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RESEARCH ARTICLE

AUDIOVISUAL SYNAESTHETIC STIMULI AND NEUROPHYSIOLOGICAL SONIC TRIGGERING: A SURVEY IN DIACHRONY

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ABSTRACT

High quality audiovisual performances are deeply rooted in traditional patterns. The scenery, the lighting, the garments, the postures, the kinetic elements and many more subtle sensations comprise synaesthetic elements. In kinaesthetic terms, theatrical stages, musical scores, hymnography or the texts of plays are factors that conceptually elicit neurophysiological potentials. This research attempts to decipher how tradition and renewal mingle in historical buildings and surroundings, based on well documented and amply commented musical credentials within the diachrony of the last 8 centuries.

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INTRODUCTION

Although the saying of Epicharmus (540 – 450 BC) "The mind sees and the mind hears" ("Νοῦς ὁρᾶ καὶ νοῦς ἀκούει") seems to be administering rather philosophical insight than neuroscientific pieces of data, the artistic approach through the ages, for which more or less there is a global consent for appreciation, seems to be practically adopting this theoretic perspicacity. In contemporary terms, the wuthering snow misted mountains, the appalling tempestuous sea, the vibrant green leaves of trees, the twitting of song birds, the perfume of citronella, the breeziness of the aura, and in general, what we see and hear, even in TV, what we scent, what we touch, what we taste, …, what we call "tangible" reality, does not exist *per se*, but rather is an imprint of what electrochemical signals ripple over cerebral activity. For instance, when one sees dewy green leaves it is not that certain that all living creatures sense them in the same chromatic zone. What really exists is atomic and sub-atomic range elementary particles, electrons shifting from one excitation level to another, electromagnetic radiation emissions, moving photons causing spectral dynamic allocations, molecular interactions and strenuous energetic activity when particle displacement originated transmissions interact with matter, both in the macro world of balanced geothermal equilibrant and within the micro worlds of personal sphere perceptions. In the world outside the human body there is no "cold" or "hot", but intensity of molecular activity, i.e. a comparative scale of thermal efficiency. Humans see not the real physical matter but a derived form of objects around them, i.e. the light they reflect or they transmit - and for this reason eyesight vision is reduced dramatically in darkness. The incoming light enters the eyes through the cornea and is accordingly directed towards the pupil and iris, and through the lens it focuses on the retina. The photoreceptors of the retina, namely the rods and cones, translate visual stimuli to electrical pulses, which are transmitted via the optic nerve as "messages" to the brain (Baloyannis, 2012). A tremendous 3D recomposition of these neural impulses takes place and the stimulating energy that has been transmitted as sensory input highlights representations of external forms as sequences of moving images. Within the brain's visual, auditory, olfactory etc. areas immeasurable sensations mould into complex perceptions (Hubbard and Ramachandran, 2005). The brain sees and scents culinary delights using the central nervous system; it is not the tongue or the pharynx causing relish, but cerebral activity over some 100 billion neurons, each of them connected with thousand others, forming an immense network

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of 100 trillion synapses – one of the most complex structures within the universe (Baloyannis, 2005).When acoustic impressions are encountered, literally "sounds" do not subsist as independently existing constructions. Rather concentrations and dilutions of atmospheric pressure modules that are conceived as pulse wavefronts forming acoustic stimuli in outer and middle ear modules, which are translated in a series of meaningful "events" within the inner ear – cerebrum interface (Politis *et al.*, 2017). These events compose learnable "small episodes" of music scores, either autonomous, or as an accompaniment that may dramatize a narration, conclude a score for a film, build the performance for an opera and many more (Palaigeorgiou, and Pouloulis, 2017). It is cerebral activity that translates adroitly matched sequences directing the mind to wander into track fields, where strong influences from the premeditated conscious part mingle with the non-directly perceptible part of the subconscious. This approach explains the holistic contrivance for considering the acoustic nerve, which shares common resources with the vestibule, as the covariant vestibulocochlear channel of communication (Rouw*et al.*, 2013; Tsalighopoulos *et al.*, 2008). Even further, from the well attested five sensory inputs, what in older times was called the "five senses", contemporary research has concluded that up to 25 or more sensations may by evoked (Jarret, 2014).

In many cases, the exact nature of stimulating dynamics exerted through neural pathways remains rather fuzzy; the formal link between neural network structure and its emergent functions hinders the understanding of how brain processes information (Cooper *et al*., 2007). Of course, since business promotion, market research and advertising prove to be an instigating force for neuroscientific research, visual stimuli, sounds, melodies and ambient scents associated with positive emotion arousal have been used for quite a while in coercing instinctive or intuitive feelings over reasoning, as far as the customers' spending activity is concerned (Margounakis *et al*., 2006).

Entangled sensations and emotions that structure mental faculties

Contemplated mental processes vary considerably for subjects as problem solving is involved in coping with intricate plots, complex interactions and convoluted thinking. Sets of rules are followed in calculations or elaborate problem solving operations are devised for the explanation, interpretation and finally the compound problem solution. Common features of these situations are their concrete specific objectives. They may vary considerable in range, from "how to knit a beautiful garment, by interlocking loops of wool or other spun with knitting needles or on a machine" up to "how to efficiently release energy in nuclear fusion by triggering atomic particles." Therefore, in each case the terms, signification and target may differ, but the characteristic attitudes of the mind may be the same. Experiences are far more complex phenomena, since they are not mere outcomes of mental activity and calculation.Mental faculties are the constuctivistic building blocks of thinking. They are the semantic elements that represent real objects and symbolize situations far beyond their visible or sonic impressions. Furthermore, notions are set as arrangements of ideas that promote the process of thinking. However, one thing is the awareness of notions that represent objects or situations, and another is the symbolic embodiment, the particular signification between objects and situations (Sundberg, 2013).This rather abstract statement is more easily received when "translation" is taken into account: when attempting from sensory organ stimuli to move forward to mental events analysis, it becomes evident that not all "languages" describe that accurately the situation (Hong and Mallorie, 2004). For instance, a well-known song when performed in various languages does not provoke the same physical or mental impressions: the phraseology and the vocabulary may differ significantly (Wang *et al*., 2006; Thompson and Balkwill, 2006).Once a mental problem has been adequately solved, the repetitive confrontation with it or its variants becomes easier: fewer mistakes are committed and less time is consumed. Eventually, subjects are transferred to the stage of automated thinking (Stevens, 1936; Seashore, 1937; Sundberg, 2013).

Not rarely, mental problem solving may encounter unsurpassable hurdles; dead ends however may be leapfrogged by reversing the pedantic order in the direction from the end to the beginning. This "reverse engineering" process may hence achieve a reconstruction of the internally or externally imposed limits on the resources and come up with different imaginative illustrations or representations i.e. to inventive creative thinking (Postle, 2006).These mental and emotional factors studied comprehensively for their psychological foundations seem to be of great significance for the decision making part of Artificial Intelligence. The decision making alongside the overall way of thinking comprise essential qualities for forming an individual's distinctive character. Other characteristics, that combined together are essential for the distinctive qualities of one's personality are: biological, environmental, social, climatic, educational, religious, of national or cultural tradition, etc. (Cole and Engestrom, 1993). They constitute an amalgam that is perceived more than a mere sum of its parts. Indeed, these constituents group together in constantly varying portions and dynamically biased interactions, explaining perceptions in terms of Gestalts rather than as an enumerated list (Spreckelmeyer *et al*., 2013). More advanced neuroscientific approaches give an insight on how human communication is integrated by relations of subjects to the world, concurrently adjusting their internal distinctive qualities by role-playing and reassurance of past conflicts.

Although these facts have been reported extensively in the past as essential elements of a psychotherapeutic approach, they currently constitute a daily experience for most netizens (Patokos, 2008). Indeed, contemporary people live in different kind of reality, in comparison with what their parents encountered. They are in a practical contact with observation and facts, events and sensory impressions that come as high quality audiovisual activities, practically at no cost (O'Regan and Noe, 2001) Furthermore, these ubiquitous, readily available input signals apart from evoking specific functional reaction arouse activity in unprecedented levels. Accordingly, subjects not only live in extra dimensions, those of an augmented and mix reality, but inevitably move in accordance with a very fast rhythmic contraptions. For instance, heaps of music plunge listeners to new experiences, with an estimate in 2018 for more than 1 billion songs freely available to the general public via WiFi, 4G or wired Internet connections. As smartphones become more capable recording machines, nearly every artistic performance is filed in huge audiovisual repositories, intended for public use (Rao, 1999; Koch and Tsuchiya, 2006). Therefore, in HCI terms, multimedia interaction is not only exerting superfluous reception to limits

beyond human capacity, but simultaneously it engages the reciprocal conjugate action of full steam overload (Merchant, 2014). Unprecedented throughput in input and output does not affect only broadcasting streams but also accelerates informal and non-typical multimedia learning. Multimedia learning is arousing faster and in more depth cerebral activity, accelerating learning to unprecedented depths and rhythms (Assaad *et al*., 2017).The educational material that lies in the Internet cloud is immense - currently at least 100 times more than what exists in scholarly editions or government-aroused educational TV-like open courses (Jiow *et al*., 2017).Nevertheless, this survey does not extend to how globalized technological advances contrive with different cultures and intellectual values further more than the neuroscientific, musicokinetic and acoustic channel of communication (Thompson, 2008). Although sensory organs have the responsiveness to instinctively record thousands of unorganized external stimuli every minute, more or less in random fashion, the awareness of human organism for the surrounding conditions in which it operates are characterized by good organization, meaning and significance, reasoning and rationale, which efficiently coordinate the activity for arrays of structured subsystems on a large scale.

The sensory organs see, hear, touch, ..., but the whole organism exercises the activity for vision, listening, empathetic awareness for contact, etc.

In terms of cognitive focalization on sensory cues and signals that generate attention or consciousness (Vargic *et al*., 2015), the complex mental processes that evaluate the triggering input are based on

- The physical characteristics of the stimulant signal and its association with one, two or more sensing organs, e.g. the sense of balance that correlates movements and rhythm in dance music (Vargic *et al*., 2015)
- At second stage, its significance, e.g. as such may be perceived a music performance of a street artist and not as arbitrary sounds out of the noisy roads
- At third stage, the semantic integration into meaning (Cummings *et al*., 2006), i.e. if it is music, what kind of labels, exclusive categories or identities we can assign to it

On the whole, the human organism carefully manages available resources and functions purposively, assigning different meaning and importance, not only to different kind of stimuli but even to different sections of an irritation (Mattingley, 2009). It seems that cerebral activity culminates effectively on discriminating between "data" and "information" (Rasheed *et al*., 2015). When understanding reaches the third stage, subjects become pretty much aware of the overall artistic "design": they may recognise purpose, planning or intention.
Theoretical models have been developed to give a consistent interpretation on how "raw" data are transformed to digestible information, stimulant enough to encourage interest or activity (Mattingley, 2009), and finally lead to the extraction of meaning and the emergence of conscious experience (Kamke *et al*., 2012). If pieces of data are missing or, on the contrary, if the brain becomes exposed to excessive information, the conscious mind may be obstructed from achieving task completion. This state is often insinuated as "information anxiety" (Kaur, 2015); it ensues when data have not been appropriately translated into relevant information, and in terms of "data science" it is often referred as "information overload." This condition however does not imply inability to handle abundant stimuli input but rather inefficacy to invoke routine mechanisms that will bring out of user experiences a deeper understanding or a formal conclusion (Sperling and Dosher, 1986). It rather implies that the human attentional system has limits, deficits and furthermore, prerequisites for stipulated multitasking.

One of the three major co-active processes of the working brain is attention, i.e. the process with which, our organism, in a certain time, selects which stimuli of the outer world should be further processed, while it procrastinates or entirely disinterests on others (Posner, 2012). This focalization on sensory cues generates consciousness on the component tasks to perform (Braun and Julesz, 1998). When it comes to synaesthesia, it is questionable whether neurobehavioral patterns as far as emotion (Kanai *et al*., 2006), motivation and finally thinking are affected by the excessive load of the human multitasking system or the strain of the single pool of intentional resources due to poor design (Desimone and Duncan, 1995; Cytowic and Eagleman, 2009).

Synaesthesia: the basis for acoustic information visualization

Contemplated mental processes of ordinary people convolve synaesthetic production of sense impressions relating one sense or part of the body by stimuli received by another sense or part of the body. Although recent research focuses primarily on the extraordinary abilities of a diminutive minority, the synesthetes (Cytowic and Eagleman, 2009; Rouw *et al*., 2013), synaesthesia involves the common pool of sensory modalities, that nearly all people deploy (Ward *et al*., 2007), by consistently and automatically triggering concurrent percepts in another modality (Zamm *et al*., 2013; Lacey *et al*., 2016). By monitoring component tasks of the attentional system, the neural correlates for the cross-modal association (Goller *et al*., 2009) of the human multitasking system may be probed (Grossenbacher and Lovelace, 2001). Although current advances in technology overwhelmingly produce data, from mobile technologies and/or social media, on how netizens navigate into arbitrary virtual worlds, their processing has difficulty in correlating subjective experiences or mental activities with long attained theoretical foundations. Therefore, for this research, when it comes to thinking and behaviour, historical evidence and mental stances that have been accurately recorded are used. They provide ample material for exact computational intelligence oriented analyses and syntheses of the phenomenon, as it was perceived and attentively coerced in daily activities of everyday people (Skanland, 2013).In this research data from the domain of acoustics, music and architecture have been used extensively, giving evidence for the diachrony of the attentional system based synaesthesia, for at least the last 8 centuries. When decoding behavioral parameters and neurophysiological feedback from activities involving strenuous triggering of the senses, the multimodal human system correlates specific spatial locations with experiences in colors (Arend *et al*., 2016).This attitude implies that the human organism is not a passive receiver of stimuli coming from the surroundings or the conditions of the social environment; on the contrary, it actively communicates with its associated receptors. These may be other peers, in such a way as to have effect on them,

him self, as interaction may act reciprocally, and his past, as one may energetically use his memory to return to a previous condition, in mental terms (Fig. 1). The architectural styles and the designs of building constructions, the colours used in garments or decoration, the sounds produced, the characteristic scents, etc., act as passive or active components of the human attentional system affecting the subject's neurobehavioral performance. Spatial visual-auditory tracks may interfere with spatial visual-tactile tasks, whether in real mode or as memory recalls, facilitating object detection by simultaneous recalls from the attentional system resources (Kamke *et al*., 2012; Sale and Mattingley, 2013).

mosaics of the Rotunda (Fig. 2), ascribed to Early Byzantine Period artists (4th - 6th centuries AD), roughly in the period between Emperors Theodosius I (379-395 AD) and Justinian I (527-565) (Deckers, 2007; Miles, 2017; Europeana Collections, 2017). Experts assign the creation of the mosaics during that period; Artistically they are interconnected in skill and style with those found in Ravenna, Italy (Beckwith, 1993). These clues increase in number for Thessaloniki during its various phases. After the end of iconoclastic period (842 AD) the voluminous upper niche of the sanctuary was illustrated with extensive frescoes of the Ascension.

a **b**

c

Fig. 1. Expressions of synaesthetic stances in social interactions through colour, posture, architecture and gesture. a. A painting by Osman HamdiBey, 1888, depicting ladies walking in front of a mosque. b. Contemporary people walking in front of the 4th century AD Rotunda monument, Thessaloniki. The minaret on the right is a remnant from the period it was used as a mosque (1591-1912 AD), after the Ottoman conquest of Thessaloniki (1430-1912 AD). c. The Galerian complex of Thessaloniki (299-311 AD). In front the Arch of Triumph and on the back end the Rotunda. Picture cropped from social media

The daily immersion to colourful synaesthesia, performed by nearly all humans, takes place when they dress (Baumgartner, 2012). The articles of clothing, being by themselves exhibits of popular trends, specifically expressed in each era, reveal personal and social manners of behaviour. This is depicted in Figs. 1a and 1b; taking into consideration the sculptured figures of the Arch of Galerius (299 - 303 AD) (World Heritage Encyclopedia, 2017; Ephorate of Antiquities, 2017), the women wandering around the mosque in the 1880s and the tourists of our times, we have pretty good representations of the external form of social behaviour as far as acceptable principles for mixing with other people are concerned. Pieces of evidence and information for the integration of dressing within the social habitat can be found at the newly restored

However, most of the iconography and the mosaics of the middle and lower zones have been wiped out, probably during the reign of iconoclasts or hostile to figurative representations leaders. Therefore, at the restoration of the building in 1889 AD, serving then as a mosque, the Italian S. Rossi was commissioned to complement the mosaics with paintings (Hendrix, 2017; Hellenic Ministry of Culture, 2017). For the Later Byzantine Period and the years of the Ottoman conquest (10th - 19th centuries AD) iconographic evidence is not found that much in Rotunda, but abundantly in other UNESCO world heritage monuments (UNESCO 1998-2017), like Panaghia Chalkeon ("Our Lady of Coppersmiths") church (11th century), the Hosios David Latomos ("of quarries") church - renewed with mosaics and frescoes between the 12th and 14th centuries,

the St. Panteleimon church build between 1295-1318 AD, the St. Nikolaos Orphanos interior decoration, dated 1310-1320 AD, the Vlatadon monastery, founded in 1328 AD, the Prophet Elijah church, illustrated between 1360-1380 AD, the churches of St. Catherine and the 12 Apostles, with their 14th century frescoes and a handful of similar monuments.Of course, people do not always dress appropriately to each occasion their personal trajectory leads them to; there are situations or events where neither personal finances nor the fashion supply endow with particular quality, appropriate with the subject's wishes for an influential interaction with other members of an ordered community (Baumgartner, 2012).

behavioural and performance attitudes may be encountered within the kinaesthetic performance of a singer - dancer. No matter how professional he may be, human recital is usually a complex rendition, subject to physical and mental conditioning. Performers are affected by the environment they function in, with prevailing factors being the atmospheric conditions, their nutrition, the illumination, etc. (Markaki and Kokkalidis, 2016). There are even techniques for "warming up" in order to attain by effort and skill adequately expressive and aesthetically accomplished interpretations. Artists always interact with the audience and their fellow musicians, vocalists and other dancers (Bachorowski and Owren, 1995).

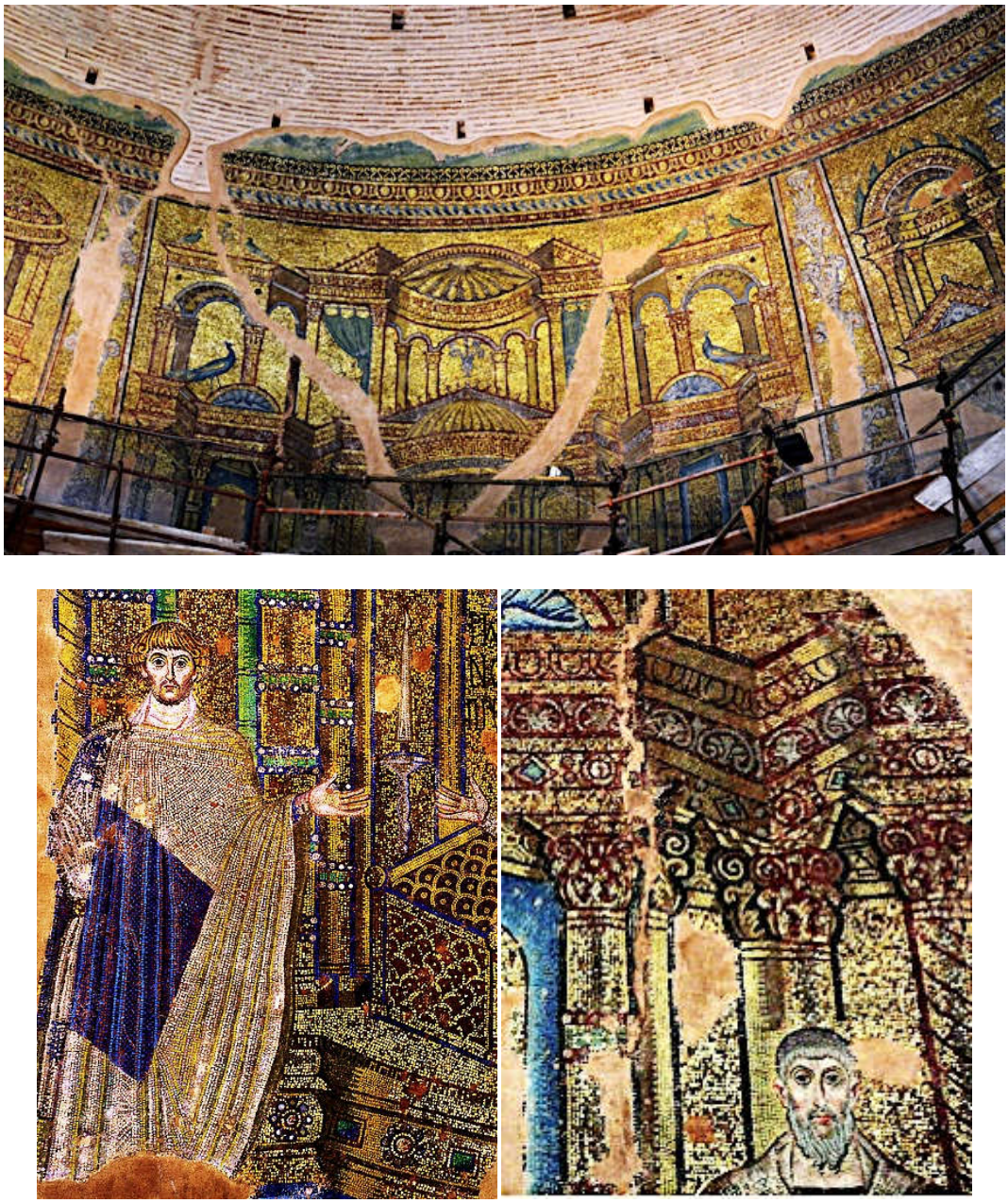

Fig. 2. Impressive recently restored mosaics at the upper part of the dome, dating from the Early Byzantine Period. Usually made of small pieces of coloured glass or marble, sometimes of pure gold and other precious metals, they shape decorative symbolic images from Old and New Testament stories or pictures of saints. The gold background of the mosaics reflects light providing an illuminated, brightfull and majestic hallucination for the rituals performed inside. Pictures cropped from social media

Sometimes, subjects even have to dress hurriedly, in order to accomplish a task, and therefore they imperfectly or unsatisfactorily manage to dress, negligently decorate themselves with jewellery, or nonobservantly enhance their appearance with perfumes, cosmetics and make-up. Similar

Live performances are dynamic manifestations, and nearly not two of them can be found "identical." Performers are vulnerable and susceptible to input stimuli from the environment and the audience. Never these factors are exactly the same, and therefore no single performance is identical with

another occurrence of the same opus (Kriegstein and Giraud, 2006).

Fig. 3. Open social gathering at which people perform traditional East Mediterranean circular choreography under the auspices of the "Chororama" dance school outside the Rotunda. Young children and toddlers mimic their parents' sequences of steps and bodily movement exerting their own version of the tune they hear, according to their physical and mental kinaesthetic stage of understanding

The written "instructions" (e.g. the score) are always a brief account of what an artistic rendition is, implying usually a complexity that surpasses the customary formalities of an operational system that describes the sequences of a staged event (North *et al*., 2004).As performers gain more knowledge by study, practice and experience, alongside the fast moving technological advances in audio-visual technology for staged events, they extrapolate the artistic sensation in new horizons, both for them and their respected audience. This is clearly obvious in Fig. 3. Dancers may participate sufficiently in this circular dance only if they have a previous adequate knowledge of the sequence of steps and the kinetic motives that constitute this particular form of dancing. Secondary elements, like the rhythm used or the gesticulated movements of fellow dancers may be adjusted by using interactive resources of the attentional system (Juslin and Laukka, 2003; Koch and Tsuchiya, 2006).

However, if there is no sufficient memory residue of former experience on how to accomplish this specific dance, performers will not stage a decent rendition (Evans and Treisman, 2010; Velmans, 2012).In such case, the learning practice used for centuries, was to instigate repetitive participation in similar performances, from young age, until dancing operational capabilities as behavioural accomplishments have been achieved (Iwasaki, 1993; Merikle and Joordens, 1997).All these elements, concisely depicted in Fig. 1 are regarded as active constituents of a civilization in a particular area in its diachrony. In Fig. 3 it is impressive that little children of schooling age extemporaneously participate in their parent's public exhibition. They do not have any prior knowledge of the dancing rituals, but they naturally feel the systematic arrangement of the musical sounds and move rhythmically according to the repeated stress patterns of harmonious sequences (Iwasaki, 1993). Indeed, in literature it is reported that children at the age of five or six, apart from learning how to read and write, they can recognise more than 10 notes of the pentagram, namely the whole, half and quarter notes, quivers, sixteenths, etc. (Tierney*et al.*, 2015; Palaigeorgiou and Pouloulis, 2017). At this age, a child is capable of playing simple musical instruments, as is the metallophone.

For even younger children, like the ones depicted in Fig. 3, it is obvious that pre-schoolers have the ability to comply with artistic sensitivity (Ortony *et al*., 1988; Schubert, 2004) i.e. to move rhythmically to music, although they cannot decode the exact sequence of the footwork nor comprehend the meaning of the forcefully stressed and unstressed movements of the thigh and the lower leg in a quick and lively way, resulting in performers not having both foot on the ground. It seems that popular art at its best may provide, along maternal care and affection, a framework from which a child may elicit a favourable reaction absorbing essential characteristics for his social, cultural and moral development (Krumhansl, 2002).

Participation in popular activities facilitates the acquisition of knowledge under the triptych of experience, practice and study, as far as fundamental constituents of the surrounding world are concerned and diachronic values of its civilization are promoted for social development. They constitute the pool of mental, cognitive, emotional and social dexterities that characterize stages that units or groups of a society may reach. They are enriched by visiting, in regular intervals, museums, appropriate professional habitats, and places where dramatic or musicokinetic performances are given (Cole and Engestrom, 1993).Even further, paintings, icons and mosaics that have survived in monuments, like the Rotunda in Thessaloniki, apart from their incomparable artistic excellence, provide to contemporary researchers valuable information about the interpretation of audiovisual elements, colouring habits, posture and gesture through ages. Under the enormous interior of the vault, a spacy interior with exceptional acoustic attributes is offered for unsurpassed audiovisual interactions, since no columns or other supportive structures obstruct vision and hearing (Ephorate of Antiquities, 2017). It is evident that this monument and its similar in Thessaloniki follow suit Vitruvius' (80 - 10 BC) constructing cannon, as testified on his comprehensive 10 volume treatise "On Architecture": The composition of sacred buildings should be evolved around symmetry, the qualities of which architects should in particular demonstrate in their constructions, with regard to its specific mathematical qualities and analogies (Tatarkiewich, 1999).

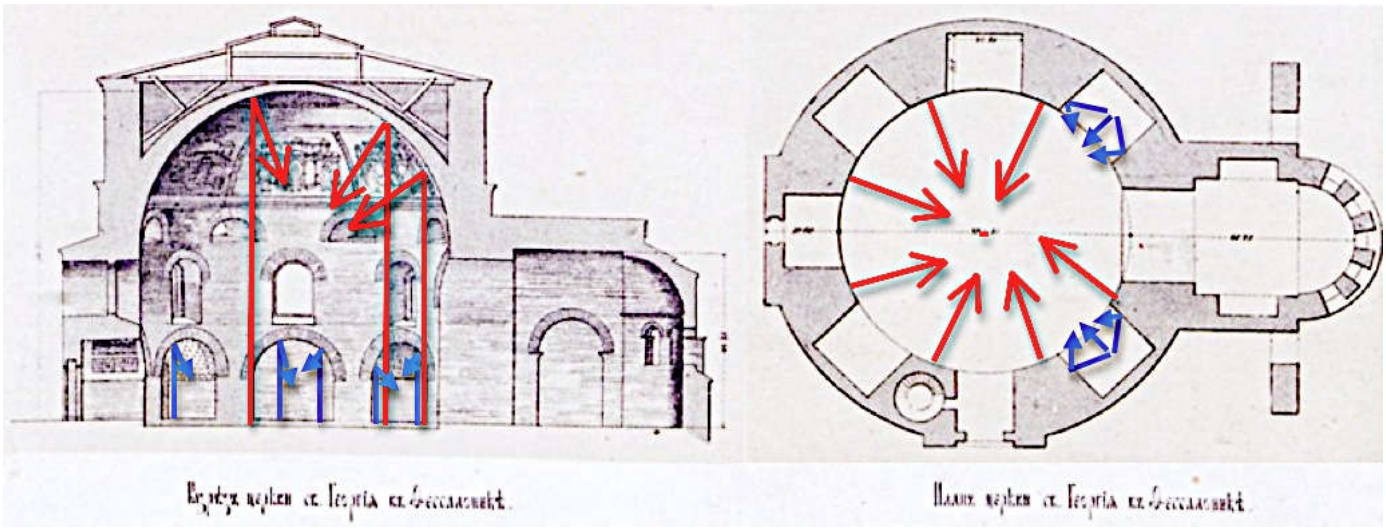

Fig. 4. Very accurate architectural designs (longitudinal section and ground plan) of the Rotunda, as depicted in 1870 AD Russian lithographic prints. The red and blue arrows demonstrate the acoustic properties of the building, with emphasis on its 31m high dome and its side porticos. The focal point is under the apex of the dome. At this point the building has dazzling acoustic properties and panoramic view for the ceremonies held

In certain cases these architectural rules and principles were serving not only visual aspects of the aesthetics of buildings, but the acoustic organization as well, as seen in Fig. 4 (Patieridis and Stamatis, 2009).The splendour and grandeur of the building, which was seemingly part of the royal complex in Thessaloniki, founded somewhere during Galerius's reign (298/299-311) or Constantine's sovereignty (311-337 AD) and completed during Theodosius's rule (379 - 391 AD), along with its architectural organization helps to mould conceptual structures and faculties, of meaningful Information Visualisation when attending performances under its enormous dome (World Heritage Encyclopedia, 2017). Researchers can only hypothesize how a liturgy or a communal ritual took place in it during the first millennium AD. For later periods we have adequate reports (Cousinéry, 1831). However, there is strong evidence from similar circular or polygonic monuments throughout the Greco-Roman world, like Hadrian's Pantheon in Rome, Italy (126 AD). For the Pantheon it self, which has been renovated for use as a church, not sufficient clues exist for its original inside decoration.

However, the aesthetic and functional attributes of the Greco-Roman world have sufficiently survived. Along with urban landscapes from well preserved paintings and mosaics in Pompeii, Italy (79 AD), the Fayum portraits in Egypt (1st century BC-2nd century AD), to temple and tomb architectural elements in Petra, Jordan, researchers may reshape the visual appearance for the everyday living of a very advanced society and the audiovisual perspectives of the natural scenery for the urban environments of that civilization (Beckwith, 1993). Even further, after Decius' era (249-251 AD) and the public use of Christian places for Worship, many circular buildings have started to emerge throughout the Roman Empire (Beckwith, 1993; Deckers, 2007). These are, in chronological order, the Church of St. George in Diyarbakir, Turkey (3rd Century AD), the 4th century Rotunda and Aedicule, which contains the Holy Sepulchre in Jerusalem, Santo Stefano Rotondo, the oldest example of a centrally planned church in Rome (4th century), Santa Costanza round building church in Rome, constructed the same century, the church of St. George Rotonda (4th century), considered the oldest building in Sofia, Bulgaria,the St. George church in Ezra, Syria, having hosted St. George's relics and reinitiated in 515 AD as a Christian site, the Church of St. Gregory, Ani, Turkish Armenia (4th century), the 5th century Red Church near Plovdiv, Bulgaria, the 520 AD mausoleum of Theoderic in Ravenna, Italy, a rotunda inscribed within two decagonal orders, the early 6th century church of Sts. Sergius and Bacchus (Küçuk Ayasofya Camii) in Istanbul, Turkey, the early 6th century octagonal concentric church of St. Sergius, Bacchus, and Leontius at Bosra, Syria, and later, the Boyana Church (Боянска църква), a medieval church on the outskirts of Sofia, the Coptic church of St. Sergius in Cairo, Egypt, and many others not that well preserved. Unfortunately, in several recent VR reconstructions for monuments of that era, arbitrary and insubstantial evidence has been promoted. For this reason, as it will be presented in this research, these clues *per se* are not enough. For instance, as the early 20th century musicologist Suzanne Demarquer puts it, "an attempt to reconstruct ancient tragedy from a musicological point as well as from the theatrical point of view would be futile" (Floros, 1972). Therefore, this research rewinds diachrony for only the last 8 centuries, during which, we have ample sources for how Byzantine Music was written, pronounced and performed (Alexandru, 2017). Indeed, all the performances encountered use as a triggering mechanism auditory signals. All the kinaesthetic actions are synchronised as responses to events mostly screening functions of the autology battery.

Within this scenery, the background nonverbal mode of communication is the basis for proposing the notional framework of "emotional reality." It correlates primary facts of psychological life with thoughts expressed in words as the derivative fact (Lothane, 2015). As processes of development, emotions and ideas become united in complexes that are composed of emotional coloration of ideas and the ideational content of emotions (Simon-Thomas *et al*., 2009; Lacey *et al*., 2016).Methodologically, social gatherings, whether for entertainment purposes or ceremonial occasions, aim to gradually submerge participants into a different reality from the everyday state of things, which is often depressing or disheartening. The sequence of staged events that take place, seeks user participation and interaction, targeting to a notional idea that is not only seen or heard, but is actually experienced

(Russell, 2003). The interior design is to a certain extent in accordance with the seasonal characteristics or the festive content of the ecclesiastical calendar. Performers and participants dress accordingly, and hierarchically part in the commemorating ceremonies. In Psychological, Neurobiologicalor Communication terms, the attention of the public should be attracted to enjoyable for the senses and the mind incidents that give communicative competences to notional patterns (Moridis *et al*., 2010).

fierce struggle for social development and organization, the antidote to disorder, confusion and finally destruction. Therefore, specialists at every age put their skill to effectively provoke the desired cerebral and emotional activity. For instance, architects and sound engineers provide such acoustic characteristics to amphitheaters, auditoriums and churches so to provoke controlled auditory Auditory Brainstem Responses (ABR) to attendants (Tsalighopoulos *et al*., 2008) that the available technology of their era can afford (Schmidt, 2000).

Fig. 5. Left, visitors attend a morning service. Sunlight amply illuminates the interior of the monument, along with some decorative fluorescent lamps, prompting liveliness to the participants. However, the destruction of the lower and middle zone decoration is degrading the aesthetic quality and the synaesthetic stimuli. Right, an acoustic nocturnal performance by the Symphonic Orchestra of Thessaloniki, as broadcasted by ERT3 in April 2016. The two choirs are positioned inside the lateral domed porticos enjoying middle frequency amplification of their singing. The instrumentalists and the distinguished guests are placed beside the center of the dome taking advantage of its extravagant acoustic effect experience. Adjustable illumination of permanent spotlights, reinforced by portable, pole vaulted powerful floodlights, creates shades and decorative illuminations that may be simulating synaesthetic impressions very closely the original ones during periods that the internal decor of the monument was intact

User participation comprises a grid of events that take place before, predominantly during, and after the prime event. For instance, Christmas and New Year rituals are celebrated more or less globally; however, the specific gravity of the festivities varies significantly, depending on the mood of the recipient community (Juslin *et al*., 2008). Sensory and emotional stimulation merit the use of subconscious potential sources that depart from the established course of a rational approach: obsessions, phobic syndromes, aggressive behaviours, along with ideas, concepts, wishes (Naranjo *et al*., 2011). The architects, the composers, the authors, the creators, and in modern times the advertisers, the producers and the distributors of consumer goods know very well how people fit within the framework of applied psychology, as far as reaction, participation and control is achieved over masses or audiences, by biasing psychological and physiological patterns of behaviour. The amalgam of rational thinking and the astounding depth of the emotional world constitute the driving force for communication, by expressing with speech, phonation, singing, dancing, acting, literature, iconography, garments and gestural performances aspects of the rich human content (Illie, 2006). Even further, the sense of humour, amusement or laughter, sorrow, annoyance, unimportance and many other arrangements of such elements are fine-tuned nuances of elegance (Scherer, 2003).

Thus far, only humans can express and the same time create beautiful structures.When participating in celebrative occasions within historic premises, users are emotionally triggered (Miranda *et al*., 2013; Morinville *et al*., 2013) by the achievements of their ancestral generations. They evaluate how their progenitors faced the difficulties of living and what advanced products of civilization they culminated in their

These acoustic effects are different from one building to another. As a result, apart from the artistic and emotional value of a staged performance, audiovisual effects like contrastive paintings, striking mosaics, lighting and echo effects, deliberate reverberations and remissive amplifications create enhancements of the apparent intelligibility of the artistic event (Safran and Sanda, 2015). Every generation, every era promotes its own solutions to the eternal problems that human diachrony has produced as evidence. Historic buildings, creations and artistic events homogenize in a creative manner all these stances. Places of worship, shrines, music theatres, concert halls, opera houses, cultural buildings and recently, high quality cinematic productions, all these serve as outlets that pipeline spiritual, intellectual, moral and social instruction (Postle, 2006). High quality activities or performances in theatre, painting, music, poetry, hymnography, literature, dramaturgy provoke a series of sensational or impulsive psychopathological episodes that educate the attendants by thoughts, emotions and desires that provoke mental activity within the psychosomatic entirety, i.e. independent notions and abstract concepts (Goudbeek and Scherer, 2010).

In particular, the following have been measured:

Visual Effects and Illumination: Through Rotunda's various historical phases and conquests, the middle and lower zone paintings-mosaics have been completely torn out, probably when iconoclast rulers were in charge. However, as seen in Russian lithographic prints (Patieridis and Stamatis, 2009) of the Ottoman period (Fig. 4), the upper zone mosaics, some 25 meters beyond ground level, were not destroyed, but were considerably obscured, perhaps due to smoke and waste gases,

the unavoidable secondary production of lighting and heating fuel-burning installations used in previous ages. High precision restorative works (1978 - 2013 AD) have brought mosaics to their original shine and have revealed some 30 male figures in multi-figure scenes (Ephorate of Antiquities, 2017; Miles, 2017). Unfortunately, the middle zone mosaics have been completely destroyed. In the lower zone the situation is the same. However, in the base of the dome, although crepidomas, porticos, domed ciboria have been stripped off their ornamental valuable resources, some decorative mosaics have been restored on the openable hemispherical porches (Europeana Collections, 2017). As a result, contemporary visitors do not experience the illuminating enforcement gold plated mosaics offer to daily, and predominantly, evening services or nightvigils. In morning rituals, ample hallucinations occur as sunlight from the huge windows of the building glows into the open space.

stimulate particular emotion or mood that seems to be closer to the original experience. The capability of modern lighting equipment to provide mixtures of all visible wavelengths, according to the insight of its operators, projects to the walls of the monument shades and hallucinations that may be equivalent to the impressions of permanent torch-styled, candles or portable oil-lamp sources of illumination reflected on the gold-plated phantasmagoric mosaics (Fig. 5, right). To perceive how visible impressions are correlated with music performance (Goller *et al*., 2009), the following online experiment was conducted. It involved tunes that were heard for centuries in and outside Rotunda, considering the ethno geographic background of the people living in the rather recent diachrony of Thessaloniki.53 University students were shown the images of a well-known choir, accompanied with traditional instruments, namely the Bahçeşehir University of Istanbul orchestra (Fig. 6).

Song A: Circassian, in Turkish language

Song B: Balkan tune, in Greek language, with influences from Smyrna

Song C: Middle East traditional melody in Turkish

Fig. 6. Images from the Bahçeşehir University choir and orchestra performance in *Les Lazaristes*, Thessaloniki, November 2017

Although impressive as a visual architectural effect, the absence of the decorative wealth of the monument is critical, nonetheless (Fig. 5, left). Visitors cannot be aware through physical sensation of the emotional excitement produced by the aesthetic stimulation of qualitative, illuminating, variegated decorative patterns that adorned the walls some centuries ago. Therefore, the visual synaesthesia of morning services is rather limited in comparison to its corresponding situation for the first millennium of its existence. In nocturnal events he situation seems to be reversible, however. Although the absence of the mosaics cannot be aestheticized through any substitutes, in synaesthetic terms the visual impression produced by high quality electronic sources of illumination can

It performed in Thessaloniki, in November 2017, long established songs within the cultural background of the Balkans, Asia Minor (now Turkey) and northwest Caucasus (now Russian Federation).

The orchestra while performing was subject to variable arrangements of the lighting effects, according to the modal content and the genre of the music performed. The subjects of the experiment, 33 males and 19 females, aged 21-25, all students of the Computer Science Dept., Aristotle University of Thessaloniki, had to arrange the images of three songs, one Circassian, one Greek and one Turkish, with corresponding segments of the performed melodies.

They were also encouraged to justify their selection.

The subjects accomplished as follows in attaining the music pieces with the illumination patterns:

Song A: **Quantitative Identification Data**

	Correct (%)	Wrong (%)	Cannot discriminate (%)
Males	84.849	0	15.151
Females	89.474	5.263	5.263
Overall	86.539	1.923	11.538

Qualitative Identification - Comments: It was performed in Turkish, and the listeners could not communicate with its content, but its musical elements formed recognizable patterns suggestive of its message. Most students agreed that it is a familiar tune to the musical substrate of contemporary Balkan audiences, amidst its clear Eastern orientation. It is brightful, fast paced, with motives that are alternating rather speedily; it is prompting with repeating sound movements and distinctive high frequency vocal arrangements, performed mainly by the female members of the choir, while definitively it is not a dancing song.

The Experts' Evaluation: It is a compassionate, tendering melody, characterized by eurhythmy. In musical terms, it corresponds to the Phrygian Mode (Byzantine Music equivalent: 5th Mode, or Mode Plagal A') and it is clearly diatonic in its genre.

Song B:**Quantitative Identification Data**

	Correct (%)	Wrong (%)	Cannot discriminate (%)
Males	51.515	33.333	15.151
Females	47.368	47.368	5.263
Overall	50	38.462	11.538

Qualitative Identification - Comments: It is a well known "rebetiko" song, performed by the Turkish choir in Greek. The majority of subjects correctly identified its evident influences from Asia Minor and the fact that being very popular for quite a while has more or less infiltrated Balkan audiences. Although in Slavic populations variants with brass instruments are preferred, the traditional rendition is developed around lute-originating string instruments like bouzouki. It is a dance song; nevertheless this specific rendition is characterized by a mellifluous and meek temperament, suitable for "boîte" style entertainment places, where live music is propelled as accompaniment to gatherings.

The Experts' Evaluation: This song was written and performed for the first time in 1937, by M. Vamvakaris in Athens ("Haramata, i ora treis"). It is clearly a dancing song, of the *hasapiko* family in Greek, or "the butcher's [dance]" (from Turkish: kasap), a Greek folk dance from Constantinople. The dance originated in the Middle Ages from the Makellarios Horos, a battle mime with swords performed by the Greek butchers' guild, adopted from the military of Byzantine era (Encyclopædia Britannica, 2010).Usually it is widely danced in its fast rendition, known as *hasaposerviko*, i.e. Serbian hasapiko. It is extensively spread within the Balkans, in the Slavic speaking regions known as "Otvori mi belo Lenče." The original song, although mostly diatonic and in a major scale has obvious alterations that give it a mild chromatic character. In Byzantine Music terms it is very close to Mode 8 (Plagal D'). However, since it is performed by non native Greek speaking singers, it is rather flat in its prosodic features and lacks the distinctive mode of accentuation for intervals smaller than a semitone. The same happens with the Balkan variants of it, that fail to keep the chromatic character intact, both for the prosodic characteristics of the song and its distinguishing melodic alterations; its more easily then recognized by its rhythmic patterns than by the note arrangements within its scale. The world wide dispersed *Sirtaki* dance, easily identified from its cinematic versions, is a choreographically pretentious clearly diatonic offspring of this family.

Song C: **Quantitative Identification Data**

	Correct (%)	Wrong (%)	Cannot discriminate (%)
Males	51.515	33.333	15.151
Females	47.368	47.368	5.263
Overall	50	38.462	11.538

Qualitative Identification - Comments: The majority of subjects identified it as an unmistakeably Eastern tune, performed in Turkish, which is familiar, however, to Greek audiences. It uses characteristic sounds from instruments dating from antiquity, like a variant of the wind instrument ney. Most subjects detected its chromatic nature, but some others could not easily distinguish the degree of chromaticism involved, when comparing it with Song B. Therefore, there was ambivalence on how to sort out the synaesthetic illuminations for Songs B and C. Especially the female audience was split to half.

The Experts' Evaluation: In modal terms, it is affiliated somehow to the 6th Mode (Plagal B') and the so-called "Hejaz" way for rendition, but no explicit correspondence can be made. It is very chromatic, as far as the wind instruments and in some cases the string instruments are concerned, with very small intervals intertwining with intervals as big as a minor third. However, the choir, consisting of young performers, accustomed more to Western style renditions than to traditional oriental ones, contributes with a rather diatonic rendition, with the female singers giving a mezzo-soprano diatonic voice in the overall rendition, without, however, alterations and afflictions characteristic of hard chromatic hearings. Overall, the song causes mixed sensations. This seems to be in a way confusing, when compared chromatically to Song B.

The results for Song B and Song C reveal that it is somewhat difficult for the non-expert, i.e. the listener that has no prior knowledge or does not posses a very well trained ear to discriminate between two melodies that are variably chromatic. Degrees of chromaticism are somehow prediscursive on how musical essence permeates with acoustic intelligible sense. In simple words, the acoustic quality created by the combination of very subtle coalescent tractions and alterations, in intervals smaller than a semitone (Barsky, 1996), moulds different elements in a work of music.

Acoustic Effects and Performance

The undistorted acoustic "image" of a singer is received when he performs in anechoic, insulated chambers or in the open space in absence of noise. Only an accomplished performer can bring out of such circumstances a melodious rendition for a piece of music. Not only he has to be extremely skilled and gifted, as far as his phonation characteristics are involved, but he also should be able to modify his voice characteristics over

a wide range of speech sounds, covering more than one or two spoken languages, over different phonation techniques that foster different music styles and genres, along the ability to use strong articulators when breathing techniques for voiced sounds are involved.These are a few of the contradicting parameters for modifying the voice characteristics according to the repertoire to be performed (Sundberg, 2013).Most of these restricting factors, indeed, are cured nowadays with the use of electronic technology, digital processing of incoming signals and plenteous amplification power, which shields linguistic incompetencies, phonation frequency shifts and lack of loudness by modifying voice characteristics while in motion and progress. Definitely, the perceived voice of a singer, which is promoted by recording companies under such circumstances, is quite different from the one heard when modern electroacoustic instrumentation eclipses, and his real phonetic potential is revealed.The shortage of sheer amplification power was a real challenge in previous eras. For buildings like the Rotunda, solo chanting would be insufficient to provide enough acoustic energy for the whole length of liturgical services. It seems that choirs were used, so that enough audible power was produced for the spacey interior.
When a choir is involved, between the altar and the nave, the quality characteristics of the melodious rendition are altered, since the coincidence of pitched voicing is not exactly uniform but has a bias from the individual features of each singer. Choral voice is not a mere sum of the personal voicing potential of each cantor, but rather an incorporation of common characteristics.

Even further, singing in the Rotunda, is like singing within a loudspeaker. Various effects due to the architectural design take place, introducing deliberate architectural-based alterations on the original unechoic voicing (Fig. 3). The authors of this paper monitored the performance of cantors and choirs in various historic churches and buildings in Thessaloniki, virtually all the UNESCO world heritage paleochristian and Byzantine Monuments of Thessaloniki (UNESCO, 1998-2017). The audiovisual synaesthetic patterns that have been recorded for these recitals have been cross correlated with the liturgical, musicological and proprioceptoral sources. The latter have to do with the emotional, devotional and philosophical continent of the theurgical practices. As such, it is beyond the scope of this research. However, the emotional part is highly correlated with the sensorial mechanisms of perception, either as discrete or continuous entry devices (Saarikallio, 2010). These concepts, part of which has been explored thus far within diachronic liturgical practices, extend their proprioception within the context of global audiovisual events, as is the contemporary music scene or televised influential events, with worldwide anticipation, like the Eurovision song contest. The structuralist association in musical diachrony and synchrony was revealed with a sonic triggering synaesthetic on-line research.

RESULTS AND DISCUSSION: ANTICIPATING SYNAESTHETIC MUSICAL TRIGGERING

A survey was conducted between May and July 2017 within the Aristotle University of Thessaloniki to decipher how sonic stimuli is associated with the anticipation of chromaticism (Barsky, 1996). It included well known songs, at least for the Western part of the hemisphere, with a few historical highlights of the global heritage, dating from the previous couple centuries.

MATERIALS AND METHODS

The survey evolved on the sample of $N = 23$ students aged 23 and older, 14 (61%) males and 9 (39%) females. Students participated anonymously, voluntarily and individually. The role of the examiner was to give initial instructions and ensure testing conditions. Testing was administered at the Aristotle University of Thessaloniki, Greece. The students that participated combined their personal experience from listening to music from their CD/DVD collection, local mass media distributors, and predominantly through the global music scene as it is projected over the Internet.

RESULTS

When participants were asked about if they have any special knowledge of music, for example if they attended music/singing lessons or have formal/informal knowledge in playing a certain musical instrument, $N = 20$ (87%) had none or very little. Students mostly listened to music a fair amount of time or a lot (about 65% of them). As for music genres, they most often preferred Rock ($f = 11$; 48%), Pop ($f = 10$; 43%), Entechno or Westernized style music with a serious aspect ($f = 7$; 30%), Laika or Greek-musical tradition oriented pop songs ($f = 7$; 30%), Classic ($f = 5$; 22%) and Metal ($f = 5$; 22%). An independent samples t-test was conducted to examine whether there was a significant gender difference in preferred music genres. The test revealed that there were statistically significant differences between male and female students in preferring Metal ($t = 2.29$; $df = 13.0$; $p = 0.019$), Opera ($t = 1.88$; $df = 13.0$; $p = 0.082$), Classical ($t = 2.69$; $df = 13.0$; $p = 0.019$) and Byzantine Music ($t = 1.47$; $df = 13.0$; $p = 0.165$). Males significantly more preferred previously stated genres ($M = 0.36$; $SD = 0.49$) ($M = 0.21$; $SD = 0.43$) ($M = 0.36$; $SD = 0.5$) ($M = 0.14$; $SD = 0.36$) than females did, respectfully. About half of participants considered themselves as not at all good singers (52%), while 17% considered themselves as quite good singers.

Chromatism

Graduate students were asked to rank seven songs according to their perception in terms of chromatism. Table 1 presents the ranking results starting from highest ranked song.

Table 1. The test pool for chromaticism in singing

Rank	Song	M	SD
1.	Elena Paparizou: My Number One (2005)	2.43	1.59
2.	Alexander Rybak: Fairytale (2009)	3.22	1.91
3.	Sertab Erener: Everyway That I Can (2003)	3.83	2.12
4.	Ruslana: Wild Dance (2004)	4.22	1.65
5.	Marie Myriam: L'oiseau et l'enfant (1977)	4.39	2.04
6.	Alma: Requiem (2017)	4.65	1.82
7.	France Gall: Poupée de cire, poupée de son (1965)	5.17	1.80

At this stage, the focal point of the survey evolved around contemporary performances from the well know Eurovision song contest, for which ample audiovisual recordings exist. Participants were asked to perceive songs using the colors of the given pallet (ranging 1÷20 in chromatism).

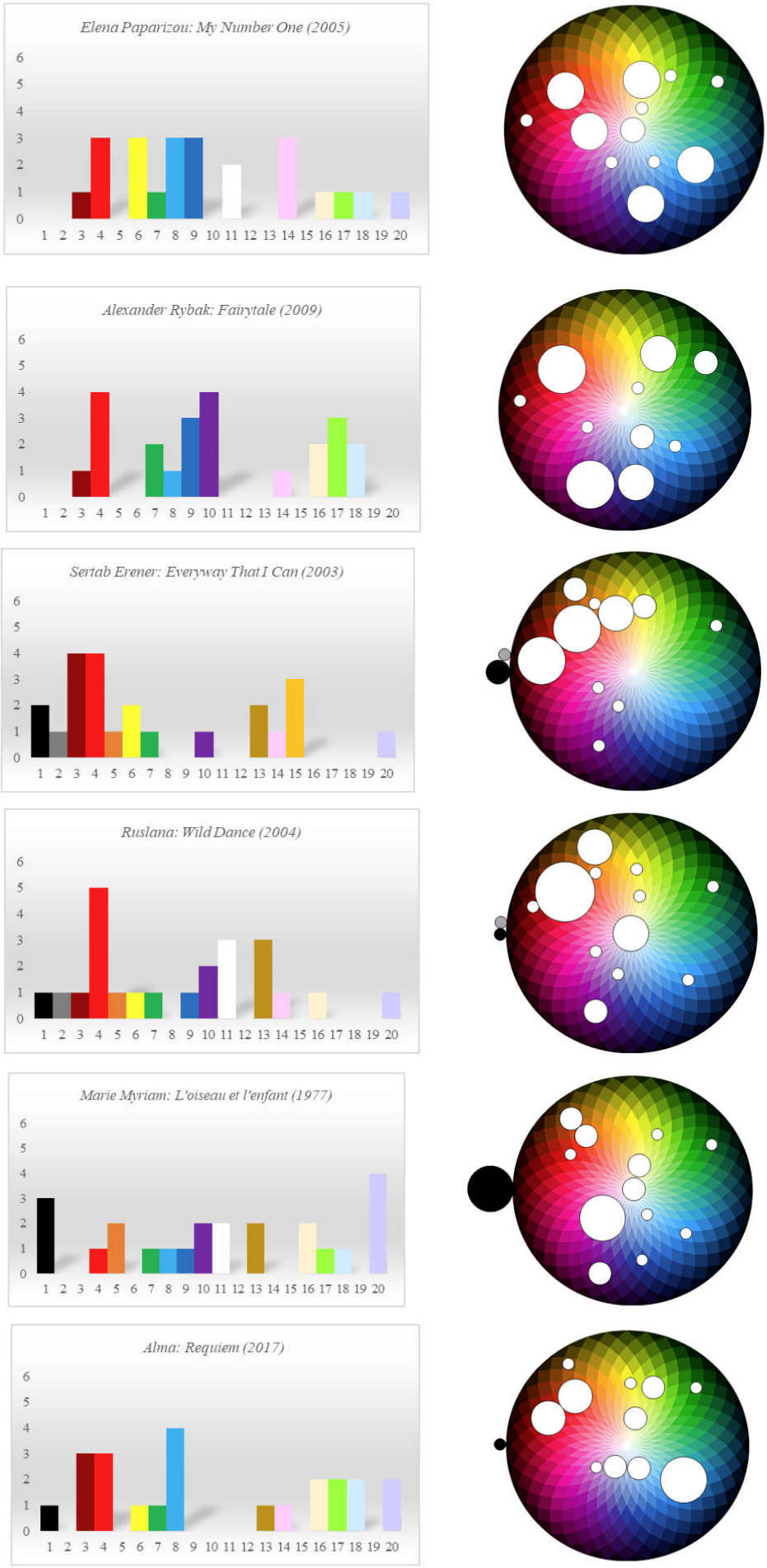

Fig. 7. The statistical imprint for the colour impression of chromaticism, as it was perceived when listening to internationally acclaimed Eurovision songs of the last four decades

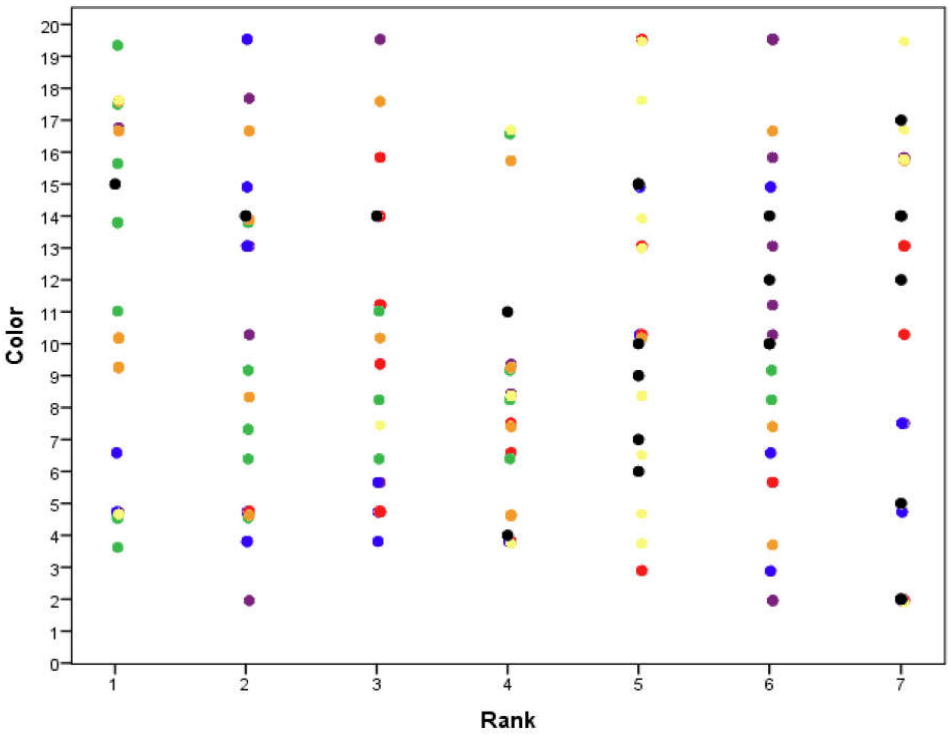

Fig. 8. Tabular view demonstrating the composite results of chromatic perception for the 7 songs, ranging from 1to 20

Table 2. Constituent elements of chromaticism in music, as perceived for the test pool of 7 songs

Author	Language		Rhythm		Instruments		Voice		Melody	
	M	SD	M	SD	M	SD	M	SD	M	SD
France Gall	6.39	2.55	6.04	2.10	6.35	2.10	6.43	2.33	6.43	2.17
Marie Myriam	6.70	1.72	5.87	1.84	5.91	1.70	6.87	1.60	6.48	2.00
Sertab Erener	3.61	2.27	7.30	1.89	5.09	2.48	4.65	2.37	5.78	2.33
Ruslana	4.00	2.35	7.00	2.17	5.48	2.23	4.70	2.20	5.91	2.29
Elena Paparizou	5.91	1.93	7.70	1.15	7.43	1.56	7.00	1.41	7.39	1.37
Alexander Rybak	5.39	1.70	7.04	1.72	7.83	1.47	6.22	1.81	7.87	1.46
Alma	6.17	2.29	5.35	2.40	4.70	1.92	5.91	2.11	5.77	2.54

The results are depicted in appropriate graphics, denoting how the subjects perceived the chromatic impression of each song (Fig. 7).The chromatic correlation of the perceived chromaticism is shown in tabular mode in Fig. 8, iconifying the composite results. Participants were asked to assess what influence and contribution did the language, rhythm, musical instruments, voice quality and melody have in the chromaticism of the songs. Since music is inherently correlated with rhythm, it was very important to have an assessment of how the perception of musical "colouring" is connected with movement. Indeed, for the musical sounds surveyed, rhythm was reported to have greatest average influence on song chromatism (M = 6.61; SD = 1.90), while language contributed the least on average (M = 5.45; SD = 2.12). These results are amply presented on Table 2.

Conclusion

From the resources having survived since antiquity, scientists from various disciplines examine how artistic stimuli is inducing cerebral processes for acquiring knowledge through the apprehension of senses. Although cultural and historical divergence leads to disparities, the idiom of great civilizations is the creation of intellectual, conceptual and semantic pervasiveness and universality. This research examines how musicokinetic stimuli triggers chromatic impressions and how these mental states are mingled with multicoloured arrangements. Within this scheme, visual information, as it was used in diachrony, is correlated with documented singing patterns, in an attempt to examine the exact "nature" of colour sensations over the full spectrum of synaesthetic awareness.

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