Audio Visual Association test in non synesthetic subjects: Technological Tailoring of the methods

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Abstract. Synesthesia is a relatively rare condition for which a specific stimulus activates one or more senses different from the ones usually designed for its evaluation; this can happen in any combination of senses or cognitive paths. In this work, we focus on audio-visual synesthesia, one of the most common. Many investigators have studied the connection between music and colours in synesthetic and non-synesthetic subjects in the past years, exploring the possibility of an emotional gate between the perception of these stimuli. In this study, an experiment was designed to verify whether this connection can be extended to music and images, considering not only colour but also shape and their spatial distribution. In the study, participants' musical and visual abilities will also be tested to explore any correlation with their music-images association.

Keywords: synesthesia · music and color association · generative art

1 Introduction

According to Rothen [1], synesthesia has neural bases: it is thought that the synesthetic experience of colour activates brain regions responsible for normal colour perception, contrary to what non-synesthetic subjects experience when remembering or imagining colours. There are many theories on this atypical neural activation. The most credited are cross-activation, in which the cause could be an extraneuronal connection in contiguous areas of the brain responsible for senses processing, and disinhibited feedback theory, in which it is caused by some differences in subjects' neuronal transmission. Ward states that these differences could be present at a cortical level, showing the complex nature of the inducer/concurrent process [2]. All the models agree in explaining synesthesia as caused by an atypical pattern of connections between the processing brain centres, which could be functional or structural [3].

The first study on music-colour association was conducted by Sabaneev in 1929 [4], in which participants were asked to choose a colour that best described notes and harmonies that they were listening to; this type of experiment has been reproduced many times over the years with the addition of other factors: in Howell's study subjects were also administered Ishihara and Seashore test [5], Marks asked subjects to associate volume and lightness volume [6], and finally, Odbert introduced emotion in the experiment [7]. Since it turned out to be an important factor, many studies replicated the experiment, asking participants to associate music and emotion, colour and emotion, and music and colour [8, 9]. Our study aims to investigate the connection between music, emotion, and images, adding shape and spatial distribution of elements in pictures as other features. As a second goal, it aims to evaluate the influence of one's visual and musical abilities in the image-music-emotion association. In this paper, we present the test and preliminary results obtained on a small population of subjects.

2 Material and Methods

This study received the approval of the university's ethical committee on February 16 2022 with number of clinical studies register 2021.236. All tests are delivered through a computer, and the interaction is achieved through a graphical interface.

2.1 Experiment design

Once enrolled, participants will be asked to complete a form, stating their basic information, their musical and artistic background, their likes and dislikes of musical genres, the level of emotion evoked from certain colours and shapes and if they have ever experienced synesthesia. Subjects will be sent the link to access the experiment via email and they will be given the possibility to complete the test in one or more sessions, depending on their fatigue after each session. Before the beginning of the test, participants are informed of each test's duration, they are asked to be alone, to use a PC with a high resolution screen, to deactivate night shift on their monitor and to wear headphones. The test consists of a pretest and two main phases.

Pretest: This part consists of 5 different tests: (i) Ishihara Test for Colour Blindness detection; (ii) Perfect Pitch Test; (iii) Melodic discrimination test [10]; (iv) Mistuning Perception test [11]; (v) Beat alignment test [12]. These tests are simplified versions of the cited tests. In particular:

- Ishihara Test: The subjects are shown 24 tables and asked to identify numbers or lines in the picture and write it in the input box underneath the image.
- Perfect Pitch Test: The subjects can play a tone only once and choose the corresponding note on a 2 octave keyboard. Each time a key is pressed, users are given the possibility to listen to the next tone.
- Melodic Discrimination test: The participants can play only once three melodies. Two of them have the same melodic structure, the last has a different note. The second and third melodies are higher in pitch than the first one by a semitone and a tone, respectively. They have to detect the different melody. They can play the melodies of an example before starting the trial.
- Mistuning Perception Test: The subjects can play the same song twice and have to choose in which one of them the singer is in tune.
- Beat Alignment Test: The subjects can play the same song twice and have to choose in which one of them the triangle is on time.

The pretest assesses the user's visual abilities and then its musical ones from the most to the least challenging.

Phase One: In this phase the participants compose an image configuring a set of parameters while listening to a song and are then asked about their feelings on the song. The subjects can see the image they are generating, while setting the image's parameters. The parameters are: number of objects, objects dimensions, objects dispersion, objects shape, hue, saturation and brightness. Objects shape ranges from an angular to a rounded figure similar to the Maluma/Takete [13]. They can play and listen to the song once, and are only able to submit their image after the song is over. Once they submit their image, they can move 9 emotion sliders and, if they want, they can listen to the song a second time. Emotions are expressed with the 9-term version of GEMS with the replacements made in Aljanaki's study [14]. Once they are finished, they can move to the next song. Before starting the test, they can play with a trial image's parameters to understand how image composition works. All songs are composed by Andrea Sorbo, a composer hired specifically for the study, to avoid any influence of memories generated by song recognition. Moreover, the songs belong to different musical genres.

Phase Two: In this phase the subjects are shown twenty one images in which all parameters listed in phase one are set on neutral values and only one parameter is exaggerated (e.g. a very bright image). The respondent are asked to describe their emotions upon seeing the image by modifying the same emotion sliders of phase one. Figure 1 shows examples of images composed by the subjects or presented to the participants in our tests.

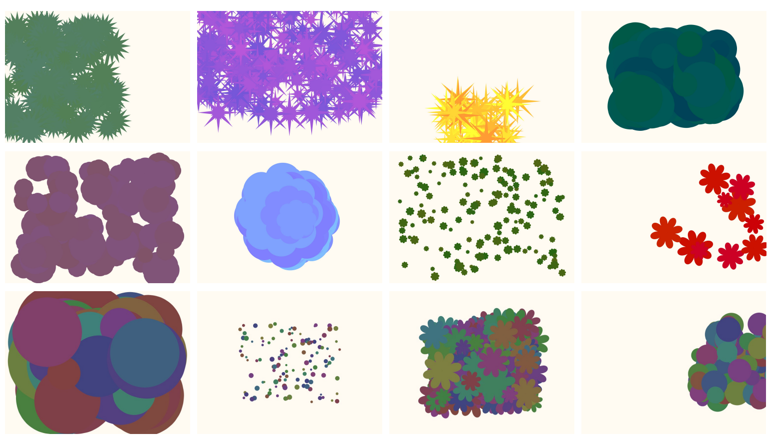

Fig. 1. Rows 1-2: examples of images generated in phase one. **Row 3**: examples of images shown in phase two.

Test development: The test is administered remotely via a website. Both front-end and back-end development of the website was realized using `javascript` [15], in the first case using `p5.js`[4] and in the second `node.js`[5]. The users' answers and

[4] `https://p5js.org/`

[5] `https://nodejs.org/`

their actions on the elements on the screen are saved on a `firebase`[6] database at the end of each test.

2.2 Pilot trial data analysis

Before conducting the synesthesia trial on a 100-subject recruited cohort, a pilot study was conducted aimed at verifying the whole testing platform and exploring some of the outcomes that could be generated from the tests. The pilot study was conducted on 14 subjects, and the findings are briefly discussed below. In order to have a better understanding of the information collected in the pilot trial, the form data and the results from the pretest were analyzed using scatter plot matrix and linear regression in MATLAB R2020a. Data from phase one and two was not analyzed at this stage due to its complexity compared to the small number of the subjects.

3 Results and discussion

The platform collected the information entered by participants in the tests correctly, with no reported errors. The satisfaction in using the system was high, all participants found it accessible and easy to use. Collected data was split in 3 groups: musical preferences, artistic preferences and pretest results and was then analyzed to look for correlation between the features of these different groups. Some interesting results emerged from this analysis: for example, data shows that the more you like Hip-Hop, the less you perform in the melodic discrimination test, the more you like yellow, the more you like the splash shape. Some examples of results can be seen in Figure 2. These results, which are preliminary in nature, together with the ability to scale the number of participants quickly upward, suggest excellent developments for a more comprehensive testing campaign.

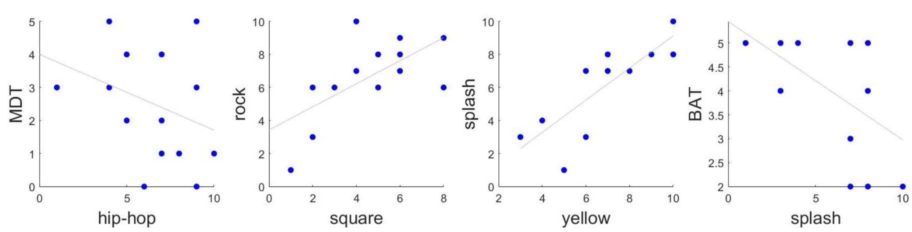

Fig. 2. Examples of data analysis results. MDT=Melodic Discrimination test, BAT=Beat Alignment Test

4 Conclusion and future developments

In this article, we presented a web-based platform designed and developed for the assessment of synesthesia. The platform includes several standard tests and some custom-developed tests, integrated into a web-based delivery system. Some preliminary results supporting the functionality of the system have been presented. Future developments concern the use of the platform in an extended

[6] `https://firebase.google.com/`

experimentation from which actual results of interdependence between stimuli can be deduced. Moreover, the developed approach builds the foundation for the development of new tests aimed at revealing the interdependence between the different artistic qualities that a subject can possess. These studies represent basic research towards the exploitation of the emerging interdependence between senses to develop new inclusive smart systems for sensory integration and augmentation in subjects with disabilities.

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