Synaesthesia Gallery AR: Journey Through the Senses – Using Augmented Reality for Education

Svetlana Rudenko[1] and Mads Haahr[2(✉)]

[1] Haunted Planet Studios, Dublin, Ireland
rudenkos@tcd.ie
[2] Trinity College Dublin, Dublin, Ireland
haahrm@tcd.ie

Abstract. This work-in-progress paper presents *Synaesthesia Gallery AR: Journey Through the Senses*, an educational game-like experience designed to bring awareness of synaesthesia, to learn and understand creativity of cross-modal perception. Synaesthesia is a perceptual trait characterised by cross-modal wiring of the brain experienced by a 4–6% of the population. Synaesthesia research has a long history (as far back as 1690), and sometimes synaesthesia was confused for hallucinations. The AR app documents creative synaesthesia experiences of individuals who have contributed significantly to synaesthesia research, including international artists, such as Carol Steen (president of USA Synaesthesia Association), and scientists, such as Jamie Ward (Professor at the University of Sussex, UK). Ramachandran and Hubbard have called synaesthesia "a window into perception, thought and language" that can help explain how the brain works. The app experience takes a form of an interactive digital gallery for the outdoors, a locative Augmented Reality (AR) art gallery with music by Liszt, Chopin, Schuman, Scriabin and others painted by artists-synaesthetes and music composed on art. The work is the result of a seven-year collaboration between artists-synaesthetes and pianist/researcher Dr Svetlana Rudenko. The app provides pleasing aesthetic experience as well as learning, to general population, neuroscience and psychology students, synaesthesia associations and music art lovers.

Keywords: Augmented Reality · Synaesthesia · Music and Art · Creativity · Games for Learning

1 Introduction

About 4–6% of the population [1] experience *synaesthesia,* a perceptual trait due to the cross-modal wiring of the brain [2, pp. 319–33]. In addition to perceiving one stimulus, such as sound, people with synaesthesia may perceive an additional quality to the experience – a colour or smell or feeling. Synaesthesia research goes as far as the year 1690 in which a case was documented by John Loche about a blind man experiencing colour on the sound of trumpet. A medical study of synaesthesia was described by George Tobias

M. Haahr et al. (Eds.): JCSG 2023, LNCS 14309, pp. 211–217, 2023.
https://doi.org/10.1007/978-3-031-44751-8_15

Ludwig Sachs in 1812 (Wikipedia). After synaesthesia inspired the whole generation of German Romantic artists (e.g., Caspar David Friedrich), American neurologist Richard Cytowic brought synaesthesia research into mainstream science in the 1980s [3]. Many people of creative professions who are synaesthetes use synaesthesia creatively as an additional sensory stimulation. Because there are many types of synaesthesia and the experience is highly subjective, the trait has sometimes been confused with hallucinations or neurological disorders [4]. For children with synaesthesia and their parents, this is a particular challenge, since children may describe their experiences in ways that their parents do not understand, which can lead to confusion and difficulty in learning. For example, a child with grapheme-colour synaesthesia will perceive letters and numbers in colours, which easily could distract the learning process and cause misunderstanding, because educational techniques for primary school reading and writing often use colours, which will not match the child's experience. Many synaesthetes are not aware of their sensory pairings and think that everyone else experiences it too.

This paper presents a game-like educational experience entitled *Synaesthesia Gallery AR: Journey Through the Senses,* which is designed to give insight into sensory perception and to help people learn about synaesthesia, and perhaps also turn sometimes overwhelming sensory experiences into the creativity of cross-modal perception. The experience takes the form of an interactive digital gallery for the outdoors, a locative Augmented Reality (AR) art gallery with music by Liszt, Chopin, Schuman, Scriabin and others painted by artists-synaesthetes. The gallery contains 15 multisensory soundscape art episodes and is the result of a seven-year collaboration between artists-synaesthetes and concert pianist, composer and researcher Dr Svetlana Rudenko. The game runs on smartphones (Android, iOS) and is available in the respective app stores. The app has received a funding award from Federation of European Neuroscience Societies (FENS) and the DANA foundation for brain research and was launched at Trinity College Dublin for Brain Awareness Week 2022.

Ramachandran and Hubbard [5, pp. 52–59] stated that 'synesthesia causes excess communication amongst brain maps… Depending on where and how widely in the brain the trait was expressed, it could lead to both synesthesia and to a propensity towards linking seemingly unrelated concepts and ideas – in short, creativity." The App is creative itself, as a psychogeograpical augmentation of location with Art and Music soundscapes. It has two modes: site-specific and random. In site-specific mode, the experience is set in a curated location. In random mode, it will stage itself to any location in the world. (See Fig. 1.) In random mode, the experience works best in a park, or close to nature because it uses the environment as a relevant context for (and backdrop to) to the AR encounters. In a natural environment, this combination encourages multisensory experiences, such as feeling of the wind on the skin, the smell of the grass and fresh leaves, in combination with the sound of music and the visual stimulation through the AR art. The app was originally staged at Trinity College Dublin for Brain Awareness Week 2022 demonstration and to offer easy campus access for students carrying out research on synaesthesia and visitors attending BAW lectures.

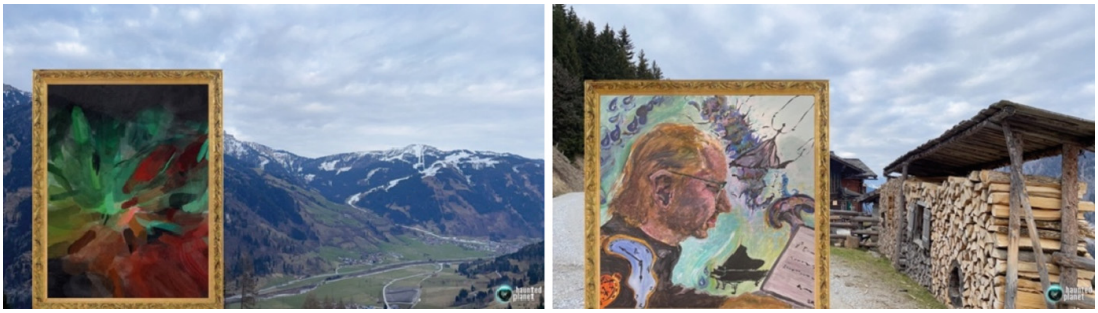

Fig. 1. *Synaesthesia Gallery AR.* Augmented Reality images: Episode N8 (Art by Carol Steen on Schuman Quintet Op. 44) and N15 (Music and Art for Alice Dali AR by Dr Svetlana Rudenko).

2 Types of Synaesthesia, Infants Synaesthesia and the Multisensory Brain

Ramachandran and Hubbard has called synaesthesia "a window into perception, thought and language" [6]. There are 75 types of synaesthesia registered according to Sean A. Day who is president of the International Association of Synaesthetes, Artists, Scientists (IASAS).[1] Research has shown that people with Synaesthesia are more aware of cross-modal sensory pairings due to stronger connections in their neural system [7]. Furthermore, there is evidence that the brain of a new-born baby is cross-modal and have infants synaesthesia [8]. While synaesthetes only represent 4–6% of adult humans, it is still a large number of people, as observed by Cytowic who stated, "one in twenty-three people carry the gene of synaesthete" [3]. There is also "a growing body of empirical research on the topic of multisensory perception [which] now shows that even non-synaesthetic individuals experience cross-modal correspondences" [2, pp. 319–33]. There is evidence that multisensory perception stimulates the brain and Infants Synaesthesia is a natural sensory state for newborn baby [8]. Research shows that synaesthesia-enhanced applications have promising potential for education and mental health programs, such as Bor et al.'s experiment to train non-synaesthetes for grapheme-colour synaesthesia (shapes, letters and numbers have colour), which showed an IQ improvement and provisionally concluded that "cognitive training including synesthetic associations may in the future be a promising new tool for vulnerable clinical groups to enhance general mental ability" [9]. Also, designer and researcher Dr Michael Haverkamp established a methodology for multisensory design based on synaesthesia [10], and sensory substitution devices research uses a synaesthesia principle in which the lost sense (e.g., vision for blind people) could be compensated for in another sensory modality (e.g., seeing with sound) [11].

Many artists, musicians and writers who were synaesthetes found an inspiration in their sensory perceptions. Cretien van Campen observes that the famous artist Wassily Kandinsky described synaesthesia as a "phenomenon of transposition of experience from one sense modality to another, as in unisonous musical tones" [12, p. 56]. Greta Berman, Professor of Art History at the Julliard School, NY, noticed: "Synesthetes invariably manifest a multi-layered, complex way of looking at and interpreting things.

[1] http://www.daysyn.com/Types-of-Syn.html.

In synesthetic art, both paintings and music exploit unexpected and startling rhythms" [13, p. 28]. Russian science researcher, artist and director of the Prometei Institute, B. M. Galeyev said: "Synesthesia (and the particular case of 'color hearing') is the essential component of musical thinking, first of all, music intended to evoke images" [14, p. 3]. President of American Synaesthesia Association Carol Steen describes the sensation of synaesthetic colours: "Regardless of the synesthetic trigger, that sometimes the colors are translucent like a haze of smoke or fog sometimes they're dense with a weight that feels almost physical. The shapes are soft-edged, exist in space, and are three dimensional but cast solar system (…) The speed of these moving shapes is gentle. They go as fast as the changing color waves of aurora borealis appear to the naked eye" [15, p. 19]. Some experiences of synaesthesia can cause confusion, for example children with grapheme-colour synaesthesia might see "their own" colours on letters, not the alphabet colours shown by the teacher.[2] Or, as Carol Steen describes, when synaesthesia was overwhelming or even frightening: "The first time was when I was 7 and told my best friend that the letter 'a' was the prettiest pink I had ever seen. She said I was weird and we stopped being friends. I decided that silence was safer and didn't mention my colored letters to anyone until I was 20."[3]

Synaesthete Lidle Simpson describes his experience as "I have been deaf all my life and I like to say that I have never known silence. I learned at an early age that hearing people are not hearing what I hear. I called it 'Photonic Hearing' before I learned the word 'Synaesthesia.'"[4] But most important, as Lucie Bouvet *et al.* observe in their article "When synesthesia and savant abilities are mistaken for hallucinations and delusions: contribution of a cognitive approach for their differential diagnosis" [4], awareness of Synaesthesia and self-discovery if the person is synaesthete can prevent many upsetting cases because almost all synaesthetes start their journey with "I thought everybody sees it!".

3 Augmented Reality Experience: The App

Synaesthesia Gallery AR shows how music could be perceived with other senses; it shows music as vision, painted by artists-synaesthetes. It teaches creativity and diversity of perceptions. The app could be helpful for that one child in the class who is different, and it also teaches non-synaesthete children to respect their individual experience and gain confidence that they are allowed to be different. In this fashion, the app serves as a social game experience with classmates that lets them experience the aesthetics of music and art, increases awareness of their own sensory responses, perhaps leading to them to paint music or other emotional experiences themselves. For adults, the app is a tool for self-exploration to learn more about the sensory perception of music, as well as the psychogeography of location, augmented with art and music. In addition to painted music episodes, *Synaesthesia Gallery AR* has episodes with a scientific talk by Prof. Jamie Ward and with talks by artists-synaesthetes about their synaesthetic experience and

[2] https://www.syntoolkit.org/teacher.

[3] https://mitpress.mit.edu/spotlight-on-science-carol-steen/.

[4] https://static1.squarespace.com/static/5fbbf00ba552d609bac0798b/t/60467feb69aafb17f6cc7de0/1615233019217/Art-on-Classical-Music-by-artists-synesthetes-converted.pdf.

music composed on art, when the colours and shapes "sound." Many countries, including the US, Canada, Germany, Spain and others have Synaesthesia Associations that bring awareness of the trait to schools and the general public. Neuroscience societies, such as British Neuroscience Association (BNA), the Federation of European Neuroscience Societies (FENS), the Dana Foundation and Neuroscience Ireland work on dissemination of brain science and very often host Synaesthesia events during their world-wide, annual Brain Awareness Week (BAW) event.

3.1 Gameplay AR

The *Synaesthesia Gallery AR* experience is set outside and works through a smartphone screen. The first step is to download the app from the Play Store (Android) or App Store (iOS). The app is free and free of advertising. When the app starts, you can choose "Random" to play in your local location (e.g., a park) or "Trinity" to play in curated locations in Trinity College Dublin (Fig. 2 right, screenshot 1). After that, the main experience begins. The steps to find and capture a music art encounter are as follows: 1. Use the map to orient yourself and make sure you are inside the purple area where the music art encounters are (Fig. 2 right, screenshot 2). 2. Use the radar to get close to a music art encounter (Fig. 2 right, screenshot 3). The radar works like a naval radar where you are in the centre and the music art encounters are around you. As you get closer to an encounter, you will hear the music begin. You should keep going until the LEDs light up and the AR button flashes yellow. 3. Use the AR mode to scan around you and find the artwork hanging in the air (Fig. 2 right, screenshot 4). A yellow arrow on the display tells you which way to pan. When you see the artwork, capture it by taking a photo. If the artwork disappears before you can capture it, go back to step 2 above and move a little bit closer to it.

The captured artworks go into your gallery casebook (Fig. 2 right, screenshot 5) where you can review them and read more about the artwork and the music. When the music finishes, you can proceed to find the next music art encounter, beginning with step 1 above.

Fig. 2. Synaesthesia *Gallery AR* cards with instructions

3.2 Content

The majority of the episodes of *Synaesthesia Gallery AR* demonstrate experiences of the chromaesthesia type (experiencing colours when hearing music). In addition, there is an episode by James Wannerton "Tastes of Kandinsky," which presents lexical-gustatory synaesthesia (experiencing taste when hearing, speaking, reading, or thinking about words) [16]. The app documents creative synaesthesia experiences of individuals who contributed significantly to synaesthesia research, including academics and international artists such as Carol Steen (president of the US Synaesthesia Association), Prof. Maria Jose de Cordoba Serrano (director of Spanish Synaesthesia Association Artecitta), Dr Timothy Layden, Ninghui Xiang (president of Synaesthesia Alliance, China), James Wannerton (president of the UK Synaesthesia Association) and Geri Hahn, textile artist-synaesthete, New Jersey, as well as one scientific episode by leading researcher on synaesthesia Prof. Jamie Ward, University of Sussex. The variety of music episodes include compositions such as Schuman Piano Quintet Op. 44 (painted by Carol Steen), Chopin ballad N1, Op. 23 (painted by Ninghui Xiong), Scriabin Piano Sonata N5 and Liszt B-minor Sonata (painted by Timothy Layden) and so on.

4 Conclusion and Future Work

In *Synaesthesia Gallery AR,* we show how artists-synaesthetes use their sensory perceptions on music creatively. We hope that some people will use the app to discover their own synaesthesia, and that all people who use it will learn about diversity of perceptions. For some people, it could be the start of creative practice, e.g., painting music as a therapeutic exercise.

The app will be used as a tool for further study, including a user study on the app as an educational tool for teachers, and use of the app as an alternative to online synaesthesia tests, offering a soft informative and playful experience of music art that has the potential to discover more non-identified synaesthestes with "rare" sensory pairings. In comparison, the most common tests for synaesthesia are based only on chromaesthesia and grapheme-colour synaesthesia. There are many additional possible applications for location-based art galleries like *Synesthesia Gallery AR*, including encouraging healthy walking habits, promoting physical exercise and as a cultural outdoors experience for intergenerational play for families.

We also think the app could be of interest to scientists exploring computational models of the neural circuits of the brain. There are patterns and shapes revealed in art (including the artworks in *Synaesthesia Gallery AR)*, which are characteristic also to multisensory perception under psychedelic states. The German-American biological psychologist Heinrich Klüver described these shapes as "form constants," and Jack Cowan and others [17] later used them to develop computational models that describe the dynamics of interactions between populations of model neurons.

References

1. Farina, F.R., Mitchell, K.J., Roche, R.A.P.: Synaesthesia lost and found: two cases of person- and music-colour synaesthesia. Eur. J. Neurosci. **45**, 1–6 (2016)

2. Parise, C., Spence, C.: Audiovisual crossmodal correspondences and sound symbolism: a study using the implicit association test. Exp. Brain Res. **220**(3–4), 319–33 (2012). https://www.researchgate.net/publication/227175048_Audiovisual_crossmodal_correspondences_and_sound_symbolism_A_study_using_the_implicit_association_test
3. Cytowic, R.E.: Synesthesia. MIT Press, Cambridge, London (2018)
4. Bouvet, L., Barbier, J.-E., Cason, N., Bakchine, S., Ehrle, N.: When synesthesia and savant abilities are mistaken for hallucinations and delusions: contribution of a cognitive approach for their differential diagnosis. Clin. Neuropsychol. **31**(8), 1459–1473 (2017)
5. Ramachandran, V.S., Hubbard, E.M.: Hearing colors, tasting shapes, pp. 53–59 (2003)
6. Ramachandran, V.S., Hubbard, E.M.: Synaesthesia- a window into perception, thought and language. J. Conscious. Stud. **8**(12), 3–34 (2001)
7. Cytowic, R.E.: Synesthesia: A Union of the Senses, 2nd edn. MIT Press, Cambridge, London (2002)
8. Ward, J.: The Frog Who Croaked Blue: Synesthesia and the Mixing of the Senses. Routledge, London and New York (2008)
9. Bor, D., Rothen, N., Schwartzman, D., Clayton, S., Seth, A.: Adults can be trained to acquire synesthetic experiences. Sci. Rep. **4** (2014). https://www.nature.com/articles/srep07089
10. Haverkamp, M.: Sinesthetic Design: Handbook for a Multi-Sensory Approach. Birkhauser Verlag AG (2013)
11. Rudenko, S., Haahr, M.: Psychogeography with Jack B. Yeats art sounding gallery: augmented reality locative experience for blind people. Presented at the 13th International Conference on Applied Human Factors and Ergonomics (AHFE) (2022). https://doi.org/10.54941/ahfe1001639
12. Van Campen, C.: The Hidden Sense. Synesthesia in Art and Science. The MIT Press, Cambridge and London (2010)
13. Berman, G.: New perspectives on synesthesia art: shared characteristics. In: Synesthesia: Art and the Mind, pp. 27–32. McMaster Museum of Art, Hamilton (2008)
14. Galeyev, B.M.: The nature and functions of synesthesia in music. Leonardo **40**(3), 285–288 (2007)
15. Steen, C: What a synesthete sees: or why Tom Thomson sends me over the moon. In: Synesthesia: Art and Mind, pp. 17–26. McMaster Museum of Art, Hamilton (2008)
16. Ipser, A., Ward, J., Simner, J.: The MULTISENSE test of lexical-gustatory synaesthesia: an automated online diagnostic. Behav. Res. Methods **52**, 544–560 (2020)
17. Bressloff, P.C., Cowan, J.D., Golubitsky, M., Thomas, P.J., Wiener, M.C.: What geometric visual hallucinations tell us about the visual cortex. Neural Comput. **14**(3), 473–491 (2002)