[Template:Other uses](/wiki/Template:Other_uses" \o "Template:Other uses) [Template:Distinguish](/wiki/Template:Distinguish) [Template:Use dmy dates](/wiki/Template:Use_dmy_dates) [Template:Page numbers needed](/wiki/Template:Page_numbers_needed) [Template:Use American English](/wiki/Template:Use_American_English)

[Template:Infobox medical condition](/wiki/Template:Infobox_medical_condition) **Synesthesia** (also spelled **synæsthesia** or **synaesthesia**; from the [Ancient Greek](/wiki/Ancient_Greek) [Template:Lang](/wiki/Template:Lang) *syn*, "together", and [Template:Lang](/wiki/Template:Lang) *aisthēsis*, "[sensation](/wiki/Wikt:sensation)") is a neurological phenomenon in which [stimulation](/wiki/Stimulation) of one sensory or cognitive pathway leads to automatic, involuntary experiences in a second sensory or cognitive pathway.[[1]](#cite_note-1)[[2]](#cite_note-2)[[3]](#cite_note-3)[[4]](#cite_note-4) People who report a lifelong history of such experiences are known as synesthetes.

In one common form of synesthesia, known as [grapheme-color synesthesia](/wiki/Grapheme-color_synesthesia) or color-graphemic synesthesia, [letters](/wiki/Letter_(alphabet)) or [numbers](/wiki/Numerical_digit) are perceived as inherently colored.[[5]](#cite_note-5)[[6]](#cite_note-6) In spatial-sequence, or [number form](/wiki/Number_form) synesthesia, numbers, months of the year, and/or days of the week elicit precise locations in space (for example, 1980 may be "farther away" than 1990), or may appear as a three-dimensional map (clockwise or counterclockwise).[[7]](#cite_note-7)[[8]](#cite_note-8) Synesthetic associations can occur in any combination and any number of senses or cognitive pathways.[[9]](#cite_note-9) Little is known about how synesthesia develops. It was proposed that synesthesia develops during childhood when children are intensively engaged with abstract concepts for the first time.[[10]](#cite_note-10) This hypothesis – referred to as *semantic vacuum hypothesis* – explains why the most common forms of synesthesia are grapheme-color, spatial sequence and number form. These are usually the first abstract concepts that educational systems require children to learn.

Only a fraction of types of synesthesia have been evaluated by scientific research.[[11]](#cite_note-11) Awareness of synesthetic perceptions varies from person to person.[[12]](#cite_note-12) Difficulties have been recognized in adequately defining synesthesia:[[13]](#cite_note-13)[[14]](#cite_note-14) Many different phenomena have been included in the term synesthesia ("union of the senses"), and in many cases the terminology seems to be inaccurate. A more accurate term may be [ideasthesia](/wiki/Ideasthesia).[Template:TOC limit](/wiki/Template:TOC_limit)

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## History[[edit](/index.php?title=(none)&action=edit&section=1)]

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The interest in colored hearing dates back to Greek antiquity, when philosophers asked if the color (*chroia*, what we now call [timbre](/wiki/Timbre)) of music was a quantifiable quality.[[15]](#cite_note-15) Isaac Newton proposed that musical tones and color tones shared common frequencies, as did Goethe in his book, "Theory of Color".[[16]](#cite_note-16) There is a long history of building color organs such as the [clavier à lumières](/wiki/Clavier_à_lumières) on which to perform colored music in concert halls.[[17][17]](#cite_note-17)[[18]](#cite_note-18) The first medical description of "colored hearing" is in an 1812 German thesis by the German physician Sachs.[[19]](#cite_note-19) The "father of psychophysics," [Gustav Fechner](/wiki/Gustav_Fechner), reported the first empirical survey of colored letter photisms among 73 synesthetes in 1876,[[20]](#cite_note-20)[[21]](#cite_note-21) followed in the 1880s by [Francis Galton](/wiki/Francis_Galton).[[7]](#cite_note-7)[[22]](#cite_note-22)[[23]](#cite_note-23) [C.G.Jung](/wiki/CG_Jung) refers to "color hearing" in his Symbols of Transformation in 1912.[[24]](#cite_note-24) Research into synesthesia proceeded briskly in several countries, but due to the difficulties in measuring subjective experiences and the rise of [behaviorism](/wiki/Behaviorism), which made the study of *any* subjective experience taboo, synesthesia faded into scientific oblivion between 1930 and 1980.

As the 1980s [cognitive revolution](/wiki/Cognitive_revolution) made inquiry into internal subjective states respectable again, scientists returned to synesthesia. Led in the United States by Larry Marks and [Richard Cytowic](/wiki/Richard_Cytowic), and later in England by [Simon Baron-Cohen](/wiki/Simon_Baron-Cohen) and [Jeffrey Gray](/wiki/Jeffrey_Alan_Gray), researchers explored the reality, consistency, and frequency of synesthetic experiences. In the late 1990s, the focus settled on grapheme → color synesthesia, one of the most common[[25]](#cite_note-25) and easily studied types. Psychologists and neuroscientists study synesthesia not only for its inherent appeal, but also for the insights it may give into cognitive and perceptual processes that occur in synesthetes and non-synesthetes alike. Synesthesia is now the topic of scientific books and papers, PhD theses, documentary films, and even novels.

Since the rise of the Internet in the 1990s, synesthetes began contacting one another and creating web sites devoted to the condition. These early grew into international organizations such as the [American Synesthesia Association](/wiki/American_Synesthesia_Association), the [UK Synaesthesia Association](/wiki/UK_Synaesthesia_Association), the [Belgian Synaesthesia Association](/wiki/Belgian_Synaesthesia_Association), the Canadian Synesthesia Association, the German Synesthesia Association, and the Netherlands Synesthesia Web Community.

## Forms[[edit](/index.php?title=(none)&action=edit&section=2)]

There are two overall forms of synesthesia: **projective** synesthesia and **associative** synesthesia. People who project will see actual colors, forms, or shapes when stimulated, as is commonly accepted as synesthesia; associators will feel a very strong and involuntary connection between the stimulus and the sense that it triggers. For example, in the common form chromesthesia (sound to color) a projector may hear a trumpet and see an orange triangle in space while an associator might hear a trumpet and think very strongly that it sounds "orange".

Synesthesia can occur between nearly any two senses or perceptual modes, and at least one synesthete, [Solomon Shereshevsky](/wiki/Solomon_Shereshevsky), experienced synesthesia that linked all five senses.[Template:Mcn](/wiki/Template:Mcn) Types of synesthesia are indicated by using the notation x → y, where x is the "inducer" or trigger experience, and y is the "concurrent" or additional experience. For example, perceiving letters and numbers (collectively called [graphemes](/wiki/Grapheme)) as colored would be indicated as grapheme → color synesthesia. Similarly, when synesthetes see colors and movement as a result of hearing musical tones, it would be indicated as tone → (color, movement) synesthesia.

While nearly every logically possible combination of experiences can occur, several types are more common than others.

### Grapheme-color synesthesia[[edit](/index.php?title=(none)&action=edit&section=3)]

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[thumb|From the 2009 non-fiction book](/wiki/File:Number_Form--colored.jpg) [*Wednesday Is Indigo Blue*](/wiki/Wednesday_Is_Indigo_Blue).[[3]](#cite_note-3) Note this example's upside-down clock face. In one of the most common forms of synesthesia, individual letters of the alphabet and numbers (collectively referred to as [graphemes](/wiki/Grapheme)) are "shaded" or "tinged" with a color. While different individuals usually do not report the same colors for all letters and numbers, studies with large numbers of synesthetes find some commonalities across letters (e.g. A is likely to be red).[[25]](#cite_note-25)

### Chromesthesia[[edit](/index.php?title=(none)&action=edit&section=4)]

[Template:Main](/wiki/Template:Main) Another common form of synesthesia is the association of sounds with colors. For some, everyday sounds such as doors opening, cars honking, or people talking can trigger seeing colors. For others, colors are triggered when musical notes and/or keys are being played. People with synesthesia related to music may also have [perfect pitch](/wiki/Perfect_pitch) because their ability to see/hear colors aids them in identifying notes or keys.[[26]](#cite_note-26) The colors triggered by certain sounds, and any other synesthetic visual experiences, are referred to as *photisms*.

According to [Richard Cytowic](/wiki/Richard_Cytowic),[[3]](#cite_note-3) chromesthesia is "something like fireworks": voice, music, and assorted environmental sounds such as clattering dishes or dog barks trigger color and firework shapes that arise, move around, and then fade when the sound ends. Sound often changes the perceived hue, brightness, scintillation, and directional movement. Some individuals see music on a "screen" in front of their faces. For Deni Simon, music produces waving lines "like oscilloscope configurations – lines moving in color, often metallic with height, width and, most importantly, depth. My favorite music has lines that extend horizontally beyond the 'screen' area."

Individuals rarely agree on what color a given sound is. B flat might be orange for one person and blue for another. Composers [Liszt](/wiki/Liszt) and [Rimsky-Korsakov](/wiki/Rimsky-Korsakov) famously disagreed on the colors of music keys.

### Spatial sequence synesthesia[[edit](/index.php?title=(none)&action=edit&section=5)]

Those with spatial sequence synesthesia (SSS) tend to see numerical sequences as points in space. For instance, the number 1 might be farther away and the number 2 might be closer. People with SSS may have superior memories; in one study, they were able to recall past events and memories far better and in far greater detail than those without the condition. They also see months or dates in the space around them. Some people see time like a clock above and around them.[Template:MEDRS](/wiki/Template:MEDRS)[[27]](#cite_note-27)[[28]](#cite_note-28)

### Number form[[edit](/index.php?title=(none)&action=edit&section=6)]

[Template:Main](/wiki/Template:Main) [thumb|A](/wiki/File:Galton_number_form.svg) [number form](/wiki/Number_form) from one of Francis Galton's subjects (1881).[[7]](#cite_note-7) Note how the first 12 digits correspond to a clock face.

A number form is a mental map of numbers that automatically and involuntarily appears whenever someone who experiences number forms thinks of numbers. Number forms were first documented and named in 1881 by [Francis Galton](/wiki/Francis_Galton) in "The Visions of Sane Persons".[[29]](#cite_note-29)

### Auditory-tactile synesthesia[[edit](/index.php?title=(none)&action=edit&section=7)]

In auditory-tactile synesthesia, certain sounds can induce sensations in parts of the body. For example, someone with auditory-tactile synesthesia may experience that hearing a specific word feels like touch in one specific part of the body or may experience that certain sounds can create a sensation in the skin without being touched. It is one of the least common forms of synesthesia.[[30]](#cite_note-30) However, many consider the common phenomenon of [ASMR](/wiki/ASMR) (where auditory stimulus or trigger words creates a tingling sensation in the body without being touched) to be a form of auditory-tactile synesthesia, as it fits the definition of sounds inducing physical sensations, meaning that it could be more common than current statistics imply.

### Ordinal linguistic personification[[edit](/index.php?title=(none)&action=edit&section=8)]

[Template:Main](/wiki/Template:Main) Ordinal-linguistic personification (OLP, or personification for short) is a form of synesthesia in which ordered sequences, such as [ordinal numbers](/wiki/Ordinal_number), week-day names, months and alphabetical letters are associated with personalities and/or genders ([Template:Harvnb](/wiki/Template:Harvnb)). For example, the number 2 might be a young boy with a short temper, or the letter G might be a busy mother with a kind face. Although this form of synesthesia was documented as early as the 1890s ([Template:Harvnb](/wiki/Template:Harvnb); [Template:Harvnb](/wiki/Template:Harvnb)) researchers have, until recently, paid little attention to this form (see [History of synesthesia research](/wiki/History_of_synesthesia_research)). This form of synesthesia was named as OLP in the contemporary literature by Julia Simner and colleagues [[31]](#cite_note-31) although it is now also widely recognised by the term "sequence-personality" synaesthesia. Ordinal linguistic personification normally co-occurs with other forms of synesthesia such as [grapheme-color synesthesia](/wiki/Grapheme-color_synesthesia).

### Misophonia[[edit](/index.php?title=(none)&action=edit&section=9)]

[Template:Main](/wiki/Template:Main) [Misophonia](/wiki/Misophonia) is a neurological disorder in which negative experiences (anger, fright, hatred, disgust) are triggered by specific sounds. Richard Cytowic suggests that misophonia is related to, or perhaps a variety of, synesthesia.[[32]](#cite_note-32) Miren Edelstein and her colleagues have compared misophonia to synesthesia in terms of connectivity between different brain regions as well as specific symptoms. They formed the hypothesis that "a pathological distortion of connections between the auditory cortex and limbic structures could cause a form of sound-emotion synesthesia."[[33]](#cite_note-33)

### Mirror-touch synesthesia[[edit](/index.php?title=(none)&action=edit&section=10)]

[Template:Main](/wiki/Template:Main) This is a rare form of synesthesia where individuals feel the same sensation that another person feels (such as touch). For instance, when such a synesthete observes someone being tapped on their shoulder, the synesthete involuntarily feels a tap on their own shoulder as well. People with this type of synesthesia have been shown to have higher empathy levels compared to the general population. This may be related to the so-called [mirror neurons](/wiki/Mirror_neuron) present in the motor areas of the brain, which have also been linked to empathy.[[34]](#cite_note-34)

### Lexical-gustatory synesthesia[[edit](/index.php?title=(none)&action=edit&section=11)]

[Template:Main](/wiki/Template:Main) This is another rare form of synesthesia where certain tastes are experienced when hearing words. For example, the word basketball might taste like waffles. The documentary 'Derek Tastes Of Earwax' gets its name from this phenomenon, in references to pub owner James Wannerton who experiences this particular sensation whenever he hears the name spoken.[[35]](#cite_note-35)[[36]](#cite_note-36) It is estimated that 0.2% of the population has this form of synesthesia.[[37]](#cite_note-37)

### Spatio-temporal synesthesia[[edit](/index.php?title=(none)&action=edit&section=12)]

In the manner of number form synesthesia, the spatio-temporal synesthesia is a mental map of days, weeks, and/or months of the year. Individuals presenting this synesthesia type declare that they can "see the time", for example, in the form of a ribbon, ring, or circle. According to certain researches,[[38]](#cite_note-38) those individuals possess peculiar synaptic connections in their brain, allowing them to perceive time as a spatial construction.

Like other forms of synesthesia, spatio-temporal synesthesia is consistent in its occurrences; even when tested months later, a synesthete will report the same experiences that they previously did. [[39]](#cite_note-39)

### Other forms[[edit](/index.php?title=(none)&action=edit&section=13)]

Other forms of synesthesia have been reported, but little has been done to analyze them scientifically. There are at least 80 different types of synesthesia.[[40]](#cite_note-40) The common phenomenon of [ASMR](/wiki/ASMR) Is considered by some to be a type of auditory-tactile and visual-tactile synesthesia.

Less common types include but are not limited to:[Template:Citation needed](/wiki/Template:Citation_needed)

* phoneme-color
* lexeme-color
* smell-color
* flavor-color
* month-flavor
* sound-flavor
* visual-tactile
* pain-color
* personality-color (commonly referred to as "auras").

## Characteristics[[edit](/index.php?title=(none)&action=edit&section=14)]

Some synesthetes often report that they were unaware their experiences were unusual until they realized other people did not have them, while others report feeling as if they had been keeping a secret their entire lives.[[11]](#cite_note-11) The automatic and ineffable nature of a synesthetic experience means that the pairing may not seem out of the ordinary. This involuntary and consistent nature helps define synesthesia as a real experience. Most synesthetes report that their experiences are pleasant or neutral, although, in rare cases, synesthetes report that their experiences can lead to a degree of [sensory overload](/wiki/Sensory_overload).[[25]](#cite_note-25) Though often stereotyped in the popular media as a medical condition or neurological aberration, many synesthetes themselves do not perceive their synesthetic experiences as a handicap. To the contrary, some report it as a gift—an additional "hidden" sense—something they would not want to miss. Most synesthetes become aware of their distinctive mode of perception in their childhood. Some have learned how to apply their ability in daily life and work. Synesthetes have used their abilities in memorization of names and telephone numbers, mental arithmetic, and more complex creative activities like producing visual art, music, and theater.[[11]](#cite_note-11) Despite the commonalities which permit definition of the broad phenomenon of synesthesia, individual experiences vary in numerous ways. This variability was first noticed early in synesthesia research.[[41]](#cite_note-41) Some synesthetes report that [vowels](/wiki/Vowel) are more strongly colored, while for others [consonants](/wiki/Consonant) are more strongly colored.[[25]](#cite_note-25) Self reports, interviews, and autobiographical notes by synesthetes demonstrate a great degree of variety in types of synesthesia, intensity of synesthetic perceptions, awareness of the perceptual discrepancies between synesthetes and non-synesthetes, and the ways synesthesia is used in work, creative processes, and daily life.[[11]](#cite_note-11)[[42]](#cite_note-42) Synesthetes are very likely to participate in [creative](/wiki/Creativity) activities.[[43]](#cite_note-43) It has been suggested that individual development of perceptual and cognitive skills, in addition to one's cultural environment, produces the variety in awareness and practical use of synesthetic phenomena.[[12]](#cite_note-12)[[42]](#cite_note-42) Synesthesia may also give a memory advantage. In one study conducted by Julia Simner of the University of Edinburgh, it was found that spatial sequence synesthetes have a built-in and automatic mnemonic reference. So the nonsynesthete will need to create a mnemonic device to remember a sequence (like “Please excuse my dear Aunt Sally.”), but the synesthete can simply reference their spatial visualizations.[[44]](#cite_note-44)

## Mechanism[[edit](/index.php?title=(none)&action=edit&section=15)]

[Template:Main](/wiki/Template:Main) [thumb|Regions thought to be cross-activated in grapheme-color synesthesia (green=grapheme recognition area, red=V4 color area)](/wiki/File:synaesthesiabrain.jpg)[[45]](#cite_note-45)

Dedicated regions of the brain are specialized for given functions. Increased cross-talk between regions specialized for different functions may account for the many types of synesthesia. For example, the additive experience of seeing color when looking at graphemes might be due to cross-activation of the grapheme-recognition area and the color area called [V4](/wiki/Visual_area_V4) (see figure).[[45]](#cite_note-45) This is supported by the fact that grapheme-color synesthetes are able to identify the color of a grapheme in their peripheral vision even when they cannot consciously identify the shape of the grapheme.[[45]](#cite_note-45) An alternative possibility is disinhibited feedback, or a reduction in the amount of inhibition along normally existing feedback pathways.[[46]](#cite_note-46) Normally, excitation and inhibition are balanced. However, if normal feedback were not inhibited as usual, then signals feeding back from late stages of multi-sensory processing might influence earlier stages such that tones could activate vision. Cytowic and Eagleman find support for the disinhibition idea in the so-called acquired forms[[3]](#cite_note-3) of synesthesia that occur in non-synesthetes under certain conditions: [temporal lobe epilepsy](/wiki/Temporal_lobe_epilepsy),[[47]](#cite_note-47) head trauma, stroke, and brain tumors. They also note that it can likewise occur during stages of [meditation](/wiki/Meditation), deep concentration, [sensory deprivation](/wiki/Sensory_deprivation), or with use of [psychedelics](/wiki/Psychedelics,_dissociatives_and_deliriants) such as [LSD](/wiki/LSD) or [mescaline](/wiki/Mescaline), and even, in some cases, [marijuana](/wiki/Marijuana).[[3]](#cite_note-3) However, synesthetes report that common [stimulants](/wiki/Stimulant), like [caffeine](/wiki/Caffeine) and cigarettes do not affect the strength of their synesthesia, nor does [alcohol](/wiki/Ethanol).[[3]](#cite_note-3)[Template:Rp](/wiki/Template:Rp)

A very different theoretical approach to synesthesia is that based on [ideasthesia](/wiki/Ideasthesia). According to this account, synesthesia is a phenomenon mediated by the extraction of the [meaning](/wiki/Meaning_(non-linguistic)) of the inducing stimulus. Thus, synesthesia may be fundamentally a [semantic](/wiki/Semantic) phenomenon. Therefore, to understand neural mechanisms of synesthesia the mechanisms of semantics and the extraction of meaning need to be understood better. This is a non-trivial issue because it is not only a question of a location in the brain at which meaning is "processed" but pertains also to the question of [understanding](/wiki/Understanding)—epitomized in e.g., the [Chinese room](/wiki/Chinese_room) problem. Thus, the question of the neural basis of synesthesia is deeply entrenched into the general [mind–body problem](/wiki/Mind–body_problem) and the problem of the [explanatory gap](/wiki/Explanatory_gap).[[48]](#cite_note-48)

## Diagnostic criteria[[edit](/index.php?title=(none)&action=edit&section=16)]

Although often termed a "neurological condition," synesthesia is not listed in either the [DSM-IV](/wiki/DSM-IV) or the [ICD](/wiki/ICD) since it most often does not interfere with normal daily functioning.[[49]](#cite_note-49) Indeed, most synesthetes report that their experiences are neutral or even pleasant.[[25]](#cite_note-25) Like [perfect pitch](/wiki/Perfect_pitch), synesthesia is simply a difference in perceptual experience.

[thumb|Reaction times for answers that are congruent with a synesthete's automatic colors are shorter than those whose answers are incongruent.](/wiki/File:Stroop_interference.jpg)[[3]](#cite_note-3) The simplest approach is test-retest reliability over long periods of time, using stimuli of color names, color chips, or a computer-screen color picker providing 16.7 million choices. Synesthetes consistently score around 90% on reliability of associations, even with years between tests.[[1]](#cite_note-1) In contrast, non-synesthetes score just 30–40%, even with only a few weeks between tests and a warning that they would be retested.[[1]](#cite_note-1)[thumb|The automaticity of synesthetic experience. A synesthete might perceive the left panel like the panel on the right.](/wiki/File:synaesthesiatest.jpg)[[45]](#cite_note-45) Grapheme-color synesthetes, as a group, share significant preferences for the color of each letter (e.g. A tends to be red; O tends to be white or black; S tends to be yellow etc.)[[25]](#cite_note-25) Nonetheless, there is a great variety in types of synesthesia, and within each type, individuals report differing triggers for their sensations and differing intensities of experiences. This variety means that defining synesthesia in an individual is difficult, and the majority of synesthetes are completely unaware that their experiences have a name.[[25]](#cite_note-25) Neurologist [Richard Cytowic](/wiki/Richard_Cytowic) identifies the following diagnostic criteria for synesthesia in his *first* edition book. However, the criteria are different in the second book:[[1]](#cite_note-1)[[2]](#cite_note-2)[[3]](#cite_note-3)

1. Synesthesia is involuntary and [automatic](/wiki/Automaticity).
2. Synesthetic perceptions are spatially extended, meaning they often have a sense of "location." For example, synesthetes speak of "looking at" or "going to" a particular place to attend to the experience.
3. Synesthetic percepts are consistent and generic (i.e. simple rather than pictorial).
4. Synesthesia is highly [memorable](/wiki/Memory).
5. Synesthesia is laden with [affect](/wiki/Affect_(psychology)).

Cytowic's early cases mainly included individuals whose synesthesia was frankly projected outside the body (e.g. on a "screen" in front of one's face). Later research showed that such stark externalization occurs in a minority of synesthetes. Refining this concept, Cytowic and [Eagleman](/wiki/David_Eagleman) differentiated between "localizers" and "non-localizers" to distinguish those synesthetes whose perceptions have a definite sense of spatial quality from those whose perceptions do not.[[3]](#cite_note-3)

## Epidemiology[[edit](/index.php?title=(none)&action=edit&section=17)]

Synesthesia is found in 4.4% of the population, as a lower estimate, which is equivalent to 1 in 23 people. This figure was arrived at in the first large-scale random-screening study by Julia Simner and colleagues.[[50]](#cite_note-50) This study had also concluded that one common form of synesthesia—grapheme-color synesthesia (colored letters and numbers) – is found in more than one percent of the population, and this latter prevalence of graphemes-color synesthesia has now been independently verified in a yet larger sample.[[51]](#cite_note-51) Earlier estimates of the prevalence of synesthesia were based on "best-guess" estimations only (*e.g.* 1 in 250,000) or had limitations in their methodologies because they required synesthetes to refer themselves for study (*e.g.* 1 in 2000) and for this reason the authors of those studies had been moderate in their claims.[[52]](#cite_note-52) One problem with self-referral is that numbers are lowered by the effort involved in the act of self-referral. Also, some individuals will not self-classify as synesthetes because they do not realize that their perceptions are different from those of everyone else.[[45]](#cite_note-45) The most common forms of synesthesia are those that trigger colors, and the most prevalent of all is day-color.[[50]](#cite_note-50) Also relatively common is grapheme-color synesthesia. We can think of "prevalence" both in terms of how common is synesthesia (or different forms of synesthesia) within the population, or how common are different forms of synesthesia within synesthetes. So within synesthetes, forms of synesthesia that trigger color also appear to be the most common forms of synesthesia with a prevalence rate of 86% within synesthetes.[[50]](#cite_note-50) In another study, music-color is also prevalent at 18–41%.[Template:Citation needed](/wiki/Template:Citation_needed) Some of the rarest are reported to be auditory-tactile, mirror-touch, and lexical-gustatory.[[53]](#cite_note-53) There is research to suggest that the likelihood of having synesthesia is greater in people with [autism](/wiki/Autism).[[54]](#cite_note-54)

## Society and culture[[edit](/index.php?title=(none)&action=edit&section=18)]

### Notable cases[[edit](/index.php?title=(none)&action=edit&section=19)]

[Template:Main](/wiki/Template:Main) As mentioned before, one of the most notable synesthetes is [Solomon Shereshevsky](/wiki/Solomon_Shereshevsky), a newspaper reporter turned celebrated mnemonist, who was discovered by Russian neuropsychologist, [Alexander Luria](/wiki/Alexander_Luria), to have a rare fivefold form of synesthesia.[[55]](#cite_note-55) Words and text were not only associated with highly vivid visuo-spatial imagery but also sound, taste, color, and sensation.[[55]](#cite_note-55) Shereshevsky could recount endless details of many things without form, from lists of names to decades-old conversations, but he had great difficulty grasping abstract concepts. The automatic, and nearly permanent, retention of every little detail due to synesthesia greatly inhibited Shereshevsky from understanding much of what he read or heard.[[55]](#cite_note-55)

### Artistic investigations[[edit](/index.php?title=(none)&action=edit&section=20)]

[Template:Main](/wiki/Template:Main)

Other notable synesthetes come particularly from artistic professions and backgrounds. Synesthetic art historically refers to multi-sensory experiments in the genres of [visual music](/wiki/Visual_music), [music visualization](/wiki/Music_visualization), [audiovisual art](/wiki/Audiovisual_art), [abstract film](/wiki/Abstract_film), and [intermedia](/wiki/Intermedia).[[11]](#cite_note-11)[[56]](#cite_note-56)[[57]](#cite_note-57)[[58]](#cite_note-58)[[59]](#cite_note-59)[[60]](#cite_note-60) Distinct from neuroscience, the concept of synesthesia in the arts is regarded as the simultaneous perception of multiple stimuli in one [gestalt](/wiki/Gestalt_psychology) experience.[[61]](#cite_note-61) Neurological synesthesia has been a source of inspiration for artists, composers, poets, novelists, and digital artists. [Nabokov](/wiki/Vladimir_Nabokov) writes explicitly about synesthesia in several novels.[Template:Citation needed](/wiki/Template:Citation_needed) [Kandinsky](/wiki/Wassily_Kandinsky) (a synesthete) and [Mondrian](/wiki/Piet_Mondrian) (not a synesthete) both experimented with image-music congruence in their paintings. [Scriabin](/wiki/Alexander_Scriabin) composed colored music that was deliberately contrived and based on the [circle of fifths](/wiki/Circle_of_fifths), whereas [Messiaen](/wiki/Olivier_Messiaen) invented a new method of composition (the [modes of limited transposition](/wiki/Modes_of_limited_transposition)) specifically to render his bi-directional sound-color synesthesia. For example, the red rocks of [Bryce Canyon](/wiki/Bryce_Canyon_National_Park) are depicted in his symphony [*Des canyons aux étoiles*](/wiki/Des_canyons_aux_étoiles) ("From the Canyons to the Stars"). New art movements such as literary symbolism, non-figurative art, and visual music have profited from experiments with synesthetic perception and contributed to the public awareness of synesthetic and multi-sensory ways of perceiving.[[11]](#cite_note-11) Contemporary artists with synesthesia, such as [Carol Steen](/wiki/Carol_Steen)[[62]](#cite_note-62) and Marcia Smilack[[63]](#cite_note-63) (a photographer who waits until she gets a synesthetic response from what she sees and then takes the picture), use their synesthesia to create their artwork. Brandy Gale, a Canadian visual artist, experiences an involuntary joining or crossing of any of her senses – hearing, vision, taste, touch, smell and movement. Gale paints from life rather than from photographs and by exploring the sensory panorama of each locale attempts to capture, select, and transmit these personal experiences.[[64]](#cite_note-64)[[65]](#cite_note-65)[[66]](#cite_note-66) [David Hockney](/wiki/David_Hockney) perceives music as color, shape, and configuration and uses these perceptions when painting opera stage sets (though not while creating his other artworks). Russian painter [Wassily Kandinsky](/wiki/Wassily_Kandinsky) combined four senses: color, hearing, touch, and smell.[[1]](#cite_note-1)[[3]](#cite_note-3) [Vladimir Nabokov](/wiki/Vladimir_Nabokov) described his grapheme-color synesthesia at length in his autobiography, [*Speak, Memory*](/wiki/Speak,_Memory), and portrayed it in some of his characters.[[67]](#cite_note-67) Synesthetic composers include [Duke Ellington](/wiki/Duke_Ellington),[[68]](#cite_note-68) [Nikolai Rimsky-Korsakov](/wiki/Nikolai_Rimsky-Korsakov),[[69]](#cite_note-69) and [Olivier Messiaen](/wiki/Olivier_Messiaen), whose three types of complex colors are rendered explicitly in musical chord structures that he invented.[[3]](#cite_note-3)[[70]](#cite_note-70) Physicist [Richard Feynman](/wiki/Richard_Feynman) describes his colored equations in his autobiography, *What Do You Care What Other People Think?*[[71]](#cite_note-71) Other notable synesthetes include musicians [Billy Joel](/wiki/Billy_Joel),[[72]](#cite_note-72)[Template:Rp](/wiki/Template:Rp) [Itzhak Perlman](/wiki/Itzhak_Perlman),[[72]](#cite_note-72)[Template:Rp](/wiki/Template:Rp) [Alexander Frey](/wiki/Alexander_Frey), [Ida Maria](/wiki/Ida_Maria),[[73]](#cite_note-73) [Brian Chase](/wiki/Brian_Chase)[[74]](#cite_note-74)[[75]](#cite_note-75) and [Patrick Stump](/wiki/Patrick_Stump); actress [Stephanie Carswell](/wiki/Stephanie_Carswell) (credited as Stéphanie Montreux); inventor [Nikola Tesla](/wiki/Nikola_Tesla);[[76]](#cite_note-76) electronic musician Richard D. James aka [Aphex Twin](/wiki/Aphex_Twin) (who claims to be inspired by [lucid dreams](/wiki/Lucid_dream) as well as music); and classical pianist [Hélène Grimaud](/wiki/Hélène_Grimaud). Drummer [Mickey Hart](/wiki/Mickey_Hart) of [The Grateful Dead](/wiki/The_Grateful_Dead) wrote about his experiences with synaesthesia in his autobiography *Drumming at the Edge of Magic*.[Template:Citation needed](/wiki/Template:Citation_needed) [Pharrell Williams](/wiki/Pharrell_Williams), of the groups [The Neptunes](/wiki/The_Neptunes) and [N.E.R.D.](/wiki/N.E.R.D.), also experiences synesthesia[[77]](#cite_note-77)[[78]](#cite_note-78) and used it as the basis of the album [*Seeing Sounds*](/wiki/Seeing_Sounds). Singer/songwriter [Marina and the Diamonds](/wiki/Marina_and_the_Diamonds) experiences music → color synesthesia and reports colored days of the week.[[79]](#cite_note-79) Some artists frequently mentioned as synesthetes did not, in fact, have the neurological condition. [Alexander Scriabin's](/wiki/Alexander_Scriabin) 1911 [*Prometheus*](/wiki/Prometheus:_Poem_of_Fire), for example, is a deliberate contrivance whose color choices are based on the [circle of fifths](/wiki/Circle_of_fifths) and appear to have been taken from [Madame Blavatsky](/wiki/Madame_Blavatsky).[[3]](#cite_note-3)[[80]](#cite_note-80) The musical score has a separate staff marked *luce* whose "notes" are played on a [color organ](/wiki/Color_organ). Technical reviews appear in period volumes of *Scientific American.*[[3]](#cite_note-3) On the other hand, his older colleague Nikolai Rimsky-Korsakov (who was perceived as a fairly conservative composer) was, in fact, a synesthete.[[81]](#cite_note-81) French poets [Arthur Rimbaud](/wiki/Arthur_Rimbaud) and [Charles Baudelaire](/wiki/Charles_Baudelaire) wrote of synesthetic experiences, but there is no evidence they were synesthetes themselves. Baudelaire's 1857 [*Template:Lang*](/wiki/Template:Lang) introduced the notion that the senses can and should intermingle. Baudelaire participated in a hashish experiment by psychiatrist [Jacques-Joseph Moreau](/wiki/Jacques-Joseph_Moreau) and became interested in how the senses might affect each other.[[11]](#cite_note-11) Rimbaud later wrote *Voyelles* (1871), which was perhaps more important than [*Template:Lang*](/wiki/Template:Lang) in popularizing synesthesia. He later boasted *"J'inventais la couleur des voyelles!"* (I invented the colors of the vowels!).[Template:Citation needed](/wiki/Template:Citation_needed)

[Daniel Tammet](/wiki/Daniel_Tammet) wrote a book on his experiences with synesthesia called *Born on a Blue Day*.[[82]](#cite_note-82) [Joanne Harris](/wiki/Joanne_Harris), author of [*Chocolat*](/wiki/Chocolat_(novel)), is a synesthete who says she experiences colors as scents.[[83]](#cite_note-83) Her novel *Blueeyedboy* features various aspects of synesthesia.

### Literary depictions[[edit](/index.php?title=(none)&action=edit&section=21)]

[Template:Main](/wiki/Template:Main) Synesthesia is sometimes used as a plot device or way of developing a character's inner life. Author and synesthete [Pat Duffy](/wiki/Patricia_Lynne_Duffy) describes five ways in which synesthetic characters have been used in modern fiction.[[84]](#cite_note-84)[[85]](#cite_note-85)

1. Synesthesia as [Romantic](/wiki/Romanticism) ideal: in which the condition illustrates the Romantic ideal of transcending one's experience of the world. Books in this category include [*The Gift*](/wiki/The_Gift_(Nabokov_novel)) by [Vladimir Nabokov](/wiki/Vladimir_Nabokov).
2. Synesthesia as pathology: in which the trait is pathological. Books in this category include *The Whole World Over* by [Julia Glass](/wiki/Julia_Glass).
3. Synesthesia as Romantic pathology: in which synesthesia is pathological but also provides an avenue to the Romantic ideal of transcending quotidian experience. Books in this category include Holly Payne’s *The Sound of Blue.*
4. Synesthesia as psychological health and balance: *Painting Ruby Tuesday* by [Jane Yardley](/wiki/Jane_Yardley), and [*A Mango-Shaped Space*](/wiki/A_Mango-Shaped_Space) by [Wendy Mass](/wiki/Wendy_Mass).
5. Synesthesia as young adult literature and science fiction: *Ultraviolet* by [R. J. Anderson](/wiki/R._J._Anderson_(author)), and "One Is Not A Lonely Number" by Evelyn Krieger (YM Books, 2010).

Many literary depictions of synesthesia are not accurate. Some say more about an author's interpretation of synesthesia than the phenomenon itself.[Template:Citation needed](/wiki/Template:Citation_needed)

## Research[[edit](/index.php?title=(none)&action=edit&section=22)]

[thumb|Booba and Kiki shapes|Tests like this demonstrate that people do not attach sounds to visual shapes arbitrarily. Which shape would you call "Bouba" and which "Kiki"?](/wiki/File:Booba-Kiki.svg) Research on synesthesia raises questions about how the brain combines information from different sensory modalities, referred to as [crossmodal](/wiki/Crossmodal) perception or [multisensory integration](/wiki/Multisensory_integration).

An example of this is the [bouba/kiki effect](/wiki/Bouba/kiki_effect). In an experiment first designed by [Wolfgang Köhler](/wiki/Wolfgang_Köhler), people are asked to choose which of two shapes is named *bouba* and which *kiki.* 95% to 98% of people choose *kiki* for the angular shape and *bouba* for the rounded one. Individuals on the island of [Tenerife](/wiki/Tenerife) showed a similar preference between shapes called *takete* and *maluma.* Even 2.5-year-old children (too young to read) show this effect.[[86]](#cite_note-86) Recent research indicated that in the background of this effect may operate a form of [ideasthesia](/wiki/Ideasthesia).[[87]](#cite_note-87) Researchers hope that the study of synesthesia will provide better understanding of [consciousness](/wiki/Consciousness) and its [neural correlates](/wiki/Neural_correlates_of_consciousness). In particular, synesthesia might be relevant to the philosophical problem of [qualia](/wiki/Qualia),[[4]](#cite_note-4)[[88]](#cite_note-88) given that synesthetes experience extra qualia (e.g. colored sound). An important insight for qualia research may come from the findings that synesthesia has the properties of [ideasthesia](/wiki/Ideasthesia),[[13]](#cite_note-13) which then suggest a crucial role of conceptualization processes in generating qualia.[[10]](#cite_note-10)

### Technological applications[[edit](/index.php?title=(none)&action=edit&section=23)]

Synesthesia also has a number of practical applications, one of which is the use of 'intentional synesthesia' in technology.[[89]](#cite_note-89)

#### Synesthesia and virtual reality[[edit](/index.php?title=(none)&action=edit&section=24)]

One type of application is the pain-reducing virtual reality program.[[90]](#cite_note-90) In existing programs, the main purpose is to reduce pain when undergoing a specific treatment by shifting the attention from the experienced pain to the virtual program in which the patient is participating. By using artificial synesthesia and combining various senses, this can help to enhance the control of a person's attention, which can be used to improve and direct sensory distraction from the perceived pain.

For example, many treatments for burn pain and wounds may increase patients' anxiety, which increases perceived pain. Shifting attention from pain and anxiety is therefore an important part of the treatment process.[[91]](#cite_note-91) Virtual reality has proven to be very effective in managing this acute pain in several medical settings by shifting patients' attention from their experienced pain to the program in which they have been introduced. It appears to be far more effective than other distraction techniques, like playing video games.[[92]](#cite_note-92) More specifically, the convergence of many sense modalities (e.g. sound, sight, and touch) gives patients the perception of being immersed in the virtual environment, which helps them endure the pain while relying less on pharmacological therapy.

#### The Voice[[edit](/index.php?title=(none)&action=edit&section=25)]

Peter Meijer developed a [sensory substitution](/wiki/Sensory_substitution) device called The vOICe (the capital letters "O," "I," and "C" in "vOICe" are intended to evoke the expression "Oh I see"). The vOICe is a privately owned research project, running without venture capital, that was first implemented using low-cost hardware in 1991.[[93]](#cite_note-93) The vOICe is a visual-to-auditory sensory substitution device (SSD) preserving visual detail at high resolution (up to 25,344 pixels).[[94]](#cite_note-94) The device consists of a laptop, head-mounted camera or computer camera, and headphones. The vOICe converts visual stimuli of the surroundings captured by the camera into corresponding aural representations ([soundscapes](/wiki/Soundscape)) delivered to the user through headphones at a default rate of one soundscape per second. Each soundscape is a left-to-right scan, with height represented by pitch, and brightness by loudness.[[95]](#cite_note-95) Default resolution of the soundscape is 176×64. Therefore, it is roughly comparable to a retinal implant or brain implant with 10,000 electrodes.

The process of converting greyscale camera images into soundscapes works according to three simple rules. The first is 'left and right' in which left-to-right scanning results in hearing the stereo pan from left to right correspondingly. If there is a visual pattern on the left, the user hears a sound on the left, and similarly for the right. The second rule is 'up and down': every scan provides a pitch that indicates elevation. The higher the position of the visual pattern, the higher the pitch. The third and final rule is 'dark and light': loudness corresponds to brightness. The louder the sound, the brighter the visual pattern. Silence indicates no light stimuli, the loudest sounds represent white light, and everything in between is a shade of grey.

For example, a straight bright line on a dark background, running from the top left to the bottom right, would sound like a tone steadily decreasing in pitch; a dot would sound like a short beep; and two dots would sound like two short beeps. Since real-life images are much more complex, there is also much more to hear through this device. While converting the visual pattern into a sound, the device uses a predictable real-time audio and video processing algorithm, allowing users to listen to and then interpret the visual information captured by a digital video camera. The vOICe compensates for the loss of vision by converting information from the lost sensory modality into stimuli in a remaining modality.[[96]](#cite_note-96) This could lead to synthetic vision with truly visual sensations through crossmodal sensory integration through training and education. It requires a certain amount of time and effort to become proficient at differentiating objects, identifying objects, and locating them in space. Users are therefore advised to start training in a safe, familiar home environment in order to integrate the novel stimuli with other senses.

One of the remaining questions in this ongoing research concerning the vOICe is to what extent the use of a sensory substitution system can lead to visual sensations through forms of induced artificial synesthesia.

#### Eyeborg[[edit](/index.php?title=(none)&action=edit&section=26)]

The [Eyeborg](/wiki/Eyeborg) is a device developed by Adam Montandan that incorporates the auditory and visual spectra. It makes it possible for people with color-blindness to hear colors. This device was inspired by naturally occurring synesthesia.[[97]](#cite_note-97)

## See also[[edit](/index.php?title=(none)&action=edit&section=27)]

[Template:Colbegin](/wiki/Template:Colbegin)

* [Allochiria](/wiki/Allochiria)
* [Autonomous Sensory Meridian Response](/wiki/Autonomous_Sensory_Meridian_Response)
* [Fantasy prone personality](/wiki/Fantasy_prone_personality)
* [Ideophone](/wiki/Ideophone)
* [Parosmia](/wiki/Parosmia)
* [Sensory substitution](/wiki/Sensory_substitution)
* [Visual music](/wiki/Visual_music)
* [The Yellow Sound](/wiki/The_Yellow_Sound)
* [McCollough effect](/wiki/McCollough_effect)

[Template:Colend](/wiki/Template:Colend)

## References[[edit](/index.php?title=(none)&action=edit&section=28)]

[Template:Reflist](/wiki/Template:Reflist)

## Further reading[[edit](/index.php?title=(none)&action=edit&section=29)]

[Template:Refbegin](/wiki/Template:Refbegin)

* [Template:Cite journal](/wiki/Template:Cite_journal)
* [Template:Cite journal](/wiki/Template:Cite_journal)
* [Template:Cite book](/wiki/Template:Cite_book)
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[Template:Refend](/wiki/Template:Refend)

## External links[[edit](/index.php?title=(none)&action=edit&section=30)]

[Template:Commons category](/wiki/Template:Commons_category)

* [Red Mondays and Gemstone Jalapeños: The Synesthetic World](http://www.researchchannel.org/prog/displayevent.aspx?rid=29222)[Template:Dead link](/wiki/Template:Dead_link) a documentary short featuring, featuring David Eagleman and four synesthetes, from ResearchChannel.
* [Template:Cite web](/wiki/Template:Cite_web)
* Mailman, Joshua B. ["Improvising Synesthesia: Comprovisation of Generative Graphics and Music"](http://www.leoalmanac.org/wp-content/uploads/2013/07/LEAVol19No3-Mailman.pdf) in *Leonardo Electronic Almanac* v.19 no.3, *Live Visuals*, 2013, pp. 352–84.
* [Template:Cite web](/wiki/Template:Cite_web)
* [Template:Cite IEP](/wiki/Template:Cite_IEP)

[Template:Authority control](/wiki/Template:Authority_control)

[Category:Synesthesia](/wiki/Category:Synesthesia) [Category:Visual music](/wiki/Category:Visual_music) [Category:Consciousness studies](/wiki/Category:Consciousness_studies)