Bulletin of the *Transilvania* University of Braşov
Series VIII: Performing Arts • Vol. 16(65) No. 1 – 2023
https://doi.org/10.31926/but.pa.2023.16.65.1.7

An interdisciplinary approach of Synaesthesia, a brain process unifying the senses

Mădălina Dana RUCSANDA[1], Alexandra Ioana RUCSANDA[2]

Abstract: *Synaesthesia is a multifaceted phenomenon encompassing genetic, neurochemical, and cognitive elements, contributing to a deeper understanding of how our senses and perceptions are intricately intertwined. This paper approaches an interdisciplinary approach to a current subject in cognitive psychology, examined by specialists from diverse fields: cognitive psychologists, neurologists, philologists, musicologists etc. Nevertheless, the diverse manifestations of synaesthesia and its phenomenological nature have posed challenges in verifying and studying its origins and mechanisms. This article adopts a medical standpoint in its examination of synesthesia, with a particular focus on its evolutionary trends and its influence within the domain of musical tasks.*

Key-words: *synaesthesia, genetics, music, colours, perception*

1. Introduction

Synesthesia is considered, according to the medical dictionary, "*a disorder of sensibility, consisting of the occurrence of a double sensation after a single stimulus (the second sensation occurs in a region near or distant from the excited region)*" (*** 2007, 732). As a neurological condition, it manifests through the simultaneous integration of multiple sensory modalities, where one sensory system intersects and intertwines with another. Synesthesia, an enduring phenomenon, can trace its historical roots to numerous prominent intellectual disciplines. Its multifaceted expressions and inherent phenomenological aspects have found mention in the literary works of esteemed figures encompassing critical thinkers, philosophers, psychologists, psychiatrists, and theologians over the course of centuries. This pervasive presence across various domains underscores the enduring intrigue and significance of synesthesia.

[1] PhD, Transilvania University of Braşov, m_rucsanda@unitbv.ro
[2] Student, Transilvania University of Braşov, alexandra.rucsanda@student.unitbv.ro

From a cognitive psychological perspective, synesthesia refers to the effects of primary informational intermodality, which means the "transposition" of one form of sensibility into another sensory modality (Zlate 1999, 70). It is considered one of the six laws of sensations (sensitivity thresholds; adaptation; interaction; contrast; synesthesia; significance), which can be interpreted as a particular case of the interaction of sensations, manifesting not only in changes in the level of sensitivity, but also in the intensification of sensations. While synesthesia is not exclusive to individuals within the realms of artistry or musicianship, psychologists have recognized it as a distinctive condition characterized by the concurrent reception of a stimulus in one sensory modality and the simultaneous experience of a sensation in another sensory domain.

The phenomenon of synaesthetic perception involves the spontaneous association of several senses and sensations: auditory, visual, tactile, gustatory, olfactory and represents a normal brain process which occurs due to neurological connections at the brain level: neurons and synapses of one sensory system intersect with those of another sensory system. Each synesthete responds to specific triggers with a unique sequence of intense, instinctive feelings (Ward, 2013: 49-75). For example, in addition to hearing sounds and music just like any other person, people who have the so-called colorful hearing associate auditory reception with the perception of colorful images: their subconscious builds and represents the external reality through different associations of sounds and colors. Colorful audition is the synaesthetic ability to perceive two different sensations from a single external stimulus: auditory and visual; this phenomenon occurs without a precise symptomatology and in fact constitutes a psychosomatic effect.

The interdisciplinary approach involves the search and adaptation of new interpretative techniques, interactions, or new perspectives on the visual-artistic phenomenon, aligned with current aesthetic paradigms. Transdisciplinary, as a form of interplay between multiple disciplines and the coordination of research endeavours, leads to a novel synthesis of knowledge and a specialized domain characterized by intricacy, rationality, and a deep understanding of reality.

This article explores the diverse aspects of synaesthesia, a fascinating phenomenon characterized by the merging of sensory experiences.

2. Genetic basis of Synaesthesia

Historically, synaesthesia was hypothesized to have an X-linked dominant genetic inheritance, with a higher prevalence in women (John E. Harrison and Simon Baron-Cohen, 1997). However, several studies have unveiled more complex genetic mechanisms (Hubbard and Ramachandran, 2003) and molecular genetic studies have been able to identify the associated genes and genetic loci involved in synaesthesia (Tilot et al., 2018). For example, Asher et al (2009) conducted a whole-genome scan and linkage study, revealing evidence of linkage to chromosomes 2q24, 5q33, 6p12, and 12p12 (Asher et al., 2009). Studies of monozygotic twins have suggested the influence of non-shared environmental factors in the phenotypic expression of synaesthesia (Smilek et al., 2005). Furthermore, the prevalence of synaethesia was higher in monozygotic that dizygotic twins, supporting the belief of an underlying genetic mechanism, but later studies have not presented enough evidence.

According to Neufeld et al. (2013), there may be a hereditary foundation for synaesthesia and autism spectrum disorders, which could be the explanation for the increased occurrence of synaesthetes among people diagnosed with autism. Numerous genes that vary throughout families can impact both synaesthesia and autism. (Tilot et al., 2018), (Wiśniowiecka-Kowalnik and Nowakowska, 2019). A familial analysis discovered evidence of the connection between a genetic region linked to synaesthesia and autism. The increased polygenic index scores for autism in synaesthetes were not consistently seen in larger sample research (Tilot et al., 2019). Thus, the genetic underpinnings of synaesthesia remain a subject of ongoing investigation.

3. Neurochemical perspectives

The serotonergic hyperactivity theory, proposed by Brogaard (2013), suggests that an overabundance of serotonin in the brain may trigger synaesthesia, whether induced by psychedelic substances, brain damage, or autism (Brogaard, 2013: 7:657). Psychedelic drug-induced hallucinations frequently result in synesthesia-like experiences (Luke and Terhune, 2013). This phenomenon is characterized by a persistent and involuntary production of a second immediate experience in a different modality following a sensory stimulation. (Ward, 2013).

Rarely, synaesthesia-like experiences have been reported after different types of brain injuries. (Ro, T., Farnè et al., 2007). This theory builds upon the idea that brain remodeling may cause perceptual experiences, such as phantom limb sensations in amputees (Ramachandran, 1998). It is important to consider that the somatosensory system can be activated through visual input (Ebisch et al., 2008), potentially leading to synaesthetic experiences when one sensory modality is stimulated, inducing conscious sensory experiences in another modality, such as touch (Brang et al., 2013).

4. Cognitive insights

There are cognitive perspectives on synaesthesia, as well. Some propose that synaesthesia may arise from cross-activation between closely located brain regions (Hubbard et al., 2005). Brain regions involved in synaesthesia, like the visual word form area (VWFA) and color processing region hV4, are situated in proximity (Wade et al., 2002). Research has suggested that if genetic factors or developmental processes fail to establish proper connections between these regions during early development, it may result in synaesthetic experiences where individuals perceive colors when viewing numerals or letters. (Kennedy et al., 1997). This insight highlights the interplay between sensory regions in the brain and how their connections can influence perceptual experiences.

Cognitive research on synaesthesia has illuminated the role of early developmental processes in shaping sensory perception. Prenatal linkages between various brain regions, including V4 and inferior temporal areas, have been proposed as factors influencing the development of synaesthetic associations. (Kennedy et al., 1997; Rodman and Moore, 1997). Understanding the role of these prenatal connections in shaping cognitive processes provides valuable insights into the origins of synaesthetic experiences.

Synaesthesia has been associated with potential cognitive advantages, particularly in memory and creativity. For instance, synaesthetes often have enhanced memory retention due to their unique sensory associations. (Rothen and Meier 2010, 109) They can use these associations as memory aids, linking information with vivid colors or sensory experiences. Moreover, these sensory-rich associations can fuel creativity and problem-solving, as they provide alternative and vivid pathways for conceptualizing and organizing information. (Yaro and Ward, 2007).

5. Synaesthesia and the broader context

Evidence indicates that synaesthesia might obstruct the acquisition of new associations between colors and shapes (Brang et al., 2013). Additionally, the concept of mirror-touch synaesthesia, where individuals experience tactile sensations on their own body in response to touch experienced by others, highlights the intricate interactions between different sensory modalities and emotional experiences (Banissy and Ward, 2007).

Recent research suggests that mirror-touch synaesthesia is linked with empathy (Banissy and Ward, 2007). This phenomenon sheds light on the overlap between synaesthesia and social cognition, with implications for understanding empathy and social interactions (Holmes and Spence, 2004).

6. Synesthesia in the world of Arts and Music

Musicians with synaesthesia often report a deep and multifaceted connection between sound and color, with their sensory perceptions intertwining to create a rich and distinctive artistic landscape. This intricate relationship between music and synaesthesia not only influences the creative process but also offers a unique perspective on the emotional and sensory aspects of music performance and composition. Furthermore, exploring the impact of synaesthesia on musicians provides valuable insights into the unique ways in which this condition might influence artistic expression, composition, and musical experiences. Understanding how synaesthesia influences musicians can contribute to a deeper appreciation of the intricate connections between our senses and the arts.

Moreover, a comprehensive exploration of the ramifications of synesthesia on musicians unveils invaluable insights into the distinctive manners in which this condition may shape artistic expression, the art of composition, and musical encounters. A deeper understanding of the modulating role of synesthesia in the sphere of musicianship enriches our comprehension of the intricacies characterizing the interplay between our sensory faculties and the sphere of artistic expression.

7. Patterns of Synaesthesia and its impact on musicians

Historically, as early as the Renaissance period, there were artists who were concerned with inventing instruments (such as the ocular harpsichord, Clavier à lumières, optophonic piano) whose keys, when touched, generated both sounds and colors. With the invention of his clavecin oculaire in 1734, the Jesuit priest Louis Bertrand Castel (1688-1757) is credited as a pioneer of the color organ, whose keyboard has five octaves. The back of the device had a black horizontal screen with a colored strip of paper or silk that appeared when a key was depressed. The colors were pure in the first octave, "one degree lighter" in the second, and highest in the fifth.

The color organ invented by the painter Alexander Wallace Rimington (1854–1918) was played along with an orchestra, a conventional organ, and a piano, in June, 1895 (Thomas 1947, 249). Rimington tried to combine three musical factors, such as time (probably tempo), rhythm and instant combinations of colors in order to establish analogies between color and music. Bainbridge Bishop (1837-1905) received a patent for a colored organ in 1877. It has a colored glass pane at the top of the instrument that is made up of tiny windows that lit up when a few shutters were removed, and the organ flaps were pressed. (Bishop 1893, 5).

In his dissertation Opticks (1704), astronomer, physicist, and mathematician Isaac Newton (1643–1727) is the first to write a work about the parallelism between the musical notes of the diatonic scale and the colors of the spectrum. Newton was the one who first claimed that light has no color and that it only exists in our brains, just as it was later shown that sounds are psychological phenomena that only exist in our thoughts (Levitin, 2010). In his visual representation of the spectrum, Newton used a circle split into seven sections of varying colors. He found the following relationships between colors and notes in a musical scale: Red – Do, Orange – Re, yellow – Mi, green -Fa, Blue – Sol, indigo – La, purple – Si.

His organ gained notoriety and the philosopher Moses Mendelssohn in 1738 employed vibrant spirals and serpentines to depict human emotions. Despite being well-known as a mathematician, Castel saw himself as a philosopher. Regarding the invention of a "harpsichord for eyes", he wrote two writings, the first in 1725 and the second ten years later.

Swiss mathematician and physicist Leonhard Euler (1707–1783) uses the variation in air vibration speed to explain the differences between fundamental colors (Erxleben 2005, 298).

In Romania, Eduard Gruber (1861-1896), a psychologist, aesthetician, and literary critic, is considered the founder of experimental psychology in Romania, and he was the first Romanian researcher of synesthesia. Choosing as his subject the case of the scientist (archaeologist) and poet N. Beldiceanu, who had the ability to chromatize sounds (vowels, consonants, diphthongs, syllables, common nouns), Gruber investigated the phenomenon of synopsia (chromatic hearing), presenting his results at the first two international psychology congresses (Paris, 1889; Rome, 1894). Subsequent investigations into synesthesia led to the idea that this seemingly unusual phenomenon underlies artistic talent.

During the Romantic period and afterward, there were musicians who experienced synesthetic episodes: Modest Mussorgsky, Franz Liszt, and Hector Berlioz, followed by Impressionist composers such as Claude Debussy and Maurice Ravel.

At the start of the 20th century, the syncretic and synaesthetic relationship between sound and image is described. The 20th century in music dismantled the tonal-functional epicenter and emphasized the fruitful synchronization of the arts, leading to the emergence of new forms of artistic expression (happening, performance, installations), primarily taking place in unconventional spaces. The Dadaist and Futurist movements began to take shape, and composers started to suggest a visual space beyond sound, while producers of photographic and cinematic images sought a sonic dimension beyond the visual.

Among the notable representatives of the 20th century mentioned to have synesthesia are Olivier Messiaen, Iannis Xenakis, Edgar Varèse, Itzak Perlman, Syd Barrett, Marilyn Monroe, Lady Gaga, etc. As an example, we will focus on Alexander Scriabin, also known as Aleksandr Nikolayevich Skryabin. He was a composer, pianist, poet, mystic, semi-, neo-, and theo-philosopher, and is considered a prominent figure of symbolism, often regarded as the modern composer of Russia. In parallel with his efforts to establish his unique musical language, Scriabin developed a philosophical system heavily influenced by Eastern ideas, with a strong emphasis on exploring the connection between music and colors in a synesthetic manner. Starting from Isaac Newton's theories, he created a color system called the "keyboard of light", associating each tonality with the foundation of the circle of fifths. In his theory, Scriabin believed that the analogy between sound and color also conveyed a corresponding emotional state, without differentiating between major and minor tonalities with the same name. For example, the synesthetic element was used in his work "*Prométhée*" with a color organ that was meant to accompany dance, lights, and atmosphere. One of his desires was for the concert hall to be inundated with lights of various colors, creating a synesthetic fusion of all arts in a mystical manner.

While this overview does not aim to be exhaustive, the exploration of synesthesia in the field of music, considering its evolutionary perspective, must be correlated with the medical aspects and studies conducted to understand the processes or mechanisms behind this phenomenon.

8. Conclusions

In conclusion, synaesthesia continues to be a rich area of research, shedding light on the intricate interplay between genetics, neurochemistry, and cognition. This phenomenon, once considered an anomaly, now serves as a window into the complex workings of the human mind. Music participates in defining the complex forms of artistic expression, and in terms of synaesthesia, it generates sensations at the level of several senses, triggering multi-sensory perceptions that amplify the message of the creator of art.

Further exploration of synaesthesia will likely contribute not only to our understanding of sensory perception but also to cognitive science, neurobiology, and the nature of human experience. As research progresses, we may gain a more comprehensive understanding of the genetic, neural, and cognitive mechanisms that underlie this intriguing phenomenon.

References

* * *. (2007). *MEDICAL DICTIONARY*. BIG ALL Publishing.

Asher, J. E., J.A. Lamb, D. Brocklebank, J.-B. Cazier, E. Maestrini, L. Addis, M. Sen, S. Baron-Cohen, and A.P. Monaco. 2009. "A Whole-Genome Scan and Fine-Mapping Linkage Study of Auditory-Visual Synesthesia Reveals Evidence of Linkage to Chromosomes 2q24, 5q33, 6p12, and 12p12." *The American Journal of Human Genetics 84*(2): 279–285. https://doi.org/10.1016/j.ajhg.2009.01.012

Banissy, Michael J. and Jamie Ward. 2007. "Mirror-touch synesthesia is linked with empathy." *Nature Neuroscience 10*(7): 815–816. https://doi.org/10.1038/nn1926

Baron-Cohen, S., L. Burt, F. Smith-Laittan, J. Harrison, and P. Bolton. 1996. "Synaesthesia: Prevalence and Familiality." *Perception 25*(9) : 1073–1079. https://doi.org/10.1068/p251073

Brang, David, Michael Ghiam, and Vilayanur S. Ramachandran. 2013. "Impaired acquisition of novel grapheme-color correspondences in synesthesia." *Frontiers in Human Neuroscience*, *7*. https://doi.org/10.3389/fnhum.2013.00717

Brogaard, Berit. 2013. "Serotonergic Hyperactivity as a Potential Factor in Developmental, Acquired and Drug-Induced Synesthesia." *Frontiers in Human Neuroscience*, *7*. https://doi.org/10.3389/fnhum.2013.00657

Ebisch, S. J. H., M. G. Perrucci, A. Ferretti, C. Del Gratta, G. L. Romani, and V. Gallese. 2008. "The *Sense* of Touch: Embodied Simulation in a Visuotactile Mirroring Mechanism for Observed Animate or Inanimate Touch." *Journal of Cognitive Neuroscience 20*(9): 1611–1623. https://doi.org/10.1162/jocn.2008.20111

Erxleben, J. C. P. 2005. *Anfangsgründe der Naturlehre*. Wallstein Verlag.

Holmes, Nicholas P. and Charles Spence. 2004. "The body schema and multisensory representation(s) of peripersonal space." *Cognitive Processing 5*(2): 94–105. https://doi.org/10.1007/s10339-004-0013-3

Hubbard, E. M., A. C. Arman, V. S. Ramachandran, and G. M. Boynton. 2005. "Individual Differences among Grapheme-Color Synesthetes: Brain-Behavior

Correlations." *Neuron 45*(6) : 975–985. https://doi.org/10.1016/j.neuron.2005.02.008

Hubbard, Edward Michael and Vilayanur S. Ramachandran. 2003. "Refining the experimental lever: a reply to Shannnon and Pribram." *Journal of Consciousness Studies 10*(3): 77–84.

Harrison, John E. and Simon Baron-Cohen. 1997. *Synaesthesia: Classic and Contemporary Readings*. Wiley-Blackwell.

Kennedy, Henry, Alexandre Batardiere, Colette Dehay, and Pascal Barone. 1997. "Synaesthesia: implications for developmental neurobiology." In *Synaesthesia: Classic and Contemporary Readings*, ed. by John E. Harrison and Simon Baron-Cohen, 243–256. Malden, MA: Blackwell Publishers, Inc.

Levitin, Daniel. 2010. *Our Musical Brain*. Bucharest: Humanitas Publishing House.

Luke, David P. and Devin B. Terhune. 2013. "The induction of synaesthesia with chemical agents: a systematic review." *Frontiers in Psychology*, *4*. https://doi.org/10.3389/fpsyg.2013.00753

Neufeld, J., M. Roy, A. Zapf, C. Sinke, H. M. Emrich, V. Prox-Vagedes, W. Dillo, and M. Zedler. 2013. "Is synesthesia more common in patients with Asperger syndrome?" *Frontiers in Human Neuroscience*, *7*. https://doi.org/10.3389/fnhum.2013.00847

Ramachandran, Vilayanur. 1998. The perception of phantom limbs. The D. O. Hebb lecture. *Brain*, *121*(9), 1603–1630. https://doi.org/10.1093/brain/121.9.1603

Ro, T., A. Farnè, R. M. Johnson, V. Wedeen, Z. Chu, Z. J. Wang, J. V. Hunter, and M.S. Beauchamp. 2007. "Feeling sounds after a thalamic lesion." *Annals of Neurology 62*(5): 433-441. https://doi.org/10.1002/ana.21219

Rodman, Hillary R. and Tirin Moore. 1997. "Development and Plasticity of Extrastriate Visual Cortex in Monkeys." In *Extrastriate Cortex in Primates* ed. by Kathleen Rockland, Jon H. Kaas, and Alan Peters, 639–672. https://doi.org/10.1007/978-1-4757-9625-4_14

Rothen, Nicolas and Beat Meier. 2010. "Higher Prevalence of Synaesthesia in Art Students." *Perception 39*(5): 718–720. https://doi.org/10.1068/p6680

Smilek, Daniel, Mike J. Dixon, and Philip M. Merikle. 2005. "Synaesthesia: Discordant male monozygotic twins." *Neurocase 11*(5): 363–370. https://doi.org/10.1080/13554790500205413

Tilot, A. K., K.S. Kucera, A. Vino, J.E. Asher, S. Baron-Cohen, and S. E. Fisher. 2018. "Rare variants in axonogenesis genes connect three families with sound–color synesthesia." *Proceedings of the National Academy of Sciences 115*(12): 3168–3173. https://doi.org/10.1073/pnas.1715492115

Tilot, A. K., A. Vino, K.S. Kucera, D.A. Carmichael, L. van den Heuvel, J. den Hoed, A.V. Sidoroff-Dorso, A. Campbell, D.J. Porteous, B. St. Pourcain, T.M. van

Leeuwen, J. Ward, R. Rouw, J. Simner, and S.E. Fisher. 2019. "Investigating genetic links between grapheme–colour synaesthesia and neuropsychiatric traits." *Philosophical Transactions of the Royal Society B: Biological Sciences 374*(1787), 20190026. https://doi.org/10.1098/rstb.2019.0026

Wade, Alex R., Alyssa A. Brewer, Jochem W. Rieger, and Brian A. Wandell. 2002. "Functional measurements of human ventral occipital cortex: retinotopy and colour." *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences 357*(1424): 963–973. https://doi.org/10.1098/rstb.2002.1108

Ward, Jamie. 2013. "Synesthesia." *Annual Review of Psychology 64*(1): 49–75. https://doi.org/10.1146/annurev-psych-113011-143840

Wilfred, Thomas. 1947. "Light and the Artist." *Journal of Aesthetics and Art Criticism V*(4): 247–255.

Wiśniowiecka-Kowalnik, Barbara and Anna Nowakowska. 2019. "Genetics and epigenetics of autism spectrum disorder—current evidence in the field." *Journal of Applied Genetics 60*(1): 37–47. https://doi.org/10.1007/s13353-018-00480-w

Yaro, Caroline and Jamie Ward. 2007. "Searching for Shereshevskii: What is superior about the memory of synaesthetes?" *Quarterly Journal of Experimental Psychology 60*(5): 681–695. https://doi.org/10.1080/17470210600785208

Zlate, Mielu. 1999. *THE PSYCHOLOGY OF COGNITIVE MECHANISMS*. Bucharest: Polirom Publishing.

Ward, Jamie. 2013. "Synesthesia." *Annual Review of Psychology 64*(1): 49-75. https://doi.org/10.1146/annurev-psych-113011-143840