity and the fun, and many participants also expressed that with the same fairness opinion about both skewed and normal dice, they would prefer skewed dice because they are strange in appearance.

Significant to consider, majority of participants gave high importance to the events of the game such as, the most preferred dice were the dice which resulted in less number of tosses to win the game.
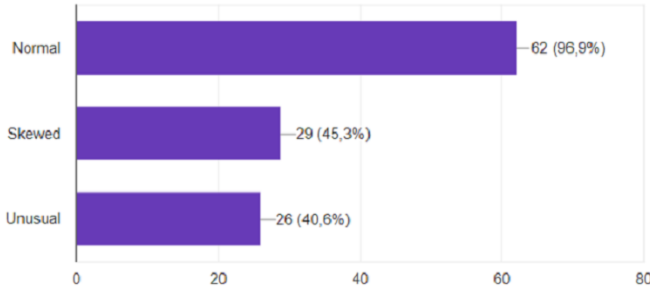
Data analysis using two tailed p- value, participants views (figures 5 and 6) were unaffected on the normal dice. More found the skewed dice to be fair after using them at a statically significant level (p=0.0209). While more participants found the unusual dice to be fair after use, it was not a statistically significant effect (p=0.1587).

3.2 Observational Analysis

An interesting observation from the experiment is, participants choosing those dice for the game play, they considered not fair. There are eight participants who have preferred unfair dice(unfair in their opinion) to play the game. Two of these have chosen unfair dice because it appeared funny to them. One of the participant chose because of curiosity. Two other participants chose because they wanted to try and confirm if the dice are fair or not. One participant chose an unfair die because he said that all dice are unfair and it is all about luck, and he chose the normal dice because it is the most common. Another participant made his choice considering the dice, which provided highest results after tossing. The participant did

Table 1: Playtest Results

	Number of people considering the dice fair before playing the game (65 in total)	Number of people considering the dice unfair before playing the game (65 in total)	Number of people that selected the dice before playing the game (65 in total)	Number of people considering the dice fair after playing the game (65 in total)	Number of people considering the dice unfair after playing the game (65 in total)	Number of people that selected the dice after playing the game (65 in total)
Normal	22	0	37	13	2	26
Skewed	0	12	13	0	9	24
Unusual	1	18	15	1	18	15
Normal and Skewed	17	1	0	18	0	0
Normal and Unusual	12	0	0	9	0	0
Unusual and Skewed	0	21	0	1	13	0
Normal, Skewed and Unusual	12	1	0	23	0	0

Figure 5: The resulting graph of the dice declared fair by participants before the experiment.
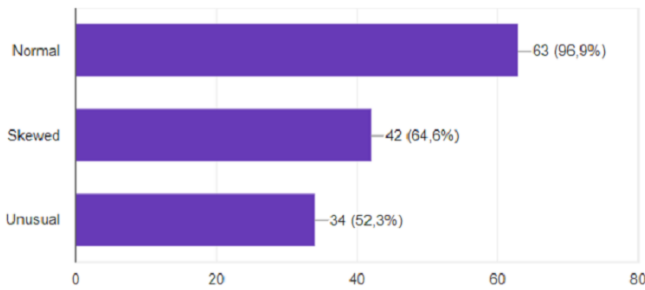
Figure 6: The resulting graph of the dice declared fair by participants after the experiment.

not care about how many throws he needed to win, but analyzing each throw itself. One participant made his choice considering his past experience, because he usually uses a dice with 12 faces while he plays Dungeon And Dragons. We could observe that winning the game in less number of throws was not always the motivation for the participants. The dice selection decisions were influenced by emotions, curiosity and past experience on dice usage.

Considering participants emotions and feedback, we could notice various reactions from people. Some people seemed bored, because they did not find the game interesting. Other people were curious and informed, they have never thought about the fairness in dice, and at the end of the experiment they wanted to know which dice were actually fair. In two cases, the participant asked if they could play against someone, to make the game more interesting.

Analyzing the emotions, we conclude that most of the participants were actually surprised from the skewed dice more than any other, because the shape is strange and unusual for them. Despite that, most of the participants liked them, because they are funny and pretty comfortable to hold.

Another consideration made by many participants, is about the edges of the dice. Some participants explained that normal dice are easier for them to roll on the table because of the edges, and consequently roll is harder to control. In case of sharp sharp edges like in the skewed dice, it is easier to set up the dice before throwing it.

Participant provided feedback on the context of the dice usage, and informed, they would pick a different dice depending on the usage context. As an example, if they bet money, they would prefer a fair die, but for a game they could choose an unfair dice just for curiosity.

The analysis summarize that people prefer things that they already know and they are used to of, as demonstrated by majority of the participants who declared normal dice fair.

4 CONCLUSIONS AND FUTURE WORK

The perception of fairness in a die study has highlighted many factors that broadens the understanding of people's preferences about dice.

The results so far from the available sample size suggest that participant's preference were influenced by their dice usage experience. Majority of the participants considered the type of die fair, which they have used mostly.

The results further inform that participants showed interest in using dice which were unfair in their opinion because of the curiosity or the likeness of the design of the dice. Participants perception about fairness of dice (when they just looked at the dice) also changed when they rolled the dice.

The study is bringing insight into dice design and and how it impacts peoples perception of fairness for the dice. In future work, an increased sample size to the study would be able to highlight concrete findings. Further, we should explore cultural differences by examinations of these results from users in other countries.

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