A playful approach for early screening of color blindness in Italian primary schools

Carlo Alberto Iocco[1], Alice Plutino[1], Ambra Cattaneo[1], Luca Armellin[1], Matteo Sassi[2], Liliana Silva[3], Alessandro Rizzi[1,2]

[1]MIPS Lab, Department of Computer Science, University of Milan

[2]SAZ (Spiele Autoren Zunft eV) Italy

[3] Department of Education and Human Sciences, University of Modena and Reggio Emilia

Corresponding author: Carlo Alberto Iocco (carlo.iocco@unimi.it)

ABSTRACT

The term color blindness in humans indicates a condition of hypo-functioning of a class of cones, a specific type of cells in the retina, which leads the subject to confuse colors or perceive some tones in a limited way. Approximately 8% of European men and 1% of European women are affected by color blindness, and in Italy the number of color-blind individuals is around 2.2-2.5 million. Color blindness is a condition related to genetic transmission and is therefore present from birth, but in Italy it is often diagnosed after adolescence.

The work described in this paper is part of a larger research project called Game4CED regarding color blindness and board games. This paper tests the possibility of diagnosing color blindness in childhood, in a playful way, using board games, to provide teaching staff, tutors and educators with support and techniques for testing in classrooms. This approach is not intended to replace a medical examination, which is necessary if a potentially color-blind child is identified but aims to propose a preliminary screening avoiding the stress of a medical analysis.

The experiment was organized at the "Dante Alighieri" Primary School of the Giovanni XXIII Comprehensive Institute of Arona (NO) and involved a sample of approximately 120 kids under 10 years, from classes from the first to the fourth grade. For the experiment some customized versions of famous board games have been prepared, in which color sensitivity is significant. The games used (SpeedColor, Dobble, Nimble and Fantascatti) have been specifically modified in such a way as to reduce the logical associations between colors and shapes, in order to work as much as possible on visual perception with the less possible cognitive processing. In addition to board games, the subjects who presented greater difficulties have been further screened with the online game qolour (http://qolour.it) to exclude any false positives.

The proposed method proved useful for involving the analyzed subjects. The success in identifying some cases attests that the approach used by the study group was effective in the early diagnosis of the disorder.

KEYWORDS color, color blindness, screening

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1. Introduction

Color blindness is a genetic condition which, in a percentage of individuals, causes the hypofunction of a class of cones cells in the human retina which makes it difficult to perceive and distinguish some colors. About 8% of European men and 1% of European women are affected. In Italy, the number of color-blind individuals is around 2.2-2.5 million (Wright and Martin 1946), (Birch 2012), but the diagnosis is often made only after adolescence. Currently the most used methods for testing color blindness are the Ishihara Test and the Farnsworth-Munsell Test (Birch and McKeever, "Survey of the accuracy of new pseudoisochromatic plates" 1993), (Cole 2007), which can be associated to more accurate clinical tests such as the Nagel anomaloscope or the CAD test.

Color blindness diagnostic tests are carried out mainly for the purpose of issuing authorizations to drive vehicles (e.g. driving license) and for carrying out specific tasks. For this reason, many color blindness diagnoses are made in adulthood, especially in cases of mild color blindness, or in subjects for whom color blindness was masked by other types of dysfunctions.

Furthermore, diagnostic tests for color blindness require trained and specialized personnel, as well as high levels of attention from patients. This makes many tests difficult for children or individuals with attention deficits (Armellin, Plutino, and Rizzi 2022).

Early diagnosis of color blindness is essential for adequate management of any problems associated with this condition, especially at school. Untrained teaching staff, and lack of knowledge of this phenomenon, could cause stress, exclusion or discrimination of color-blind children, as well as slow down their learning pace.

In this context, proper teacher training, associated with some specific board games as tools, could be a first solution. Using board games as an early diagnostic tool has numerous benefits. Games are a playful and engaging method that allows you to test children's ability to recognize colors in a fun way, without creating stress and without affecting their motivation. Furthermore, games are an easily accessible and low-cost method, suitable for varying age groups and contexts, such as school.

2. Game4Ced

The Game 4 CED project has been considered valuable by the Ministry of University and Research, which has decided to support and provide the funds necessary for its completion.

Game4Ced has four main objectives:

1. Development of a board game as an educational tool for the early detection of color blindness increasing people's awareness of color blindness
2. Analyze and improve accessibility standards for color blind people in the world of board games
3. Provide teachers, educators and parents of school-age children with tools and knowledge useful for using the board game as an accessible aggregation tool

The project is structured into various sub-goals. The first is the definition of a tool capable of analyzing and evaluating the color-blind accessibility of modern board games. During this phase we will explore the state of the art of accessibility policies and, above all, their actual functioning. To do this, it will be important to keep track of the feedback from color-blind players against the complexities encountered while playing various board games. There are mainly two objectives. The first is to correctly frame the problem and understand the level of attention and awareness of the industry today. The second is to comply with these standards and apply them correctly when designing our games.

Then the main goal will be the design, development and playtesting of ColorFit, the first board game we have created for this goal, and a set of other board games and instruments that can be used to execute an initial screening of players.

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The games will then be brought to real contexts, mainly schools and board game fairs, where they will also be a tool for disseminating problems related to color blindness. Educators and teachers in school will therefore be of fundamental importance given that they will be trained on the use of games in order to be able to organize game sessions that have the dual purpose of transmitting the gaming culture in schools and creating a relaxed and favorable environment for carrying out of initial screening of subjects suffering from color blindness.

The aim of the project is to develop an educational toolkit composed of videos, booklets and educational materials that can guide educators and children in creating a more accessible environment. The material will have the aim of training staff on issues relating to color blindness and allowing the autonomous use of ColorFit and other playful tools to carry out an initial screening of people affected by color blindness in a school environment.

3. The test in the school

A first test of ColorFit and other selected modified versions of different board games was conducted at the "Dante Alighieri" Primary School of the Giovanni XXIII Comprehensive Institute of Arona (NO). Two third-year classes, a second-year class and a first-year class participated in the experiment, involving a sample of approximately 120 children under 10 years of age divided approximately equally between males and females.

The experimentation took place in four phases: (a) presentation of the project and brief explanation of the games; (b) division of the class into four groups; (c) conduct of the games; (d) conclusion and greetings. It is important to specify that the project was presented to the children as if the activity had exclusively recreational purposes without mentioning the focus on the search for players who could have altered color perception. On average the four groups had about 20 minutes to play multiple sessions of each game, at the end of which they changed games. Each group of children was led by a researcher, who remained fixed in the group (see Fig. 1). Each researcher had tables available to take note of variables such as the time it took to finish a game, the scores made by the various children and some notes. All data were collected anonymously.

Fig. 1 - The research group of the University of Milan carrying out the tests together with the students of the Comprehensive Institute Giovanni XXIII of Arona (NO).

The board games used were ColorFit, the first game we designed entirely, and modified versions of pre-existing games such as Dobble, Speed Color or Nimble. The goal of the alterations made to these games is to simplify any gameplay task that is not strictly related to color recognition. Furthermore, we have decided to modify the original colors in order to analyze the widest possible color distribution. We used the same 6 color palette for all the games presented here in the sRGB color space:

Colors/sRGB	R	G	B
Yellow	253	241	0
Orange	255	127	38
Red	237	27	36
Green	33	175	80
Blue	0	162	231
Purple	163	73	163

Table 1 - A table showing the values in the sRGB space of the colors used in the modified versions of the board games used during the activity

It is important to underline that some variables regarding the production and visual rendering of the chosen colors are not completely under our control. Depending on the characteristics of the printer used to produce the prototypes, these could show some variations. Other visual variations certainly come from the fact that a school is not a place where it is possible to completely control the light sources and the arrangement of the tables where the tests are set up. In addition to the problems described, it should also be noted that the materials of some games have been plasticized in order to be more resistant and durable. This also leads to possible chromatic appearance due to the reflections that light can generate.

However, we consider the presence of these visual alterations to have a very marginal impact on the experimentation since this is not intended to be a medical test but only an activity with screening purposes.

ColorFit:

ColorFit is an abstract tile placement game for two players. Each player starts with 8 tiles of different colors, each with one of the colors represented on the game board. During their turn, players can place a tile on a free node on the game board as long as this has the same color as the node and that the node is connected to at least one node already occupied by a tile. The first player to play all his tiles wins. ColorFit requires players to develop a strategy with the aim of forcing the opponent into an area of the graph where he cannot place any tiles. At the same time, however, the game tests players' ability to recognize colors. ColorFit is also extremely customizable and can be used in various contexts. In fact, we have created game boards and tiles with various color palettes capable of testing various types of color vision deficiencies.

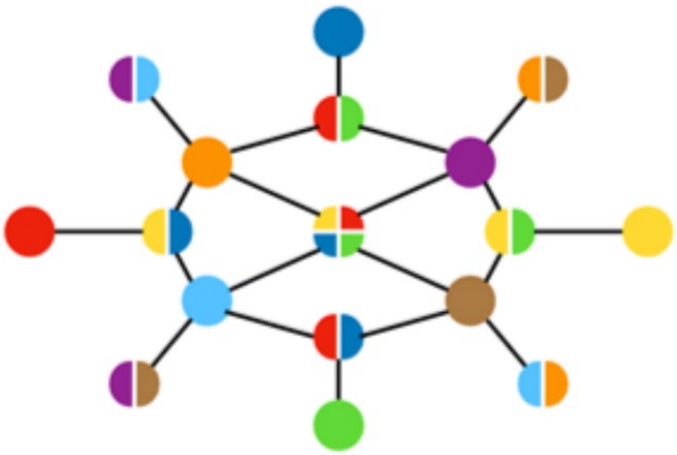

Fig. 2 - A game board from ColorFit

Dobble:

Dobble is a game made up of 55 cards (usually round shape), each of which contains 8 drawn symbols; In the game, there is always only one symbol in common between two cards. The aim of the game is to be as quick as possible to identify the common symbol, declare it out loud, and collect as many cards as possible. The images used were created using the PC application Krita, which allows you to use color selection and color correction gradients tools to uniform the colors of the image. For the game have been used simple images like triangles, squares, circles and hearts, etc each with a uniform color. Dobble has been alterated to simplify the various shapes on the cards with the aim of making the task of recognizing them less complex. Each shape has a black border and is filled with a single color.

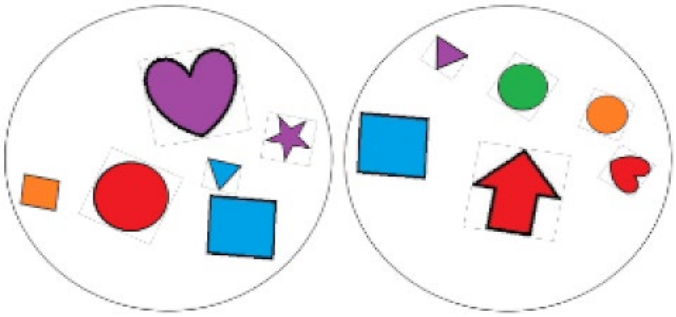

Fig. 3 - Two cards from the modified version of Dobble

Fantascatti:

Fantascatti is a game made up of a deck of cards and five colored tokens representing objects and characters all different in shape and color.

At the beginning of each round the five pawns are placed in the center of the table. Then, the top card of the deck is turned over and positioned in such a way as to be clearly visible to all players. Depending on the colors and images present on the drawn card the players must grab the pawn perfectly represented in the image (therefore with the same shape and the same color) or, if it is not present, grab the piece of the only color does not present in the image. The first player to grab the correct piece shown on the card previously drawn wins. The players then reposition the pawns to the center of the table and place the next card in the center of the table. We used the standard version of Fantascatti.

SpeedColor:

SpeedColor is a color memory game based on vision, the analysis of the colors of an image and their position. Each player has 6 markers and/or colored pencils namely red, orange, yellow, green, blue and purple. For this game, we allowed the children to choose their own pencils, with the restriction that they were like the colors we indicated. In this specific game, it is not necessary to check specific colors; what matters is that they are used to color in the correct area of the previously shown drawing. The colored cards we provide, on the other hand, follow the same color scheme as we displayed in the table. Each card in a SpeedColor deck has a black and white front image and on the back of the card the same image colored with 5 different colors selected from the colors of markers. At the beginning of each round each player takes a card from the deck and places it in front of him on the colored side. Each player then memorizes the colors and their position in the image, after which he turns the card over on the black and white side and, without turning the paper over, he must color it exactly like the image on the colored side. Once they have finished coloring, the players draw the next card of the deck and repeat the process. Points are earned based on how many parts of the card have been colored correctly and, at the end of a game, the player who has scored more points wins.

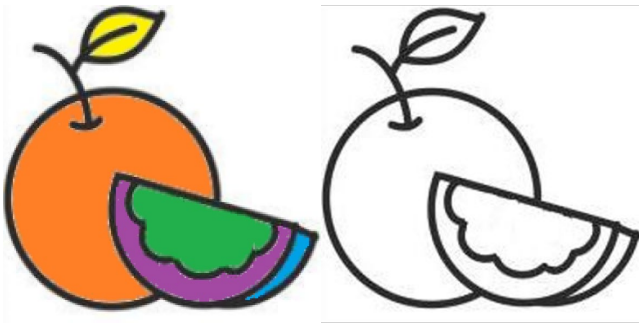

Fig. 4 - Two cards from SpeedColor

Nimble:

Nimble is a board game where motion speed and vision processing speed are put to the test. The game itself is very simple: each player starts with their own deck of cards in hand, recognizable from the symbols on the back. On the front side of the cards there is a monochrome circle and background distinctly colored. At the start of a game of Nimble, you place a card of an extra deck in the center of the table. The players at this point can place a card from their pile above the extracted card, only if the color of the edge of their own card matches the color of the circle in the center of the card in play. The game ends when the time is finished, or a player runs out of cards. At the end of a game, the player with the fewest cards in his hand wins. Nimble has been modified by removing the pattern present on the original cards and simplifying the colors to make the game objects simpler and to focus the players on the colors.

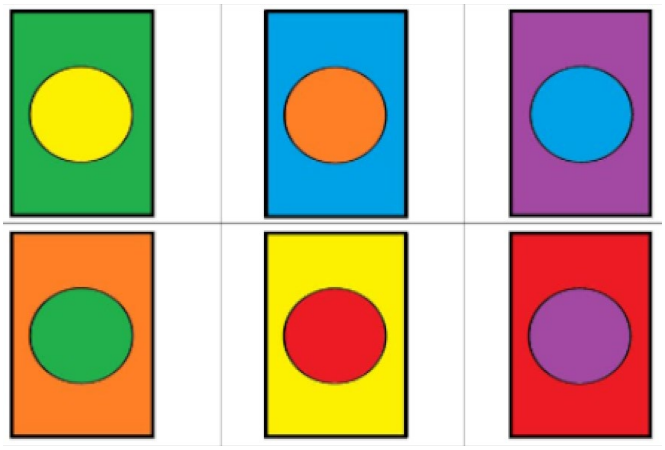

Fig. 5 - Six cards from the modified version of Nimble

In addition to board games, during the gaming session, the students who presented the most difficulties were asked to play the online game qolour. In this case children were chosen arbitrarily, or at their request. Since the qolour game can be solved individually, it was not possible to test all the subjects involved in the test.

Qolour:

Qolour is an online game available for both computer and telephone which consists of showing to the player a monochromatic geometric figure and around it six other similar figures which differ only in shades of a color. The objective of the game is to select the outer figure that has the same color as the central figure.

The game ends when time runs out or too many errors are made and, at the end of a game, statistical data related to the type of errors made and whether a possible visual anomaly is present is reported (Armellin, Plutino and Rizzi 2022). The reliability of the qolour game for a preliminary screening of color blindness has been tested in several studies, and in this experimental context, it was used as a method to have a first distinction between children who had difficulties in the game due to possible color blindness, from children who presented difficulties due to other problems.

4.Results

In general we can confirm that the project carried out at the Dante Alighieri Primary School was successful thanks to the collaboration with the coordinators and teachers of the school. The welcome that the teachers gave to the researchers allowed for excellent integration of the latter into the classroom, allowing from the first moment to create a relaxed and playful environment for the children, making the observation conditions ideal. Furthermore, the students immediately proved to be very enthusiastic about being able to participate in an experiment that had a playful component.

Overall, field observations and subsequent data collection did not highlight significant problems and the possible presence of students with color blindness was found in two out of four classes. Clearly, we would like to point out that this data collection and these results are not comparable to in-depth medical examinations, and are intended to provide parents, teachers and educators only with a preliminary idea of the presence of color blindness. Consequently, for positive cases of visual impairment we recommend examining the results with specialized eye examinations.

In the first third grade, a case of possible deficit in color vision was observed. In all the games, a student showed clear difficulties in identifying colors from the very first moments. In any case, the student is well integrated into the class and supported by classmates and teachers.

In the second grade, some cases of possible vision impairment were observed. Two female students showed difficulties in color discrimination. Given the rarity of color blindness in females, a more in-depth analysis was recommended to the family. Finally, a male student made several errors in color discrimination and became very nervous while playing the games. Also in this case, more in-depth screening was recommended.

In the third grade, no cases of color vision deficits were found. Difficulty was noted in playing the games by a student, who sometimes struggled to maintain attention and carry out the assigned tasks, but the analysis carried out with qolour together with an evaluation carried out by the teachers, revealed that the student has not color vision problems, and his difficulties are only behavioral and/or linguistic.

All students carried out the required activities as expected, showing only some normal competitive behaviors. The use of board games promoted interaction between classmates.

Several insights and ideas emerged from the experiments conducted in primary schools to enhance awareness about color blindness. Specifically, there will be a dissemination of the games used, as well as the qolour gaming app (https://qolour.it/), which is beneficial for conducting initial screenings for color blindness. Additionally, training courses will be developed for teachers and educators on this topic. The analysis, particularly if conducted by teachers and educators trained in behavioral disorders, could be beneficial in the future for making initial observations. Therefore, we recommend that teachers introduce or incorporate board games and similar activities to observe students when they are more playful and spontaneous.

5. Conclusions

In conclusion, the early diagnosis of color blindness through board games represents a useful step forward for the prevention of any discomfort associated with the condition. Thanks to the use of personalized games adapted for each specific pathology, individuals with difficulties in color perception can be identified quickly and effectively.

The research project of which this experiment is part is therefore interesting from several points of view. The possibility of designing and disseminating free and print-and-play board games with the same characteristics as those already described in this document would allow individual schools to carry out tests and game sessions independently and more regularly. Consequently, teacher's knowledge regarding visual elements in everyday teaching that can be problematic for color-blind players would also increase. Furthermore, it is presumable that through the expansion of this project the understanding of color blindness and its functioning will be clearer and more widespread in the school. This can be an extremely important factor in providing support and tools to people affected by this condition.

We want to conclude by recalling that the board games approach in no way replaces a medical examination but represents a valid support for the early diagnosis of color vision deficiencies.

6. Conflict of interest declaration

The authors declare no conflict of interest.

7. Funding source declaration

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8. Short biography of the author(s)

Carlo Alberto Iocco - researcher at University of Milan (Italy) specialized in video game design, board game design and visual accessibility issues of these medium.

Alice Plutino - Alice Plutino (Phd, Università degli Studi di Milano, 2021) is MSCA Postdoctoral Fellow at the Faculty of Media Studies of the University of Amsterdam. Her research interests are Color Science, Colorimetry, Image Enhancement, Image Digitization, and Archiving, with a particular interest in Cultural Heritage applications.

Ambra Cattaneo - Ambra Cattaneo has obtained a Master's degree in Cultural Heritage Conservation Science at the University of Milano (Italy). She has done a master's degree thesis on characterizing color photographic films' gamut. She also led a project on the preliminary identification of color photographic processes by examining photographic prints

Luca Armellin - Luca Armellin is currently a master's degree student in Computer Science at the University of Milano (Italy). His research interests mainly focus on Vision Impairments with particular attention to Color Vision Deficiencies Colorimetry and Color Science, Lighting, Image Processing and Computer Vision.

Matteo Sassi - Matteo Sassi received his Ph.D in 2008 in applied physics. Since 2013 he has been working on embedded systems in the industrial sector. Since 2018 he has been a Game Designer. He is currently a researcher at the Department of Computer Science UNIMI and is responsible for the GSRC commission.

Liliana Silva - Liliana Silva is Associate Professor of Experimental Pedagogy at the Department of Education and Human Sciences of the University of Modena and Reggio Emilia, she mainly deals with the issues of assessment applied to lifelong and lifewide learning contexts and playful evaluation approaches.

Alessandro Rizzi – Alessandro Rizzi is Full Professor at the Computer Science Department of the University of Milano. He has been doing research since 1990 in the field of digital imaging with a particular interest on colour,

visualization, photography, HDR, and on the perceptual issues related to digital imaging, interfaces and lighting.

Licensing terms

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