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Categorization of Synaesthesia

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This article is an attempt to synthesize the current knowledge about synaesthesia from many fields such as literature, arts, multimedia, medicine, or psychology. The main goal of this paper is to classify various types and forms of synaesthesia. Besides developmental synaesthesia being likely to play a crucial role in developing cognitive functions (constitutional or neonatal synaesthesia) there are types of synaesthesia acquired during adulthood (e.g., phantom or artificial synaesthesia), momentary synaesthesia triggered temporarily in people who do not show signs of synaesthesia every day (e.g., virtual, narcotic, or posthypnotic synaesthesia), and associational synaesthesia which, semantically speaking, refers to some universal sense relations (e.g., literary, artistic, and multimedia synaesthesia). There is a hypothesis that every kind of synaesthesia holds a different function—compensatory or integrative. It was suggested that synaesthesia can be described in one dimension, showing the intensity of this phenomenon. The stronger types of synaesthesia are: semantic, conceptual, intermodal, synthetic, comprehensive, external and bidirectional. The weaker types of synaesthesia are: sensory, perceptual, intramodal, analytic, partial, internal and unidirectional. There are huge individual differences in the manner that synaesthesia presents itself. By including a classification of kinds, types, and forms of synaesthesia into future experimental research will ensure a better understanding of the nature of this phenomenon, its mechanisms and the role that it plays in developing cognitive processes.

Keywords: synaesthesia, association, individual difference

Synaesthesia is an individual sensual sensation occurring when a single-modal sensual stimulus sets off the simultaneous sensation of few senses both involuntary and automatically. Seeing colors while hearing musical sounds is an example of synaesthesia. Synaesthetes—throughout almost all their lifetime involuntary, automatically, and invariably see sounds, feel scents of words, and tastes of colors, or experience tactile sensations while tasting food.

Particular forms of synaesthesia differ each other between people, configuration of joint senses and kind of sensations, but there are some general characteristics united for all. Based on scientific literature (Cytowic, 2002; Harrison & Baron-Cohen, 1997; Hochel & Mila′n, 2008; Simner, 2006; Van Campen, 2008) and on reports of people with synaesthesia (Cytowic, 1993; Hornik, 2001; Luria, 1968; Motluk, 1997; Rogowska, 2002; Steen, 2001), one can specify the following general features of this phenomenon:

1. Synaesthetic sensations are induced involuntary as a reaction to stimuli (Beeli, Esslen, & Jäncke, 2005; Mattingley, Rich, Yelland, & Bradshaw, 2001). A person with synaesthesia has no influence on what feelings he will experience. Concentrating his attention on the stimulus, however, may significantly affect the strength and consciousness of associations (Rich & Mattingley, 2005; Sagiv, Heer, & Robertson, 2006; Smilek, Dixon & Merikle, 2005).

2. A single stimulus sets off simultaneous perceptions of a number of sensory modalities—for example, hearing piano music may evoke simultaneous sensations in following modalities: hearing, visual, and olfactory (Grossenbacher, 1997).

3. Plenty of research have confirmed automatic occurrence of synaesthesia and its perceptual nature (Blake, Palmeri, Marois, & Kim, 2005; Lupianez & Callejas, 2006; Mattingley, Payane, & Rich, 2006; Mills, Boteler, & Oliver, 1999; Treisman, 2005).

4. Synaesthesia is relatively[1] constant on an intraindividual basis—they persistently correlate with the individual's perception and do not change. Particular stimuli always prompt identical sensations, for example, the E-major key will always be colored yellow for a person with synaesthesia (Baron-Cohen & Harrison, 1999; Baron-Cohen, Harrison, Goldstein, & Wyke, 1993).

5. Synaesthesia is intraindividually variable and idiosyncratic[2]—each synaesthete has a unique configuration of sensations. There are no two persons with identical sensual associations for the same set of stimulus (regarding quality and number). Even identical twins show differences in this regard (Hancock, 2005; Smilek, Moffat et al., 2002).

[1] Most synaesthetes claim that from as long as they can remember they always shown synaesthesia with their percetion. However, in some cases this ability can become stronger or weaker and can disappear altogether (Sacks, Waserman, Zeki, & Siegel, 1988; Simner, Mayo, & Spiller, 2009; Spalding & Zangwill, 1950). It can be evoked or obstructed by psychoactive substances (narcotic synaesthesia), poshyponotic suggestions (hypnotic synaesthesia) or suggestive sensations (mirror touch synaesthesia, virtual synaeshesia.)

[2] It should be noted that there are some tendencies in configuring senses in synaesthesia, for example, some persons see colors when they hearing the first letter of a word, and others—dominating vowel (Day, 2005; Marks, 1999). There are also general trends in synaesthetic associations (Beeli & Esslen, 2007; Rich et al., 2005; Simner et al., 2005; Smilek, Carriere, Dixon, Merikle, 2007; Wrembel, 2009) such as color-letter of an alphabet or color-pitch of a tone. Most likely this is a result of general rules of intersensual associations (Marks, 1989; Scholes, 1978; Ward, Huckstep & Tsakanikos, 2006; Wellek, 1954).

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At first, the stimulated sense was the second link in the description of the kind of synaesthesia. The first link specified the synaesthesia set off by this stimuli (e.g., seeing the color orange as a result of hearing the sound of trumpet is called Colored Hearing Synaesthesia - ger. *Farbenhören*; fr. *audition colore*). Presently, the first link relates to stimulation (inducer) and the second one to concurrent. For example, in grapheme–color synaesthesia, a visually presented grapheme triggers synaesthetic experiences of color (Simner, 2006), in vision–sound synaesthesia seeing visual motion triggers auditory perception (Saenz & Koch, 2008).

There are many combinations of synesthetic experiences induced in many senses simultaneously (e.g., hearing a sound may induce sensations of seeing, tasting, touching). There are also many potential forms of synaesthesia combining only two senses, like touch–taste, color–smell, or touch–hearing (Day, 2005; Rich, Bradshaw, & Mattingley, 2005). Synaesthesia is most often prompted by linguistic inducers, sounds, tastes, smells, and touch, but the most frequent concurrence of synaesthesia is color, touch, and smell (Barnett et al., 2008; Day, 2004). Colored-hearing—also called Chromesthesia or synopsia—is one of the most known form of synaesthesia (Rich et al., 2005; Baron-Cohen, Burt, Smith-Laittan, Harrison, & Bolton, 1996).

Latest research of prevalence shows that synaesthesia occurs in 4% of the population (Simner, Mulvenna, Sagiv et al., 2006; Ward & Simner, 2005), in equal number of men and women. Among various types of synaesthesia, the most frequent ones are: time–space synaesthesia (Brang, Teuscher, Ramachandran, & Coulson, 2010; Mann, Korzenko, Carriere, & Dixon, 2010; Sagiv, Simner, Collins, Butterworth, & Ward, 2006; Smilek, Callejas, Dixon, & Merikle, 2007), grapheme–color synaesthesia (Rich et al., 2005; Simner et al., 2006), and mirror–touch synaesthesia (Banissy, Cohen Kadosh, Maus, Walsh, & Ward, 2009). There are also types of synaesthesia relating semantically to personalities, genders, or emotions (Callejas, Acosta, & Lupianez, 2007; Simner & Holenstein, 2007; Smilek, Malcolmson et al., 2007; Ward, 2004). The catalog of possible forms is set off synaesthesia.

For over 20 years, scientists have shown a constantly increasing interest in synaesthesia. Studies show that synaesthesia can depend on number and kinds of senses involved (Day, 2005; Simner & Hubbard, 2006), on level of processed data (Ramachandran & Hubbard, 2001b), individual attributes of perception (Banissy, Walsh, & Ward, 2009; Nikolic′, Lichti, & Singer, 2007; Palmeri, Blake, Marois, Flanery, & Whetsell, 2002; Smilek, Dixon, Cudahy, & Merikle, 2001a), attention (Carriere, Eaton, Reynolds, Dixon, & Smilek, 2008; Edquist, Rich, Brinkman, & Mattingley, 2006; Laeng, Svartdal, & Oelmann, 2004; Mattingley et al., 2006; Rich & Mattingley: 2005, 2010; Smilek, Dixon, & Merikle, 2003), emotions (Callejas et al., 2007; Ramachandran & Brang, 2008; Smilek, Malcolmson et al., 2007), or awareness (Gray, 2005; Mattingley et al., 2001; Smilek, Dixon, Cudahy, & Merikle, 2001b), and even a context and significance of inducer evoking synaesthesia (Dixon, Smilek, Duffy, Zanna, & Merikle, 2006; Myles, Dixon, Smilek, & Merikle, 2003). It was also indicated that synaesthetes have a better imagination (Barnett & Newell, 2008; Spiller & Jansari, 2008) and memory (Mills, Innis, Westendorf, Owsianiecki, & McDonald, 2006; Rothen & Meier, 2009; Smilek, Dixon, et al., 2002; Yaro & Ward, 2007).

There are studies of synaesthesia run not only in view of psychology, but also in view of neurology, genetics, psychopathology, cognition, linguistic, philosophy, music, art, and so forth. The question is, do we examine the same phenomenon in all these cases. It happens sometimes, that even when synaesthesia is explored within the framework of one discipline of science, each research team gets different results (e.g., Dixon & Smilek, 2005 vs. Shalgi & Foxe, 2009). What makes it more difficult to answer this question is the fact that there are significant individual differences in the process of emerging the phenomenon of synaesthesia (Barnett et al., 2008; Hochel & Mila′n, 2008; Hubbard, Arman, Ramachandran, & Boynton, 2005; Ward, Li, Salih, & Sagiv, 2007. Some synaesthetes see colors outside (projectors) and others see them in their '"mind"s eye' or an internalized space (associators). There are those who only associate letters with colors, but we can also encounter the multiple synaesthetes for whom all letters of alphabet, music, surrounding sounds, and even experiencing pain—will trigger pulsing moving colors and accompanying taste experiences (Hänggi, Beeli, Oechslin, & Jäncke, 2008; Steen, 2001). There is a case of the synaesthete whose senses were relative to one another in synaesthesia combining multimodal configurations of experiences (Luria, 1968). This attribute alone that is, the extension of stimulus triggering synaesthesia and number of senses involved indicates that different individuals experience synaesthesia in different levels of intensity.

Most of current studies are limited to spectacularly strong cases of synaesthesia, dividing tested persons into two groups: experimental group with synaesthesia and control group without synaesthesia. In practice we meet, however, many weaker forms of synaesthesia (e.g., particular person associates in his or her "mind's eye" only a few numbers with colors). In order to improve future studies it seems necessary to bear in mind these individual differences while selecting experimental groups, and to suit relevant methods of studies to particular types of synaesthesia (Cohen Kadosh, Cohen Kadosh, & Henik, 2007; Hubbard & Ramachandran, 2005; Hubbard, 2007).

The aim of this article is to revise the present knowledge of synaesthesia gained from reports coming directly from synaesthetes and experimental studies conducted within various disciplines of science. Introducing the deeper differentiated diagnosis with consideration given to many forms of synaesthesia, will undoubtedly contribute to further progress of studies of synaesthesia. Therefore the main problem of the studies is in classifying various kinds, types, and forms of synaesthesia.

Kinds of Synaesthesia Known From Scientific Literature

Phenomenon of synaesthesia is being studied since the 17th century. Synaesthesia played a significant role in science and art regarding unity of senses and arts (Marks, 1975) at the end of nineteenth and beginning of 20th century. The last 20 years showed a significantly increasing number of publications leading to speeding up the progress of studies of synaesthesia. Synaesthesia shows up in various contexts, in many disciplines of science, in psychology, cognition, medicine, technical science, literature, music, or art. Below we list various kinds of synaesthesia appearing in scientific literature. Differences between individual kinds of synaesthesia apply mainly to the periods of time they occur in (age at which synaesthetic experiences start to appear, and their permanence during a life time), and its prevalence.

1. Constitutional synaesthesia (Grossenbacher, 1997)—also known as developmental synaesthesia (Harrison & Baron-Cohen, 1997), idiopathic synaesthesia, or strong synaesthesia (Martino & Marks, 2001) was most frequently explored in science during the last 200 years and is the most representative form of this phenomenon. The basic criterion of distinguishing this form from others is the period of life when it first occurs—early childhood. From the moment of the first occurrence, it does not change significantly during the lifetime of a person, it is constantly present along with every day perception.

2. Acquired synaesthesia or postaccidental synaesthesia occurs independently and unwittingly during adulthood as a result of biochemical brain changes, neurological dysfunctions, or permanent damage done to the nerve as a result of accident or disease (such as cancer, multiple sclerosis, or migraines; Jacome, 1999; Podoll & Robinson, 2002; Rao, Nobre, Alexander, & Ceowy, 2007; Ro et al., 2007; Villemure, Wassimi, Bennett, Shir, & Bushnell, 2006). Visual synaesthesia may occur unwittingly with persons who have lost their eyesight, which is probably a case of compensating for the loss of visual perception (Armel & Ramachandran, 1999; Nold, 1997). The phenomenon of synaesthesia becomes constantly present in perceptual processes from the very moment of its first occurrence.

3. Phantom synaesthesia relates to medical cases of experiencing phantom pain in nonexistent amputated parts of body (Ramachandran & Rogers-Ramachandran, 2000), which is a result of strong intermodal relations occurring during the sensual integration in perceptual processes (Holmes & Spence, 2005; Ramachandran & Rogers-Ramachandran, 1996). Many studies (Mon-Williams, Wann, Jenkinson, & Rushton, 1997; Ramachandran, Rogers-Ramachandran, & Cobb, 1995) have indicated that it is possible to experience feeling in a nonexistent amputated hand—being a result of visual experiences (i.e., looking at a mirror-reflection of a moving hand in a "virtual reality box" —a box created especially for this purpose).

4. There are also other cases of synaesthesia, which concerns bodily feelings, and are probably based on integration processes, but they are also a result of empathy. Namely, mirror-touch synaesthesia, where synaesthete experience tactile sensations on their own body when observing someone else being touched (Banissy & Ward, 2007; Banissy, Cohen Kadosh et al., 2009; Blakemore, Bristow, Bird, Frith, & Ward, 2005) and, pain synaesthesia, where a person experiences an observed or imagine pain as if it was their own (Fitzgibbon, Giummarra, Georgiou-Karistianis, Enticott, & Bradshaw, 2010).

5. Artificial synaesthesia, also known as synthetic synaesthesia, is induced voluntarily, consciously and deliberately as a result of proper training and learning. It means transporting sensations from one sensual modality to another, for example, processing visual sensations into hearing ones, or tactile into visual sensations while using special instruments constructed for this purpose and aiding perception with persons visually impaired (Foner, 1999; Mejier, 1992; Proulx & Stoering, 2006; Proulx, 2010; Ward & Meijer, 2010). This sensation is of compensatory nature resulting from flexibility of brain. From the moment of being induced it may develop, although we must note that this process is possible only with special instruments that replace the lost receptacles.

6. Virtual synaesthesia is experiencing temporarily (on certain period of time), some types of sensations (touch, smell, taste, sound) as a result of stimulating one sense (mostly vision) while plunging into the virtual world generated by computer (Biocca, Kim, & Choi, 2001), or also as a result of creating visual illusions by using video (Schaefer, Noennig, Heinze, & Rotte, 2006). This phenomenon affects some people (probably, most likely the ones of high level of suggestibility and absorption) that are not synaesthetes and lasts for a short time only while manipulating objects in virtual, three-dimensional reality (Biocca et al., 2001).

7. Latest experiments show (Cohen Kadosh, Henik, Catena, Walsh, & Fuentes, 2009) that people who are easy to hypnotize may experience an effect of synaesthesia for a short time by providing a proper suggestion. This may be given the name of posthypnotic synaesthesia. Other studies curbed synaesthesia for a given time by providing synaesthetes posthypnotic suggestions (Terhune, Cardena, & Lindgren, 2010). It is therefore possible for cognitive control to influence synaesthesia.

8. Narcotic synaesthesia is induced temporarily in some people as a result of taking psychoactive substances such as LSD, mescaline, or psilocybine (Cytowic, 2002; Kafka, 1997). This kind of synaesthesia is most likely determined by the specific pattern of distributing serotonin receptors in the brain (Brang & Ramachandran, 2008). Narcotic synesthesias are so frequent that there was an Audio-visual synaesthesia scale included in the questionnaire Altered States of Consciousness Rating Scale (OAV) used for measuring changes in consciousness while under the influence of psychoactive substances (Studerus, Gamma, & Vollenweider, 2010).

9. Neonatal synaesthesia occurs during the first four months of life, and after that it usually tapers off (Maurer, 1993). It is a transitional stage related to the process of specializing sensual modalities and brain marituration (Maurer & Mondloch, 2005; Maurer, Pathman, & Mondloch, 2006). This developmental stage is most likely the biological base for synaesthesia occurring in the early childhood or adulthood. According to the conception (Spector & Maurer, 2010, p. 175) "synesthesia appears to represent one way that typical developmental mechanisms can play out by magnifying connections present in early life that are pruned and/or inhibited during development but persist in muted form in all adults."

10. Weak synaesthesia (Martino & Marks, 2001; Marks & Odgar, 2005), relates to popular cross-modal matching, for example, matching high pitched tones with bright colors. Synaesthetes, as well as all other people independently of culture, show similar cross-modal matching, such as: associating loud and high pitched musical tones with sounds of speech (e.g., vowels "i," "e") with bright colors and associating low pitched tones with dark colors (like vowels "u," "y"; Hubbard, 1996; Marks, Hammeal, & Bornstein, 1987; Melara & Marks, 1990a, 1990b; Melara, 1989a, 1989b; Pozella & Hassen, 1997), as well as associating dark colors with intensive scents (Gilbert, Martin, & Kemp, 1996; Kemp & Gilbert, 1997; Zellner & Kautz, 1990) or negative emotions (Hupka, Zaleski, Otto, Reidl, & Tarabrina, 1997).

11. Artistic synesethesia demonstrates a strong relationship between synaesthesia and art. In literature, poetry, as well as in art, synaesthesia was frequently applied as a way of styling (Day, 1996; Galeyev, 1993; Nelson & Hitchon, 1995; Van Campen, 1999). It was applied in symbolism to transpose sensations—particularly during the break of the 19th and 20th centuries. Synaesthesia played an important role in the context of the idea of

synthesis and unity of arts. During this period there were talks about musicality of painting and poetry, or about picturesque music. Many looked for the strongest expression of synthesis between different arts in opera, theater, and film. Present times observe the return to those ideas in relation to multimedia using modern computer, film, TV, or techniques (Barbatsis, 1999; Waterworth, 1997). The capability of creating distant associations is typical for artists and is used for their art. It is possible that the frequent appearance of synaesthesia among artists (Berman, 1999; Dailey, Martindale, & Borkum, 1997; Domino, 1989, 1999; Van Campen & Froger, 1999; Van Campen, 2008) is related to particular predispositions for easy and frequent usage of metaphors, analogy or distant association. It is suggested therefore to distinguish two kinds of artistic synaesthesia functioning in two kinds of arts: music and literature.

• Multimedia synaesthesia is an artistic effect of creative operation performed simultaneously on several senses with instruments constructed for this purpose. The first such instrument was most likely constructed by an Italian painter (a representative of mannerism) G. Arcimboldo in 17th century. The 18th and 19th century marked the creation of colored organs, clavichords, and pianos (Klein, 1937; Peacock, 1988). Presently, computers are used for this purpose (Cadiz, 2006; Dean, Whitelaw, Smith, & Worrall, 2006; Gunther & O'Modhrain, 2003; Li, Tao, Maybank, & Yuan, 2008; Whitelaw, 2008; Yau & McCrindle, 2007).

• Literary synaesthesia—a term used in literature, especially of symbolism. It is a way of artistic expression by assigning to one sense's sensations taken from other senses in order to induce a particular mood, a feeling of musicality of a poem or triggering imagination by unusual association of sensations, that is, sonnet of Artur Rimbaud— "Vowels" (Ceglie, 2007; Hertz, 1999; Tsur, 2007).

While analyzing the above listed items, a question appears whether these kinds of synaesthesia encountered in literature relate to the same or different phenomenon. Does only constitutional synaesthesia have a right to assume a genuineness and should all other kinds be named pseudosynesthesia (Harrison & Baron-Cohen, 1997)? All above-mentioned kind of synaesthesia seems to have common features, granted general criteria of this phenomenon. Although, there are some difference between kinds of synaesthesia, for example, for the point of view of:

• time aspect: relatively constant form arise to the rest of life (e.g., constitutional, acquired synaesthesia) versus last temporary depend on environmental factors (e.g., virtual, posthypnotic, narcotic synaesthesia), or

• source of originate: neurobiological disorder (e.g., acquired, phantom, narcotic, artificial, neonatal synaesthesia) versus cognitional factors (e.g., posthypnotic, artistic synaesthesia).

There is rather unlikely to find one mechanism to explain all various kinds and types of synaesthesia, what seems that this is the key to solving the enigma of the nature of our cognitive development and functioning of our senses.

Is There One Synaesthesia or More?

A common feature of all kinds of synaesthesia from scientific literature is ability to create associations. The synaesthetic associations seem to be the primary form of intermodal associations while the metaphor, associations and connotations used in creative processes seem to be a secondary form modulated by consciousness and language. Synaesthesia probably characterizes earlier stage of cognitive functioning of an individual, baring in mind both aspects: Evolutionary and onto genesis synaesthesia is often not very strongly brought into attention, they are independent of will, they are automatic, they relate to perceptual level of processing data, and they are concrete. The higher forms of synaesthesia are associations generated by willful process, subordinated to free will, of a high level of discretion and originality, interceded by distinctive manner of using the language. They are abstract and symbolic. It is possible that the relation between synaesthesia and creativity is a result of this (Ramachandran & Hubbard, 2001a; Ramachandran & Hubbard, 2001b). It seems that it is not a coincident that many famous artists showed synaesthesia (composers: Nicolas Rymski-Korsakow, Alexander Skriabin, Arnold Schönberg, György Ligeti, Oliviera Messiaen; painters: Eugene Delacroix, Wasyli Kandinsky, Paul Klee, Robert Delaunay, David Hockney. Poets: Arthur Rimbaud and Charles Baudelaire; or writers: Theodor Hoffman and Vladimir Nabokov (Cazeaux, 1999, 2002; Ione & Tyler, 2003, 2004; Nelson & Hitchon, 1999; Warren, 2006). Studies confirmed the higher level of creativity among synaesthetes (Dailey et al., 1997; Domino, 1989, 1999; Rader & Tellegen, 1981, 1987; Ward, Thompson-Lake, Ely, & Kaminski, 2008).

There is more proof that synaesthesia has the same mechanisms that occur in all people in intermodal associations (Cohen Kadosh, Henik, & Walsh, 2007; Ramachandran & Hubbard, 2001b; Sagiv et al., 2006; Simner & Ward, 2006; Simner et al., 2005; Ward et al., 2006). If it is possible for synaesthetic sensations to show as a result of psychoactive substances, posthypnotic suggestions, diving into virtual reality or as a result of neurological dysfunctions of persons who never before showed signs of synaesthesia, it is most likely that we all have a potential, biological (neuronal of functional) base for inducing synesthesial perception. It would be in accordance with infant synaesthesia (Maurer, 1993; Maurer & Mondloch, 2005), conception of weak and strong synaesthesia, (Martino & Marks, 2001), or decreased inhibition (Eagleman & Goodale, 2009; Grossenbacher, 1997). Synesthetic sensations may use the same mechanism of intermodal associations that occur during the process of integrating data given by various senses. During the perceptual processes all senses are involved and form a coherent representation of various real objects. The strong relations between senses may be used to induce synaesthetic sensations in other sense than the one stimulated at the given moment. However, the most significant meaning is of processes related to memory and of high abilities relating to the imagination. These types of associations are used not only to create imitation of virtual reality in computer games, but also to support visually and aurally impaired persons (Mejier, 1992).

According to the concept of weak and strong synaesthesia (Marks & Odgar, 2005; Martino & Marks, 2001), both forms of synaesthesia are subject to the same basic perceptual mechanisms of coding in nervous and intermodal system of processing data. Developing language and perception triggers processing data on higher semantic level, reflecting postsensoric (basing on significance) mechanisms of adults. Strong synaesthesia demonstrates perceptual characteristics of multimodal inducers while the weak one bases itself on intermodal metaphoric language, associations of various senses, and selective attention. The strong synaesthesia is a result of relations that occur on a low sensory level of processing data between psycho-physical features of senses, such as: frequency, intensity and duration of sound, size, shape, and color of visual objects; and intensity and chemical composition of taste and smell. The mechanism of neuronal coding explains why intermodal associations are popular and automatic (Marks, 1975; Wicker & Holahan, 1978). For weak synaeshtesia, language, experiences, and culture (Marks, Hammeal, & Bornstein, 1987) or results of training–learning (Stevenson, Boakes, & Prescott, 1998) modify intermodal associations broadening the scope of possible joints between particular senses. Associations are subject to secondary developmental processes of integration of senses on high semantic level.

With the concept of neonatal synaesthesia (1993; Maurer, & Mondloch, 2005) synaesthesia characterizes early stages of sensual modalities of all people. Synaesthesia is a kind of atavism in cognitive processes, that is, it is a primary onto genetic and phylogenetic ability to induce multimodal associations on lower perceptual level of processing data. Associating brightness of light with intensity of sound shows in early stages of development in 3-week-old infants (Lewkowicz & Turkewitz, 1980). Differences between senses occur more frequently in infancy than in adulthood. During the first weeks of life, the perceptual processes are characterized by gradual development and senses' specializing in receiving specific data (Bahrick, 2001; Lewkowicz, 2000). Synaesthesia seems to constitute a significant link of developmental processes (Ramachandran & Hubbard, 2001b).

Taking the above into account, we suggest the consideration of all above-mentioned kinds of synaesthesia as various branches of the same phenomenon based on the general ability to induce intermodal associations. The suggested concept of understanding synaesthesia as a sign of generalized ability to induce associations is not a new idea. Many scientists shared this view during the early years of the study of synaesthesia (e.g., Bleuer & Lehman, 1881; Marks, 1975; Wellek, 1954) and many others presently go back to these ideas (see: Cohen Kadosh & Henik, 2007; Hochel & Mila′n, 2008; Hubbard, Piazza, Pinel, & Dehaene, 2005).

Differences regarding number (intensity, clarity, frequency) and kinds (depending on contents of associations, levels of processing data, on unknowing and automatic actions) would constitute characteristics of intermodal experiences. If synaesthesia presents the primary characteristics of brain, the creative associations, connotations and metaphor should be analyzed as a secondary form of associations, the more developed, various, and free, on the deeper level of processing data. Ability to make associations grows with age and brain maturing, and it seems to goes through various stages of developmental process, suggested hypothetically below:

- First stage: the neonatal synaestehesia, is common and characterized by a low level of brain development and cognitive processes, by occurring permanent intermodal links without specific differences between senses.
- Second stage: Specialization of senses and development of modality.
- Third stage: Integration of senses during the process of identifying and differentiating objects. Common intermodal associations occur, that are characterized by firm intra or intermodal links of high level of automatism, and of low level of consciousness.
- Fourth stage: In some cases of cognitive deficiency in early childhood (probably between 3 and 6 years old) synaesthesia is result of a compensation process. As seen, synaesthesia could be a result of lack of development (in constitutional synaesthesia) or brain damage (in acquired synaesthesia). Damage of cognition processes causes returning to earlier and better developed ways of processing data. For example, people with difficulties with verbal synthesis of hearing words and perfect seeing, can develop synaesthetic visualization of words in colors. Synaesthesia leads to hypercompensation and excellent result of information process, similar to savants' skills, in some cases. In that view, synaesthesia could be seen as a signs of cognitive deficiencies of ontogenesis.
- Fifth stage: Further development of associations leads to an occurrence of firm links of free, conscious, and flexible links. These associations can be more or less popular depending on individual characteristics of a person: intelligence and creativity.

Most likely differences are the results of roles that synaesthesia plays in cognitive processes. It does not seem to be a coincidence (Cohen Kadosh, Henik, & Walsh, 2009; Green & Goswami, 2008; Hochel & Mila′n, 2008) that synaesthesia is trigger by verbal inducers (like letters, words, days of week) while the synaesthetic experience is a simple perceptual feature (like color, taste). It is possible that unbalanced brain development and therefore development of cognitive processes determine occurrence of constitutional synaesthesia. Being unable to classify items on an abstract level due to brain immaturity causes regressive solutions of problems with the aid of earlier and familiar ways of thinking. Therefore most cases of synaesthesia are an attempt to organize abstract symbols such as numbers, days of the week, and letters of alphabet are based on colors rather than size or distance (these symbols seem to be too abstract and too difficult to understand to a child). This hypothesis seem to corresponding with the concept of cortical connectivity (Bargary & Mitchell, 2008), and it would explain why synaesthesia appears. However, destroying structural, biochemical, or functional parts of the brain (significant to perception in adulthood) would bring in disharmony in cognitive processes determine the occurrence of acquired synaesthesia.

Taking into account intensity of synaesthesia (strong vs. weak), its direct cause (changes of structural, biochemical, functional nature, functional changes of brain, suggestibility), the time of occurrence in ontogenesis (childhood vs. adulthood) and its duration during the lifetime (permanent vs. temporary), we suggest to divide this phenomenon into four kinds, and to divide each kind into four subkinds:

1. Developmental synaesthesia—occurs in early childhood and seems to reveal a stage of development of brain and cognitive process alike, which includes:
   - Neonatal synaesthesia
   - Constitutional synaesthesia
2. Acquired synaesthesia—occurs in adulthood, on result nervous system damage, and seems to compensate some cognitive dysfunctions. It occurs in following variations:
   - Postaccidental synaesthesia
   - Phantom synaesthesia
   - Artificial synaesthesia
3. Temporary synaesthesia—nonsynaesthete experience by moment synaesthetic sensations, influenced by drugs or strong suggestion. This is possible most likely by using intermodal links, which concern sensory integration process. It includes:

- Narcotic synaesthesia
- Posthypnotic synaesthesia
- Virtual synaesthesia

4. Associational synaesthesia is common and is based on universal rules regarding intermodal associations. It may include the following variations:

- Weak synaesthesia
- Mirror-touch synaesthesia
- Pain synaesthesia
- Artistic synaesthesia (multimedia and literary)

Future studies should explore the remaining kinds of synaesthesia as well as constitutional synaesthesia, to verify hypothesis suggested above. The precise definition of characteristics common for all above listed kinds of synaesthesia as well as their differences would certainly help to clarify the nature and mechanisms of synaesthesia.

Probable Functions of Synaesthesia

What seems to connect particular kinds of synaesthesia are the compensatory or integrative roles that synaesthesia most likely plays in cognitive processes. The basic function of the first kind would be to compensate for deficiencies occurring during cognitive processes. This mechanism could relate to higher or lower levels of processing data, occurring on semantic or sensory levels respectively. The synaesthetic sensation on a semantic level most likely constitutes the additional clue in the process of identifying specific stimulus. As the results of studies show (Dixon et al., 2006; Mattingley et al., 2001; Robertson, 2003), type of stimulation play an important role in the occurrence of synaesthesia (Bargary, Barnett, Mitchell, & Newell, 2009).

During data processing, there are constant processes of synthesis and integration of data occurring, as well as the analysis and differences of characteristics of the stimulated object. The same "cognitive platform" that constitutes intersensual associations fixed in perceptual integration processes, is most likely used in synthesizing the compensating cognitive limitations in ontogenesis. The mechanism of compensation therefore uses the already existing intersensual links that occurred during the process of integration. In this sense, integration processes are primary versus compensatory processes and they constitute the necessary (although probably inadequate) basis for its occurrence. The given kinds of synaesthesia occurred to a greater or smaller extent as a result of integrative or compensatory procedures (see Table 1).

Some researchers (Hubbard, 2008; Parise & Spence, 2009; Rich & Mattingley, 2002; Saenz & Koch, 2008) claim that synaesthesia is closely related to the process of integrating data coming from various sensual modalities. The associational or phantom, virtual, or neonatal synaesthesias seem to have strong integrative characteristics. All these kinds of synaesthesia are mainly based on the pattern of intermodal links induced during the process of integrating data, and which come from various integrations of information from multiple sensory modalities. The given configuration of intermodal associations is so strong that the occurrence of one item of this configuration in just one sense is followed by the occurrence of sensations in the remaining senses (e.g., in the case of phantom synaesthesia). The other kinds of synaesthesia (artistic, narcotic, artificial, postaccidental, and constitutional) occur most likely as a compensation for deficiencies like verbal and are termed limitations (in artistic synaesthesia), lack of biochemical balance (in narcotic synaesthesia), brain damage (in postaccidental synaesthesia) or cognitive limitations (in constitutional synaesthesia).

Table 1
Kinds of Synaesthesia Relating to Functions and Ways of Occurrence

	Functions of Synaesthesia	
Kinds of synaesthesia	Integration	Compensation
Associational	Mirror-touch, pain	Literary, multimedia
Temporary	Virtual, post-hypnotic	Narcotic
Acquired	Phantom	Post-accidental, artificial
Developmental	Neonatal	Constitutional

Constitutional synaesthesia seems to occur as a side effect during the process of data differentiation. Following the analysis of incentives regarding its characteristics (like color, height, intensity in case of sounds) there are differences occurring between inducers of the same kind (like human voices) and assigning data to relevant internal catalogues (the brain) that will be easy to identify and to later to bring back from memory (an access code to this information will be necessary). On the more developed stages of processing, the data is segregated according to the significance of the incentive. In the case of abstract terms containing a number of items organized in a given order (such as given musical sound—their intensity, their musical key, or such as days of a week, months or numbers) that are difficult to understand by a child on a given stage of development (when the process of classification is not yet possible), the brain induces an additional clue (coming from sense that has been already shaped at a given stage of development). For example, a color makes it easier to find such information in the next identification of an incentive. Synaesthesia starts functioning later as an additional memory clue very often turning the synaesthetes into memory masters. It would explain the higher level of memory of synaesthetes (Mills et al., 2006; Smilek, Dixon et al., 2002; Yaro & Ward, 2007) The results of studies show (Simner et al., 2006; Simner, 2006; Simner, Harrold, Creed, Monro, & Foulkes, 2009) that lexical color synaesthesia relates most often to sequences of items that a child learns in their critical period of life (like letters of alphabet, days of a week). Researchers (Rich et al., 2005) speculate that, synaesthetic experiences generalize later other words or categories of incentives. Studies conducted are a proof of this (Ward, Tsakanikos, & Bray, 2006).

Compensatory character of this would therefore mean that cognitive limitation being a result of brain handicap or defect crucial for data processing is compensated by inducing additional access code (i.e., color) familiar from earlier ways of data processing. Such an additional synaesthetic clue (as color or smell) is later included into already fixed items of mental representation of a given term, that occurred during the process of data integrating and from then on it is constantly present in perception. The brain, and therefore perceptual abilities, develop nonhomogeneously causing individual differences, that is, regarding hearing, visual, taste, and smell abilities. Deficiencies of one modality, that is, visual, are often compensated by a higher level of development of other modality, that is, tactile or hearing (Maurer, Lewis, & Mondloch, 2005). According to the results of studies (Cohen Kadosh & Walsh, 2006), the similar pattern of synaesthetic sensations show activity of brain of persons visually impaired while reading Braille (tactile sensation activates visual core).

The more developed sensual modality of synaesthesia would be of assistance in overcoming developmental limitations occurring in another modality, that is, with a person with phonematic hearing deficiency, visualizing letters of alphabet in color would help in analyzing and synthesizing speech. In general, the more developed cognitive processes of one modality (i.e., visual) would be a base for inducing additional clue (like color) for weaker modality (like hearing). A person with colored-hearing synaesthesia should therefore show higher cognitive abilities in the area of visual modality more than in hearing.

This thesis seems to be confirmed by the results of research and by the memories of synaesthetes (Barnett & Newell, 2008; Cohen Kadosh, Lammertyn, & Izard, 2008; Cohen Kadosh, Tzelgov, & Henik: 2008a, 2008b; Spiller & Jansari, 2008). According to researches (Banissy, Walsh et al., 2009), synaesthetes who experience color have enhanced color sensitivity and synaesthetes who experience touch have enhanced tactile sensitivity. These findings suggest the possibility that a hyper-sensitive concurrent perceptual system is a general property of synaesthesia. Synaesthesia therefore relates to cognitive processes on the level of representing the stimulation (Grossenbacher & Lovelace, 2001; Simner, 2006) and serves the purpose of organizing and placing data in the right order while creating a mental picture of objects and terms.

Classifying objects on the basis of their shapes or colors is concrete, firm, and is an early stage of arranging in order a given data. It is possible that, with synaesthetes the brain produces a familiar and more concrete way of marking data of semantic nature according to the rules obligatory in intermodal integration processes. The results of this research (Rogowska, 2007) show that there is a positive correlation between synaesthesia and perceptual-mental type of brain that is described by this particular analytical and concrete thinking. The compensatory character of constitutional synaesthesia would also explain its relation to autism (Baron-Cohen et al., 2007; Bor, Billington, & Baron-Cohen, 2007). The cognitive limitations of persons with special needs and autism are the reason that abstract terms are possible to understand only regarding concrete thinking (Murray, 2010; Simner, Mayo, & Spiller, 2009).[3] It is possible that, like in synaesthesia— concrete pictures will be brought down to multimodal configuration of chosen characteristics of given term. Spectacular cases of unusual memory of savants, their above average musical or mathematical skills are based on unusual way of associating or arranging items of given category. Savants are able to create in their imagination matrices related in visualizing items of a given category, using a nonspecific sense for this purpose (i.e., area responsible for visual and motion coordination or spatial imagination).

Compensatory synaesthesia would occur as an answer to individual needs of a person, and in specific circumstances, which would cause idiosyncratic and unique patterns of intersensual links. On the other hand, however, synaesthesia is a unique clue of cognitive problems of a given stage of development. This would explain why some variations of constitutional synaesthesia occur more frequently than others. Smartening up abstract terms related to time in time-space synaesthesia, understanding numbers and quantities of number-form synaesthesia (Gertner, Henik, & Cohen Kadosh, 2009) color-digit synaesthesia, (Dixon et al., 2006; Ghirardelli, Mills, Zilioli, Bailey, & Kretschmar, 2010), or phonetic synaesthesia and recording of speech in graphic form of colored-speech synaesthesia—this all demonstrates what type of cognitive problems are most difficult for children. Learning to speak, read and write a language, as well as learning conceptual and operational thinking are the most important and also the most difficult challenge for a small child. The higher and higher the expectations that children face from their earliest childhood, due to civilization progress, are not always tailored to the real cognitive abilities of child. The prevalence of some forms of synaesthesia maybe reflects frequency of cognitive problems on various stages of speech and intellectual development.

Based on type and form of constitutional synaesthesia we could specify the kind of cognitive problem with given child and on the basis of this we could trace the individual history of his growth. Should this hypothesis be right, synaesthesia could constitute additional information for diagnosing presumptive educational problems of children and their scholastic maturity. Such knowledge could be of priceless value in selecting individual methods of compensating deficiencies during the educational period, depending on manifested developmental problem.

It is important to note, that all kinds of synaesthesia seems to based on integrative processes. They differ from one another only by the role that they play. The hypothesis of compensatory or integrative roles of synaesthesia in cognitive processes, as well as relations between these two groups of synaesthesia mentioned above, should be explored in future studies.

Types of Constitutional Synaesthesia

Synaesthesia is not a homogenous phenomenon and it occurs in many different ways. Taking these differences into account while diagnosing synaesthesia could cause an advancement in research. Homogeneity is a condition necessary for selecting right people for research teams. Introducing a detailed differentiating diagnosis while bearing in mind not only kinds but also types and variations of synaesthesia. The constitutional synaesthesia was the one that was most frequently explored throughout the whole history of researches made. Based on a considerable amount of scientific literature on this kind of synaesthesia, there will be a classification made of its types. Due to the way in which sensations join together, one can single out in general a few types of constitutional synaesthesia.

Depending on number of modalities involved in perception, Marks and Odgar (2005) single out an intramodal and intermodal synaesthesia. In the intramodal synaesthesia the perception of the stimulating inducer and synaesthesial sensations are induced in the same modality, that is, while reading - some synaesthetes perceive the graphic presentation of words (writing, printout) in colors. In the intermodal synaesthesia—taste evokes sensations of color. One can distinguish two other variations of intermodal synaesthesia:

[3] Spatial configurations of ordinal sequences in the mind's eye or peripersonal space are, similar to *spatial-forms synaesthesia*, "*results of* reification, defined as the conversion of abstract concepts to concrete entities. It is suggested that this mechanism is also responsible for the putative concrete representations which are argued to contribute to savant skills. As such, studies in synaesthetes may provide insight into the nature of these representations in savants and facilitate the testing of hypotheses regarding savant skills" (Murray, 2010, p. 1007).

bimodal and multimodal. The most frequent one is the synaesthesia combining two sensual modalities, that is, visual and hearing (Grossenbacher, 1997). The multisensual synaesthesia, where a single-sense stimulation (like a sound) evokes simultaneous sensations in few sensual modalities inducing complexes of sensations, occurs very rarely (Beeli et al., 2005; Hänggi et al., 2008; Simner & Hubbard, 2006). Famous Russian mnemonist S.V. Shereshevskii, possessed this type of synaesthesia (Luria, 1968). Hearing each sound, for example, evoked his simultaneous experiences of taste, touch, and vision.

Both inductor and synaesthetic sensation, can relate only to single characteristics of an object, or could be a comprehensive synthesis of few features. Wellek (1954) singled out four subtypes of vision-hearing form of musical synaesthesia of colored-hearing: static, single, complex, and dynamic (see Table 2). Single musical tones (a single feature, i.e., intensity) as well as the music enfolding greater melody, rhythm and harmony complexes (synthesis of features, i.e., a fragment of Beethoven's symphony) could be associated with color (a simple feature) or a picture (synthesis of few features, i.e., color geometric figures and lines).

The above standardization could be applied in other forms of synaesthesia, that is, language, taste, tactile, and so forth The synaesthetic sensations on sensory level can relate only to single characteristics of sensations (like color) or can be a synthesis of many features (like color, texture, motion). In this case the synaesthesia can be of analytical or synthetic nature (see Figure 1).

In order to define the intensity of synaesthesia, we suggest applying differentiation relating only to the extent of the complexity of synesthetic sensation. The stimulation in analytic type induces a single feature of sensual sensation (i.e., smell induces seeing colors). The synthetic type joins few features of an object in synesthetic sensation (i.e., color and shape).

Scope of inductors hold a crucial significance in singling out various types of synaesthesia of given category. For example, there are synaesthetes for whom all sounds (sounds of environment, sounds of music and sounds of speech) induce seeing colors. This type can be described as comprehensive synaesthesia. The partial synaesthesia, with only chosen elements of a given category of inductors, evokes a feeling, for example, only some female names evoke color sensations.

Based on studies and interviews held with more than 800 synaesthetes, Day (2005) singled out two types of synaesthesia relating to the depth of cognitive processes that occur in a person experiencing synaesthesia. The synaesthesia proper combines simple and general sensations on lower sensory level of data processing, that is, tastes evoke specific color sensations. This type of synaesthesia is called by Marks (1999) sensory synaesthesia. Cognitive or category synaesthesia, as per Day (2005) and also named by Marks (1999), is a perceptual type that combines colors and semantic inductors occurring in old cultures and being a subject of studies, that is, letters of alphabet, digits, names, words, notes, or musical tones. The issues of transforming data in synaesthesia were explored in various studies (Cohen Kadosh & Henik, 2006b; Cohen Kadosh, Lammertyn, & Izard, 2008; Dixon et al., 2006; Hubbard et al., 2005; Jansari, Spiller, & Redfern, 2006; Ramachandran & Hubbard, 2001a; Simner & Haywood, 2009; Smilek, Dixon & Merilke, 2006). Ramachandran and Hubbard (2001b, 2003; Hubbard, & Ramachandran, 2005) single out the lower and higher forms of synaesthesia, depending on the fact that synaesthesia is induced correctly on the basis of an earlier analysis of processing physical features of an stimulation—lower perceptual processes or considering the importance of generator of semantic

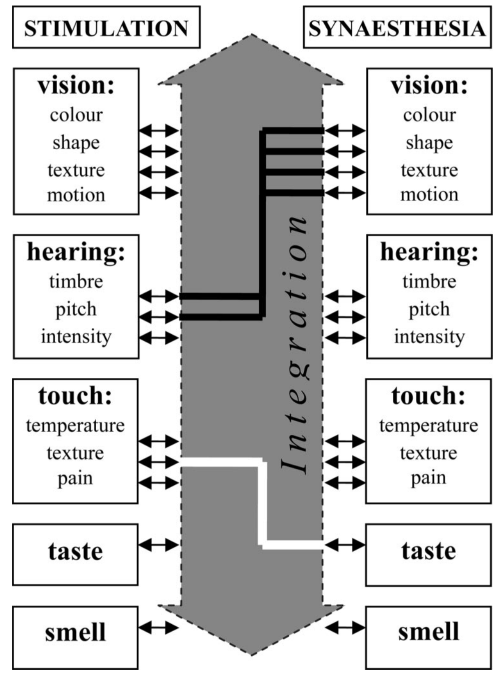

Figure 1. Possible multisensual links of sensory synaesthesia. Figure 1 shows two types of sensory synaesthesia:
• The white line joins one feature of a tactile inductor (texture) with taste. This is an example of simple synaesthesia.
• The black line joins two features (color and the pitch of a tone) with four features of the visual photism of complex synaesthesia (color, shape, textile, motion). For example, while listening to music, a synaesthete sees shining golden balls and stripes moving up and down on a mossy background.
• The arrows relating to particular features of the senses show the possibility of two-directional conjunctions.

Table 2
Types of Musical Synaesthesia (Wellek, 1954, p. 1808)

Type of synaesthesia	Style of processing	Stimulation	Sensation
Static	Analytic	Sound	Colour
Simple	Analytical-synthetic	Music	Colour
Complex	Synthetic	Sound	Picture
Dynamic	Synthetic	Music	Picture

level (referring to higher cognitive processes). An example of such semantic process is linguistic synaesthesia (Gheri, Chopping, & Morgan, 2008; Simner, Glover, & Movat, 2006; Simner, Harrold, Creed, Monro, & Foulkes, 2009; Ward & Sagiv, 2007; Ward & Simner, 2003; Ward, Simner & Auyeung, 2005). In order to unify terms describing these two forms of synaesthesia it seems necessary to single out sensory and semantic synaesthesia, respectively to the level of data process on which the synaesthetic association occurs.

Synaesthesia can be induced as a result of noticing one inductor working on one of the sensations, or as a result of thinking of an inductor (Dixon, Smilek, Cudahy, & Merikle, 2000; Spiller & Jansari, 2008). Depending on a source of stimulation, Grossenbacher and Lovelace (2001) singles out two kinds of synaesthesia: perceptual—sensual, where synaesthesia is induced by external objective stimulation (e.g., sounds of environment, touch) and conceptual—imagery-induced synaesthesia where imagining an inductor evokes synaesthetic feeling.

Synaesthetic feeling can also be experienced outside, perceptually as well as internally as an imagination. Due to the way of experiencing synaesthetic associations synaesthetes are divided into two groups, specifying various types of colored hearing synaesthesia (Dixon, Smilek, & Merikle, 2004; Smilek, Dixon, & Merikle, 2005). Some persons (associators) see synaesthetic associations with "internal eye of imagination" and others (projectors) project their synaesthetic colors into graphemes and perceive them externally as if seeing them on screen colored letters, digits, or words. Differences between these types are relative of structural and functional differences of the brain (Rich et al., 2006; Rouw & Scholte, 2007). Greater connectivity in the inferior temporal cortex was particularly strong in synaesthetes who see synaesthetic color in the outside world (projectors) as compared to synaesthetes who see the color in their "mind's eye" only (associators). Referring to various types of intellectual processes while experiencing synaesthesia. Wellek (1954) singled out four types of synaesthesia showed in below table (see Table 3).

Depending on direction of inducing sensations one can speak about uni- or bidirectional synaesthesia (Grossenbacher & Lovelace, 2001; Rich & Mattingley, 2002). Unidirectional synaesthesia occurs when combining two sensations only one may induce the other, for example, in colored-hearing synaesthesia a sound induces the sensation of seeing a color, but the inductor of color does not induce the sensation of sound (Beeli et al., 2005; Martino & Marks, 2001; Mills et al., 1999; Ramachandran & Hubbard, 2001b). The bidirectional form occurs very rarely and may lead to perceptual disorders as a result of interference of synesthetic sensations with real environment. In the bidirectional synaesthesia each one of two joined sensations may stimulate the other, for example, sound induces the sensation of color and perception of color induces a sensation of sound (Cohen Kadosh et al., 2007; Johnson, Jepma, & de Jong, 2007; Knoch, Gianotti, Mohr, & Brugger, 2005). The most recent studies show possibility of inducing bidirection in unidirectional synaesthesia (Brang, Edwards, Ramachandran, & Coulson, 2008; Cohen Kadosh & Henik, 2006a; Cohen Kadosh et al., 2005; Meier & Rother, 2007), which implicates the conclusion that the between uni- and bidirection is smooth and therefore unidirection should be analyzed in reference to measure more than to category.

To summarize the above; based on the above-described types of constitutional synaesthesia one should take up the next steps in diagnosing a given case in accordance to the following pattern:

1. How many modalities are combined in synaesthesia?

• Intramodal (single-modal) —an incentive and cosensation belong to the same modality (e.g., written word induces the sensation of color)

• Intermodal—when an incentive and synaesthesia belong to different modalities. This kind due to the frequency of occurrence— can be divided into following type of synaesthesia:

• Bimodal (e.g., musical tone induces seeing colors)

• Multimodal (e.g., hearing a word induces colors, taste and tactile sensations)

2. How many features are combined in cosensation?

• Analytic—when an inductor evokes a sensation of a single sensual feature (e.g., experiencing taste triggers seeing colors)

• Synthetic—when a synesthesial sensation constitutes a synaesthesia of few senses (e.g., a sound a = 400 Hz induces seeing golden shining ball

3. Does synaesthesia cover all components of a given scope of stimulating incentives?

• Partial—when only some components of a given scope of inductors evoke synaesthesia, e.g., only some names or only chosen days of a week are associated with colors.

• Comprehensive—when all components of a given category induce synesthetic sensations, e.g., all digits, all letters of alphabet or all musical sounds and sounds of environment induce relevant colors.

4. What are the kinds of stimulation?

• Sensory—synaesthesia induced by sensual inductors of sensual nature (e.g., touch)

• Semantic—synaesthesia evoked by a significant inductor (e.g., words that are understandable as opposed to words in foreign language)

5. What is the source of stimulation?

• Perceptual—stimulation comes from outside (e.g., sounds of environment)

• Conceptual—synaesthesia may be evoked as a result of thinking of an incentive (internal speech) or imagining it.

6. Where is the cosensation projected?

Table 3
Types of Synaesthesia (Wellek, 1954, p. 1805)

Types of synaesthesia	Stimulation		Feeling
Double sensation	External	Sensation	Sensation
Secondary representation	External	Sensation	Representation
Secondary sensation	Internal	Representation	Sensation
Double representation	Internal	Representation	Representation

• Internal (Associators) synaesthetic cosensation is seen by internally "mind's eye"

• External (Projectors) —a synaesthetic cosensation projected externally, for example, visual sensations like seeing things on screen at a distance of few centimeters from an eye.

7. Do the associations work both ways?

• Unidirectional—when synaesthetic combination work only in one direction, for example, a sound heard induces seeing a color, but a color seen does not induce hearing a sound.

• Bidirectional—when synaesthesia works both ways, that is, a sound induces a color and a color induces a sound.

Due to significant individual differences between synaethetes (Dixon & Smilek, 2005; Hubbard et al., 2005; Ward et al., 2007) resulting from idiosyncratic pattern of occurring possible configurations of various forms and types of synaesthesia, it would be necessary to analyze synaesthesia in relation to measure defining an extend of intensity of this phenomenon, as per the results of studies (Rogowska, 2007).

Taking into account the individual criteria of dividing constitutional synaesthesia into types, one should single out their weaker and stronger forms (see Table 4). The greater the extent of consciousness, imagination, or applying synaethesia in every day life (e.g., mnemotechnique), the stronger type of synaesthesia a given person will experience at every level. Weaker forms of synaesthesia occurring on lower levels of data process, less developed in regard to cognition, are the following types of synaesthesia: sensory, perceptual, intramodal, simple, internal, bidirectional. The stronger types processed on higher cognitive levels, may include the following types of synaesthesia: semantic, conceptual, intermodal, complex, external, bidirectional. Qualitative analysis should be followed by quantitative one while diagnosing an intensity of synaesthesia. The number of incentives evoking synaesthesia should decide of its strength.

One should note that different types and kinds of synaesthesia may occur with some persons while with others only one form of synesthetic associations may take place. This influences occurrence individual differences between synaesthetes. One should expect that, the more types of strong synaesthesia occurring in a given person there are, the stronger the type of synaesthesia that could be diagnosed. Such a person will rarely appear in a population. Smaller numbers of types of synaesthesiae and their weaker forms means their smaller intensity. This, however, will show more frequently.

Table 4
Weaker and Stronger Types of Synaesthesia

Criteria	Types of synaesthesia	
	Weaker	Stronger
Number of senses	Intramodal	Intermodal
Configuration of features	Analytic	Synthetic
Scope of stimulation	Partial	Comprehensive
Level of processing	Sensory	Semantic
Source of stimulation	Perceptual	Conceptual
Projection of co-sensations	Internal	External
Directivity	Unidirectional	Bidirectional

Conclusion

Despite the great extent of interest shown, the phenomenon of synaesthesia is not yet fully recognized. It seems that knowledge of mechanisms of synaesthesia will lead to understanding development and cognitive functioning of human beings in regard to synaesthetes as well as other part of population. Singling out particular kinds, types and forms of synaesthesia constitutes key feature of further studies of the nature of this phenomenon. The reductive approach, limited to studying only constitutional synaesthesia, obstructs attempts made to clarify the complexity of this phenomenon. The suggested comprehensive view of various aspects of synaesthesia provides an opportunity to single out their substantial characteristics and to get to the nature of synaesthesia. The author of this article hopes to provoke discussion of suggested integrative and compensatory functions of synaesthesia in human cognitive process.

Treating synaesthesia according to measures defining its intensity seems to be necessary in order to avoid aftereffects and to understand why in some cases the similar experiments lead to different and often conflicting results. The uniformity of experimental groups constitutes the basic condition of conducting experimental studies, enabling the interpretation of results gained during a study. The proper selection of groups of synaesthetes and nonsynaesthetes for comparative experiments while taking into account unity of attempt basing on compatibility of kinds, types and forms of synaesthesia will allow the better understanding of the nature of synaesthesia. It is, however, necessary to verify these hypotheses in future research.

We do not know if the classification of types of constitutional synaesthesia divided into stronger and weaker forms and presented in this article would be equally adequate in regard to other kinds of synaesthesia. This question should be explored in further research.

The comparative studies regarding all kinds, types, and forms of synaesthesia will allow the verification of answers to the question "is there one common mechanism responsible for occurrence of synaesthesia?" To what extent do we share the ability to experience synaesthesia? What role does synaesthesia play in cognitive processes? We need experimental verification of hypotheses discussed in this article. We do hope that progress of studies of synaesthesia will help find solution of enigma of synaesthesia in perspective of developing perception and language.

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