Visual grouping: a study on preponderances of color or shape in Match-three games

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ABSTRACT

A category of entertainment that stands out for its popularity is the Match-three electronic games, in which the player needs to form groups of, at least, three similar objects to score points. Thus, the study of how players perceive visual groupings becomes an important tool for future developments. This research investigated color and shape relationships in Match-three games, looking for preponderances in the visual grouping of color or shape in the psycho and neurological response. For this, a bibliographic and an empirical research were carried out. A beta and a final version of two Match-three games, created for this research, were applied to a sample of 52 people. One of the games was black and white with different shapes, and the other, colored formed only with one shape. Results of the bibliographical research indicated that the perception of visual grouping of color and shape depend on the elements with which it is interacting in the visual field, and this determines if one type of grouping will be perceived with prominence. The empirical research showed that, for the category of games studied, visual groupings of color are perceived more quickly and more easily than visual groupings of form.

KEYWORDS Design for Games, Color, Form, Visual Grouping, Match-three Games.

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1. Introduction

A type of entertainment that grew with the spread of smartphones (Coutinho 2014) were digital mobile games (Gualà et al. 2014), and the popularization of the category of Match-three games still stands out in Brazil (Fig. 1).

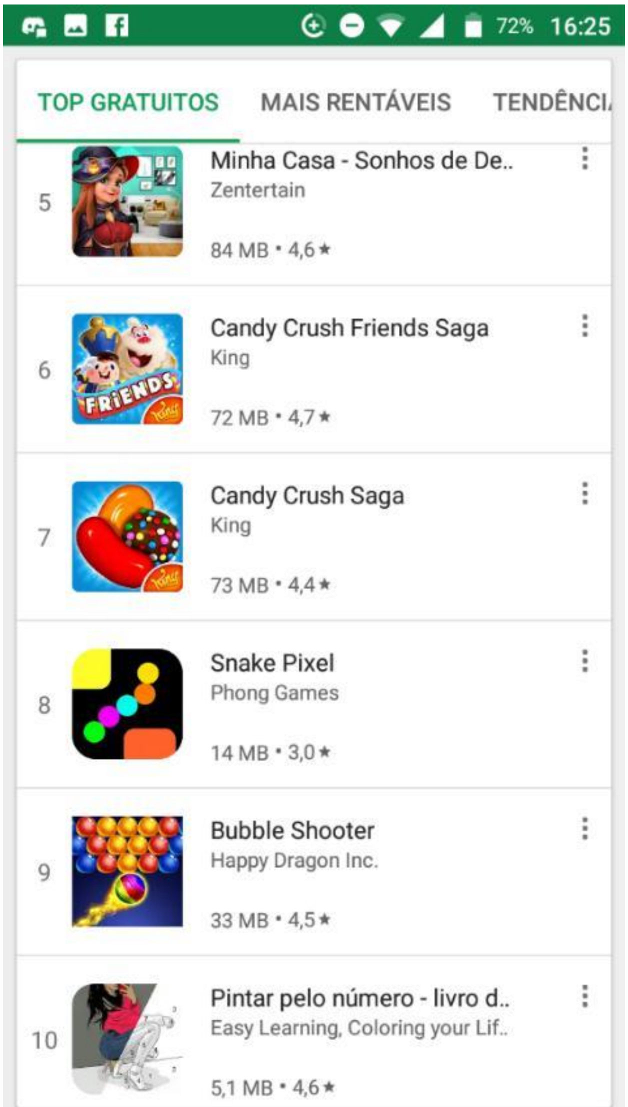

Fig. 1. Printscreen of ranking of most downloaded casual games in Brazil, from the 'Google Play' platform at 02 November 2018 [1].

For people with normal vision, the perception of visual groupings is the most important part to be observed in the mechanics of this type of game, as its dynamics is limited to making groupings of at least three similar icons by color or shape to score (Fig. 2) (Juul 2010).

This study aimed to understand the response in relation to visual groupings of color and shape and visual comfort in the scenario of digital games of this type.

Fig. 2. Printscreen of 'Candy Crush' game, an example of Match-three game [2].

1.1. *Visual grouping in psychology and visual language*

Visual perception is defined in modern psychology as an active combination of sensorially received stimuli and organic interpretation, which organizes and relates them to previous experiences (Dondis 2007).

Arnheim (2008) affirms that visual groupings can be perceived by similarity, proximity, clarity, configuration, direction, speed, consistency (regular, homogeneous) and contiguity (merged forms that are seen as unique).

The author indicates that color and shape belong to the same grouping perception, the similarity one. He highlights that depending on how the objects are related in the visual field, they will be seen more or less united: "A visual object is all the more unitary the more closely its elements are in factors such as color, clarity, speed and direction of movement." (Arnheim 2008, pp. 79)

Kepes (1944) determines that a visual grouping can be perceived through two factors: similarity due to the object's own quality or proximity. This author affirms that similarity groups appear to be perceived as more unified than groups formed by proximity. For Dondis (2007), in contrast, proximity is more important than similarity.

The three authors, Anheim (2008), Dondis (2007) and Kepes (1944) place color and shape as characteristics belonging to the same type of visual grouping, which is similarity.

1.2. *Visual grouping on neurologic studies*

For neuroscience, the difference in the perception of color and shape clusters directly depends on the way the brain perceives, processes and relates these two types of visual stimuli. Several studies debate whether color and shape are perceived in different regions of the brain or whether they are processed by the same group of neurons. This affects the understanding of speed and the way visual information is perceived (Aymoz and Viviani 2001).

In an experiment carried out by Moutoussis and Zeki (1997 apud Rentzeperis et al. 2014), the authors understand that different visual attributes presented at the same time may not be perceived simultaneously, which would indicate different ways of processing.

The Moutoussis and Zeki ‘color and form experiment’ consisted of presenting a screen to some participants, half of which was colored with a checkerboard pattern that alternated between red and green, and the other half with gray bars alternating the inclination from left to right.

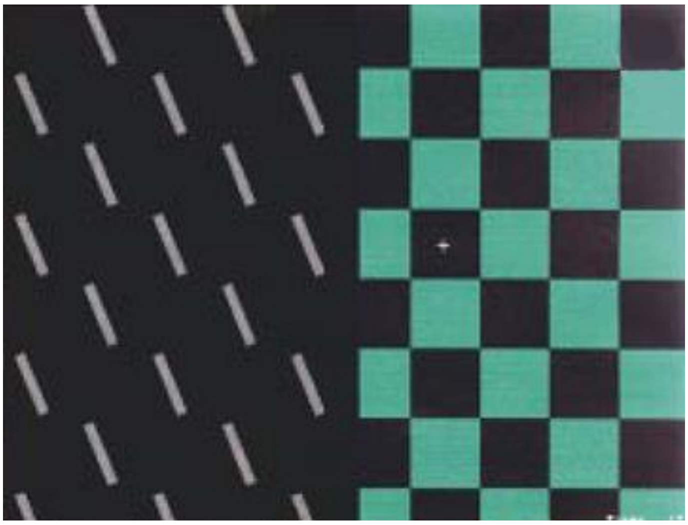

Fig. 3. The ‘color and form experiment’ of Moutoussis and Zeki from ‘Functional segregation and temporal hierarchy of the visual perceptive systems (1997)’.

The participants had to combine the colors of the squares with the orientation of the bars that were presented simultaneously. The changes in color and orientation occurred in the same proportion, presented at various phase differences (0-360º, varied in steps of 10º, randomly). For some of these differences, the sensed color and form values were different from the real ones. The temporal disparity then indicated that colors were perceived approximately 63 milliseconds before form (Moutoussis and Zeki 1997).

In another experiment, Aymoz and Viviani (2001), tested 20 students at the University of Geneva with normal vision. Participants were located 50 cm from a computer monitor and had their responses to stimuli monitored by a standard graphics program.

The experiment investigated the processing of three visual attributes: color, shape and movement. There were three conditions, one for each possible pairing of these attributes. Stimuli were combinations of two values for each attribute (red / green, circle / square, fixed / mobile). In each condition, the stimuli changed twice quickly, each attribute changing asynchronously between the two possible values. The participant should inform which change he perceives first (Aymoz and Viviani 2001).

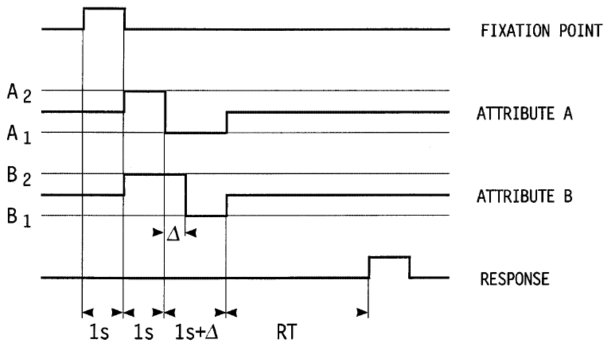

Fig. 4. Aymoz and Viviani experiments (2001). Timing of the events within trials. A1 and A2 (B1 and B2) are the two possible values of the stimulus attributes A and B. In this example, the initial stimulus (A2B2) lasts for 1 s, changes into the intermediate stimulus (A1B2) which lasts for Δ ms (SOA), and is finally transformed into the final stimulus (A1B1) which lasts 1 s.

With the experiment, they computed 13 values of asynchrony, and transformed them into estimates of perceived time. The results showed that color and shape are processed almost simultaneously, and the perception of movement is delayed by about 50 milliseconds (Aymoz and Viviani 2001).

Clifford et al. (2003 apud Rentzeperis et al. 2014) tested the perception of color and orientation using sinusoidal gratings oscillating in color and orientation at the same time frequency and for a series of phase differences. They discovered that, depending on the speed of presentation of the forms, the asynchrony of perception changed.

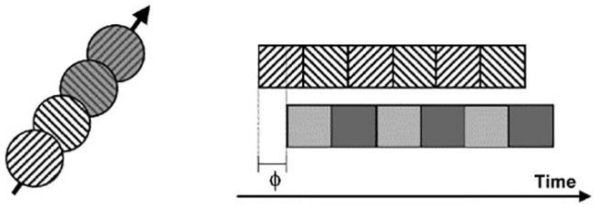

Fig. 5. Clifford et al. (2003) experiment at an oscillation period of 600 ms as a function of the relative phase of oscillation (ϕ).

It was found that for faster presentation rates, color and orientation were perceived at the same time, however, as the frequency of presentation decreased, the asynchrony between color and orientation increased. In the 1 Hz presentation, color perception preceded orientation in 50 milliseconds.

To explain the difference in perception in the two different contexts, Rosenholtz et al. (2012 apud Rentzeperis et al. 2014) propose a psychophysical model in which, depending on the target object of the vision, the vision system considers or disregards the rest of the visual plane, whether the eyes are looking for something in the scene or just following a target and disregarding the rest.

This disregard is closely linked to the locations in the brain where information will be processed. It can be processed together (color and shape), which would mean the same preponderance in the cognitive response, or processed separately, which would cause a difference in processing time.

Thus, studies move towards the understanding that, depending on the context and the relationships involved, neurons work in different ways (parallel or serial) and in different brain locations. Thus it is possible to state only that, depending on the interaction, different preponderances between color or shape will be noticed in the visual grouping.

2. Empirical Research

To understand the relationship of preponderance in visual groupings of color and shape in Match-three games, two games and a qualitative questionnaire were developed by the authors to test the speed with which players group similar sets.

One of the games applied was black and white, with well-defined shapes (square, circle, rhombus and triangle). The other was polychromatic (multiple hues), with only one shape (circles) of pure RGB hues (yellow, blue, red and green), with the same brightness and saturation.

The games and the questionnaire were applied to a sample of 52 people, between 18 and 30 years old, attending higher education at ESPM College in São Paulo, Brazil. Female and male individuals were tested, equally divided into 2 groups, with each group containing 26 people. The selected subjects claimed not to have color blindness or any other compromising chromatic pathology.

The tests had a determined order of application, half of the tested people started playing the first, the other half the second game, so that the learning of the mechanics did not influence the speed of resolution of the objectives.

Each group of 26 was divided into two new groups of 13 people, who alternated the game initially tested (13 started with game 1, the rest with game 2).

The average resolution speed of each game was compared in order to understand possible preponderances in the cognitive response of color and shape grouping.

Before the final tests, a beta test was carried out to detect aspects that could be improved. Regarding the application of the tests and methodology, the sample used was 12 people, 6 males and 6 females.

A qualitative questionnaire for data collection was carried out at the end of each test. It asked the name of the individual for further identification of the data, age, biological sex and the following questions:

- Which one of the two games, black and white or color, did you find easier to group? Why?
- Which of the two games did you find most pleasing to see? Why?
- Did you notice anything different in the way you perceived the groupings in the two games?
- Do you have any observations or suggestions? If so, which one?

3. Game development

The games were programmed on the game engine ‘Unity 3D’, with the aid of a basic free code for Match-three game from the blog Dimitris-Ilias Gkanatsios [3]. A programmer (Mario Sérgio Affonso Junior) was hired to assist in the preparation of the two games. The visual part of the games was developed with the Adobe Illustrator vector image program.

Both games work the same way, having the same programming code, just changing the visual part, ensuring that the two tests had the same level of complexity.

At the end of each game, the game program automatically generates a report informing the number of groupings made, name and time in order to better organize the information collected. The groupings that are considered in the report are those of moves made manually, that is, formations that occur in a chain are not counted.

Both games have a black background and differ from other games in the Market that have complex and/or textured backgrounds. However, this form of presentation was chosen to isolate the object of this research, in this case, the color and shape groups, without distractions.

For the empirical test, the authors intended to create greater contrast between figure and background. According to Csillag (2015), light colors are perceived prominently in contrast to a black background. This way, it was decided to use figures with 100% brightness on a black background.

For the black and white game, four basic shapes were chosen: square, rhombus, circle and triangle. The square had reduced height in comparison to the other geometric shapes in order to appear the same amount of empty area around it, guaranteeing the perception of individuality when close to other squares. Thus, as previously explained, it is also possible to form visual groupings by proximity of items but the objective of our study is the grouping by similarity.

Both the colored and the black and white game have 100% brightness of their items and a black background (R = 0 G = 0 B = 0; # 000000), in order to obtain equivalent contrasts.

Both games have a home screen where information about the participants is given, such as name, biological gender and the option of the game being colored or monochrome.

After selecting one of the games to play (previously determined), a preparation screen will appear for the player, with the intention of allowing the player to decide when to start the game.

The two games have a 30-second timer on the upper portion of the screen (Fig. 4 and 5), indicating the time remaining to group the largest possible number of similars. The stopwatch was implemented as the limiting mechanic of these games.

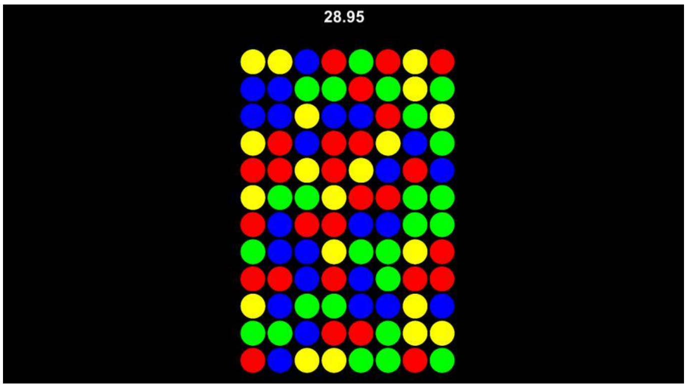

Fig. 6. Printscreen of the colorful game designed by the authors.

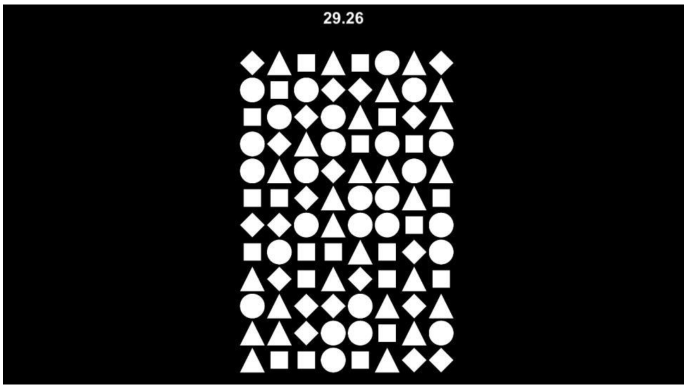

Fig. 7. Printscreen of the black and white game designed by the authors.

After the 30 seconds of the stopwatch, a game over screen will appear indicating the end of time, with the possibility of returning to the home menu and starting the other game.

4. Beta test

A beta-test was carried out, before the final tests, in order to check if there was a need for adjustment in both games and in the questionnaire.

It was found that the visual groupings of color (125 combinations in total) were better perceived by users compared to those of shapes (91 combinations in total).

Nuisances with the saturation of the colored game have been described by the players, however the modification of this parameter was not perceived relevant, because despite the discomfort, the results indicated that the perception of visual groupings by color remained prevalent. Instead of discomfort, other players described that the saturated color becomes important for a good differentiation of the hues.

The beta test revealed that the “game over” screen caused a negative feeling in the players, therefore, the red “game over” was replaced by “end of the test”. With this change, this bad feeling, which could change the test results subsequent to the first game, was overcome.

5. Final tests

At the beginning of the test, respondents were asked if they had any type of pathology that compromised their visual understanding of color or shape. In addition, permission to collect data was requested by completing two copies of a consent form. After that, a brief explanation of how the tests worked and how to perform the combinations in the game was given.

At the end of the test with the games, the qualitative questionnaire was administered through Google Forms.

The final games found that visual color groups were perceived more quickly by players, as soon as the programs accounted for a total of 644 color grouping and 435 form grouping made by the participants.

These results were made up of 47 people (90%) who make more color groups than form, 3 females and 1 male (8%) who made more combinations by shape than by color, and 1 female (2%) who made equal combinations in games of color and shape.

A little difference was noted between the number of combinations made by male and female players in both games. In the color game the male respondents made 333 combinations, while the female respondents made 311. In the black and white game, the male respondents made 221 combinations and the female 214.

It may be concluded that, even though male participants had made more combinations, the preponderance in combinations of the colorful game is perceived, in both sexes.

The qualitative questionnaire based on the players perception also demonstrated greater facility and comfort to make colored groups.

For the question: “Which one of the two games, black and white or color, did you find it easier to group? Why?”, 90% of respondents (47 people) replied that they preferred colored groups, 8% shaped ones (4 people) and 2% (1 person) presented an incongruous answer.

For people who responded that they had a preference for colored groupings, the following aspects were highlighted: greater visuality, more visible the groupings, ease of grouping, easy assimilation, more agile, more attractive, forms not sufficient to integrate the player and the game, and greater emphasis in perception.

For people who responded that they preferred shape groupings, the following aspects were highlighted: shapes are easier to differentiate, shapes help to group, more pleasant to play with less intensity than color and colors cause confusion.

For the question: “Which one of the two games did you find most pleasing to the eye? Why?”, 79% of those surveyed (41 people) replied that they preferred the colored game, 21% the form game (11 people).

It was highlighted that for the color test: there is more familiarity in playing colorful games, it is easier to understand the possible combinations, you can better identify the colors, the homogeneous shapes and saturated colors help, it is better to see, livelier and happy, better mental organization, there is greater visibility, more homogeneous space between shapes, it is more intuitive, more attractive, more flashy and inviting, because it is colorful it is more beautiful, the shapes were not enough to cause ‘integration’ with the game, greater differentiation and visualization, the black and white game it is more confusing and difficult to concentrate, color highlights the vision more, ‘it hurts’ less the eyes, greater similarity in the grouping, less effort to group, in the form everything is mixed.

For the black and white test, the highlight was: the colored game confuses the vision, which is more pleasant, which caused relaxation and making the test less intense, personal preference for black and white, too saturated colors, more aesthetically pleasing, in the color game, the contrasts were unpleasant.

For the questions: ‘Did you notice anything different in the way you perceived the groupings in the two games?’ and ‘Do you have any observations or suggestions? If so, which one?’, not all participants had observations to make, the observations made stand out from the points already presented, as shown below.

In the black and white game: A 20 years old (20 y.) male (M) needed greater concentration to find the combinations. A 20 years old (20 y.) female (F) person noticed that she made combinations from the tips of the shapes and thinks that she did not make many combinations with the circles. A player (M, 19 y.) said that everything is perceived as a unique visual mass. Another player (F, 22 y.) ‘fright’ when the white shapes appear. Other one (F, 22 y.) took a long time to "understand" the shapes.

In the color game: a person (F, 18 y.) said finding the blue circle was easier. Other one (M, 21 y.) saw the feedback of groupings was more visible. A player (M, 18 y.) used the intensity of the colors to form combinations. Other one (F, 22 y.) felt easier to play with equal shapes. Another (M, 21 y.) thought that perceiving colors is more natural than thinking about which shapes are identical. A participant (M, 19 y.) said that he managed to form "color spots" that facilitated the game.

Overall: One player (F, 21 y.) found the tests very fast and other one (M, 19 y.) thought it would be beneficial for the game to combine colors with shapes.

6. Final Considerations

The previously cited visual language and psychologic studies of Arnheim (2008), Dondis (2007) and Kepes (1944), show that color and form belong to the similarity aspect of visual groupings, and the greater the resemblance, the greater the perception of grouping.

In addition, the previously cited neurologic studies of Aymoz and Viviani (2001), Clifford et al. (2003 apud Rentzeperis et al. 2014), Moutoussis, K. and Zeki, S. (1997) and Rosenholtz et al. (2012 apud Rentzeperis et al. 2014), show that sometimes color and form are perceived without prominence; sometimes color is perceived before, and for lower exibittion rates, color is perceived before form. It may be concluded that the visual grouping of color and shape are perceived in different ways depending on the context in which they are inserted.

With the results obtained from our empirical research, it may be concluded that the factor that facilitates the speed of visual grouping in a Match-three game is the use of different colors (hues) in the game icons.

This study demonstrates that for visual groupings of color and shape in Match-three games, color is predominantly seen as a factor of better and faster assimilation of groupings. Most respondents also report greater comfort when playing the color test.

Based on this, developers are recommended to use color and shape combinations in their projects when differentiation is necessary. This will help differentiate objects by different and highly contrasting hues, as the user's response is quicker and easier for color combinations. Such differentiation can benefit the experience and user interface (UX and UI), making the action or gameplay more comfortable and intuitive.

7. Conflict of interest declaration

The authors declare that there is no conflict of interest regarding the publication of this paper.

8. Funding source declaration

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9. Short biography of the author(s)

Joyce C. Cavallini – Graduated in Design at ESPM College.

Paula Csillag – Professor Doctor at ESPM College, since 1999, lecturing in the Design Department. Research interests are related to color communication, visual language, color perception and color trends.

Notes

[1] Printscreen taken at the ranking of most downloades casual games in Brazil at November 2018, Available at: https://play.google.com/store. (Acessed: 02 November 2018).

[2] Printscreen taken at a stage of Candy Crush Saga at November 2018, Available at: https://play.google.com/store/apps/details?id=com.king.candycrushsaga. (Acessed: 02 November 2018).

[3] Complete tutorial by GKANATSIOS, D. (2015) of how to building a match-3 game (like Candy Crush) in Unity. Available at: https://dgkanatsios.com/2015/02/25/building-a-match-3-game-in-unity-3/. (Acessed: 25 April 2018).

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