reduce the uncertainty of (or variance associated with) our multisensory estimates of external stimulus qualities (given that all sensory estimates are intrinsically noisy). Subsequent research has shown that the maximum-likelihood account provides a surprisingly good account of the relative contribution of each of the senses to multisensory perception in a variety of different settings and for a variety of different combinations of stimulus modalities. Nevertheless, there may still be some residual role for directed attention in explaining sensory dominance.

### Further Research

Our awareness of the objects in the world around us is determined by a constant interplay between vision, haptics, and the other senses (e.g., audition, olfaction), and as such, multisensory integration is now (rightly) considered the norm, rather than the exception, in perception research. A large body of cognitive neuroscience research currently supports the view that our tactile/haptic perception of both the structural and surface properties of objects is profoundly influenced by what we see, when touching, interacting with, and/or evaluating them. One outstanding question in this area that has yet to receive a satisfactory answer is whether there are any substantive individual differences (perhaps attributable to differences in practice or expertise) in the way in which people integrate haptic and visual information. Are there, for example, individual differences in the extent to which vision dominates over tactile/haptic perception? Only further research will tell.

*Charles Spence*

*See also* Action and Vision; Cutaneous Perception; Haptics; Reaching and Grasping; Vision

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## Multimodal Interactions: Visual–Motor

*See* Action and Vision; Perceptual-Motor Integration

## Music Cognition and Perception

*Music cognition and perception* is the scientific study of those mental and neural operations underlying music listening, music making, dancing (moving to music), and composing. It is intrinsically interdisciplinary, drawing on methods from cognitive and sensory psychology, neuroscience, musicology, computer science, music theory, and sociocultural aspects of music, with genetics and evolutionary biology becoming increasingly relevant. Music processing is a complex, higher cognitive activity engaging many areas of the brain and employing many distinct cognitive operations. As such, music has revealed itself to be a useful window into understanding functions of the mind and brain and informing large issues in cognitive psychology such as memory, attention, perceptual organization, categorization, and emotion. This entry describes the building blocks of music; musical structure, grammar, syntax, and semantics; memory for music and musical imagery; ability, disability, genetics, "talent," and musicianship; emotion and expectation; hemispheric specialization; and music preferences and individual differences.

### Building Blocks of Music

The basic elements of any sound are loudness, pitch, duration, timbre, spatial location, and reverberation. These dimensions are separable in that each can be varied without altering the others, allowing the scientific study of one at a time. Of the six, *pitch* and *loudness* are psychological constructions that map loosely (and perhaps nonlinearly) to the physical dimensions of *frequency* and *amplitude*.

When more than one tone is present, the sequence of pitches defines a musical *interval,* and intervals define *contour*—the direction of movement in a sequence of tones (up, down, or the same) without regard to the size of the intervals. Contour may be subject to preferential processing—infants attend to it more readily than they do intervals, and contour is more easily remembered by adults learning a new melody than the precise intervals.

The sequence of durations in a set of tones gives rise to *rhythm, tempo* (the pace or speed of the piece, loosely related to the temporal interval at which one would tap a foot or snap fingers), and *meter* (the way in which tones are perceived to be temporally grouped or organized, the most common in Western music being groups of two, three, or four). Our brains organize these fundamental perceptual attributes into higher level concepts—just as a painter arranges lines into shapes, contours, and forms. In music, these higher level concepts include melody and harmony. When we listen to music, we actually perceive multiple attributes or "dimensions" interacting.

Melodies are defined by the *pattern* or *relation* of successive pitches across time; most people have little trouble recognizing a melody that has been transposed in pitch. In fact, many melodies do not have a "correct" pitch, they just float freely in pitch space, starting anywhere one wants them to. "Happy Birthday" is an example of this, typically sung with naïve disregard to whether it is being sung in the same key from one occasion to another.

One way to think about a melody is that it is an abstract prototype, derived from specific instantiations of key, tempo, instrumentation, and so on. A melody is an auditory object that maintains its identity under certain transformations, just as a chair maintains its identity under certain transformations, such as moving it to the other side of the room, turning it upside down, or painting it red. (It was this property of melodies—the fact that their identity is defined in *relational* rather than *absolute* terms—that influenced the formation of the Gestalt psychology movement more than a hundred years ago by von Ehrenfels, Wertheimer, Koffka, and Köhler.) So for example, if you hear a song played louder than you're accustomed to, you can still identify it. If you hear it at a different tempo, played by a different instrument, or coming from a different location in space, it is still the same melody. Of course, extreme changes in any of these dimensions will render it unrecognizable; pitches outside the range of human hearing, a tempo of one beat per hour, or a loudness of 200 A-weighted decibels, dB(A), might stretch the limits of identification.

The ability to recognize transposed melodies (transformations of each pitch by equal intervals) may be innate—it has been observed in some animals and in human infants—although the neurological basis for this is not clear. The human auditory system contains frequency-sensitive neurons throughout every stage, from the cochlea on up through the inferior colliculus and the primary auditory cortex. The *absolute* pitches of tones are thus "known" to the brain from the earliest stages of processing. Yet, according to music theorist Eugene Narmour, music listening requires simultaneously attending to both the absolute and the relative pitch information.

At some stage of neural processing, a pattern must be extracted. Much of music appreciation is based on the pitting of absolute against relative cues. Consider the opening phrase of Beethoven's Fifth Symphony: three tones at the same pitch followed by a descending major third; then three more tones, all the same, at a new pitch followed by a descending minor third. Our appreciation for the piece is largely because we hear the second four tones as conceptually related to the first four—a kind of variation or extension of a theme. The fact that we hear the second group of four as similar, even though the interval is different (a minor third versus a major third), owes to a property of scales—the tones fall within the same interval class but with a different tonality.

A scale is simply a discrete set of tones used within a particular musical style or culture. Because the audible range of musical frequencies is continuous, there is no physical or objective reason why one tone should be considered the preferred basis of a musical system over any other. Indeed, the present Western standard, which sets the tone A to 440 hertz (Hz), is arbitrary and of recent origin. Just 100 years ago, European orchestras tuned to a different standard from this, and from one another—musicians traveling between cities found no consistency in tuning systems. Once one has fixed a standard tone, however, certain regularities manifest themselves across all known musical cultures. One is the octave, a frequency ratio of 2:1, which most listeners regard as sounding the most "consonant" or "pleasing" of intervals except for the unison. The perceptual relationship between tones bearing this relationship is reflected in our naming scheme: the tones at 110, 220, 440, and 880 Hz are all called "A" for example. All known musical systems have the octave and even many animal species show octave equivalence. All musical systems then divide the octave up into a set of discrete tones, usually 5 to 15, known as the scale of that culture—these are the tones that are "legal" within that system. Although variable pitched instruments, such as the violin, trombone, and voice, can produce pitches other than scale tones, the scale tones form the basis for composition and performance, and pitches outside the scale are used only for musical and expressive effects. The scale is so overlearned and well instantiated that composers can create excitement or novelty by violating scale conventions and modulating to other keys. By the age of five, human infants have learned the conventions of the music of their culture and can readily detect violations in tuning or scale.

Chords are created when three or more tones are sounded either simultaneously or in close temporal proximity. Although a melody exists independently of chords, different chords can color the melody, yielding different emotional qualities. Antonio Carlos Jobim's "One Note Samba" is an example of a tune in which the melody largely plays out on one tone, but the emotional and expressive nuances are created by the intervallic relationships between that tone and the underlying chords, or "harmony." The chord progression for a song is called its harmony. The same term, somewhat confusingly, is commonly used for a secondary musical part that accompanies the main melody, but at different pitches—two voices singing "in harmony" or two or more instruments playing together, as in a string quartet. The connection between this and the more formal, first definition of harmony is that by virtue of playing two tones at the same time (an intervallic relationship), the musicians create a "harmonic context," that is, a set of tonal relations that, according to the conventions of particular musical style, convey tension and release, according to a hierarchy of tonal stability present in the scale. Generally speaking, some scale tones are perceived as less stable (tension) than others (release), and the recognition of this hierarchy is learned at a young age through passive exposure to music, even by those without explicit musical training. The tension-release mechanism is thought to be a major underlying factor in engendering emotional responses to music.

## Musical Structure, Grammar, Syntax, Semantics

Each human culture develops its own traditions for the ways in which the six perceptual attributes are employed to create music. The system of rules or conventions by which sounds are strung together in a given culture can be thought of as the grammar for that music and as reflecting a musical style, syntax, and idiom. Musical phrases are composed of notes and/or chords, but as in language, these are not randomly ordered, and a reordering of elements produces a different melody.

In probe-tone studies first introduced by Carol Krumhansl, individuals listen to a fragment of a musical sequence and are asked to judge the goodness of fit of a test or "probe" tone. Even music listeners lacking formal training demonstrate sensitivity to the structural norms of Western tonal music, assigning the highest goodness ratings to the tonic of a key, even if they lack declarative knowledge about what a tonic or a key is. This demonstrates that the average listener has implicitly internalized the rules of Western tonal music, and with increasing training, the instantiation of tonal hierarchies becomes stronger.

Experiments that introduce stimuli violating the rules of musical grammar have been employed to investigate how the human brain processes musical structure. Evidence indicates that syntax, or grammar, in language and music share a common set of circuits instantiated in frontal brain regions. Frontal brain regions have been implicated in the processing of harmonic structure and, in particular, the processing of harmonic anomalies. Several neuroimaging studies colocate musical and linguistic operations. When musical structure is disrupted, areas of the brain implicated in disruptions of linguistic syntax, Brodmann Area (BA) 47, Broca's area, and the adjoining anterior insula, are activated. The auditory cortex and the hippocampus and limbic system are activated during normal processing of both music and language. Yet music and language also employ distinct neural circuits, as evidenced by double dissociations; in general, these occur when damage to a brain region X is associated with impairment in function Y (but no impairment in function Z), while damage to a complementary region W causes the complementary pattern of performance (impairment in function Z but not Y). Following organic brain trauma, exclusive loss of musical function has been observed with little or no loss of linguistic function and vice versa.

An ongoing debate concerns the evolutionary origins of music and language, which came first, and the extent to which they coevolved. Evidence brought to bear on these questions comes from archaeological findings (for example, bone flutes at ancient human burial sites), anthropology (in particular, the study of contemporary preliterate and preindustrial societies), biology (especially the study of communication among closely related species, such as chimpanzees), and neuroscience (differential activation of brain circuits by music and language, with music tending to activate phylogenetically older structures). Some believe that music preceded language, some the reverse, but such conclusions are necessarily speculative, inductive, and not deductive. Philosopher Daniel Dennett argues that regardless of which came first, music or language, the brain no doubt had a period of coevolution over tens of thousands of years. The current neurobiological state of the human brain, proposes neuroscientist Ani Patel, is such that the syntactic processing of music and language rely on shared neural substrates, through his shared syntactic integration resource hypothesis (SSIRH).

## Memory for Music and Musical Imagery

Many people report being able to hear music in their imaginations, or to play back musical selections in their mind, abilities that are a form of "auditory imagery." Experiments have shown that the average person can manipulate musical components independently through imagery, such as speeding up the tempo of a song without altering pitch or transposing the pitch without altering tempo. Timbral alterations are also relatively easy to imagine—one can imagine a well-known song played with different instrumentation, for example. For reasons that are not well understood, however, manipulating the imagined loudness of a piece of music seems to be difficult or nearly impossible for most people. When musical imagery occurs spontaneously, and without explicit intent, during the state between wakefulness and sleep, or between sleep and wakefulness, it is termed *hypnagogic* or *hypnopompic* imagery, respectively; such imagery is frequently reported to be especially vivid, detailed, and nuanced. Another manifestation of musical imagery is when music persists in the mind, known as *ear worms,* from the German word *Ohrwurm*. This phenomenon is more commonly reported in musicians as well as individuals with obsessive-compulsive disorder, and typically occurs for fragments of songs within the capacity of auditory short-term (echoic) memory, which lasts about 15 to 30 seconds.

When asked to produce songs from memory by singing, humming, or whistling, a significant proportion people produce the song at or very near the correct pitch and tempo. When there is no correct pitch or tempo (such as with folk songs or "Happy Birthday"), people tend to produce the song at a consistent pitch and tempo across multiple occasions. Even nonmusicians possess this ability, and their memory representations tend to include fine-grained features of the original performance, such as vocal nuances and performance-specific expressive details.

Imagining music has been shown to activate neural regions that are surprisingly similar to those activated when actually *listening* to music. This finding provides important support for the current theory that the process of remembering a perceptual event requires reactivation of those neural circuits that were involved in the original perception of that event.

Music can serve as an important marker for events over the course of a lifetime, and people who listen to music often tend to describe having a "soundtrack of their life." The neurocognitive basis for autobiographical music memory has only recently been studied, and activity in the rostromedial prefrontal cortex is correlated with increased memory salience for music. This same region is activated when an individual tracks a musical event through tonal space (the scale structures that represent the identity of music). Tonal space can be seen as being a precise recognition marker for a piece of music, a process necessarily involved in musical memory.

Timbre imagery has been found to induce activation in secondary auditory areas. The fact that imagery engages regions normally associated with sensory activity suggests that imagery involves mimicking the activity itself; that is, thinking about hearing involves a form of hearing itself. One of the most valued aspects of the human mind is its capacity for imagination. Musical imagery is the act of representing music in the mind without external input. Curiously, brain areas responsible for musical performance become activated when solely imagining that performance. For example, a cellist imagining he or she is playing will in fact be engaging the motor areas of the brain recruited to move the fingers as in a real performance.

## Ability, Disability, Genetics, "Talent," and Musicianship

Music ability is popularly regarded to be innate—one is either born with musical "talent" or not. Part of the difficulty in distinguishing "nature" from "nurture" with music is that the child raised in a musical household—regardless of his genotype—is almost certainly apt to receive more musical input, feedback, and encouragement than the child raised in a nonmusical household. In one study of conservatory students, the amount of practice over the four years of their instruction was a far greater predictor of final year ability than were the ratings of potential given to them on intake. If by "talent" one means a set of unobservable, hard-wired propensities that are more predictive than factors such as hard work and time-on-task, there exists no credible evidence for it. Self-reports of world-class musicians, as well as experimental studies, point strongly to the view that musicians are made not born and that practice accounts for an overwhelmingly large proportion of the variance in who becomes an expert musician and who doesn't. Those factors that cause some musicians to practice more than others may well have a genetic component, attributes such as single-mindedness, seriousness, and conscientiousness.

There may also exist genetic components contributing to attention span, auditory memory, and auditory sensitivity, qualities that would be important for success in music, but not exclusively so. It is unlikely that there exist a "music gene" or alleles that determine musicality, but there may well be genetic contributions to many of the component skills that are necessary to become a great musician, such as those cognitive factors previously listed, as well as physical factors, such as reflexes, finger speed, or motor dexterity.

Confounding efforts to study musical ability is the fact that it can manifest itself in many forms. One can be exquisitely sensitive to music without even being a musician—many listeners display intense emotional reactions to music without the ability to play it, and disc jockeys, film music supervisors, and record company talent scouts lacking formal musical training are not necessarily at a disadvantage. One can be an expert in one domain of music and lack ability in another. There are composers who lack instrumental ability (e.g., Irving Berlin, who could barely play his own compositions on the piano), instrumentalists and conductors who do not compose (Artur Rubinstein, Herbert von Karajan), and great musicians may read music or not, and improvise or not.

A small percentage of the population appears to lack musical ability or sensitivity. When present from birth, this has been labeled *congenital amusia;* when it is the result of organic brain disease or trauma, it is called *acquired amusia.* In the popular press, these terms are used interchangeably with the terms *tone deafness* and *tin-ear syndrome.* However, the amusias no doubt comprise a heterogeneous set of disabilities with distinct etiologies. There are individuals who cannot identify songs and others who have identification defects but can't sing in tune, producing abnormal variability in the tones they generate. Specific deficits in rhythm, pitch, and timbre have also been observed, both following brain injury and congenitally. Dissociations between musical alexia (inability to read) and agraphia (inability to write) have also been reported.

The study of distinct, well-defined, and atypical populations is important because it offers a unique opportunity to investigate specific aspects of cognition and to establish the degree to which various cognitive abilities are correlated with, or can be decoupled from, one another. In particular, the study of populations with genotypic abnormalities (including Williams syndrome, autism spectrum disorders, and Down syndrome) have sparked new debates regarding the modularity of brain function, independence of mental faculties, and theories of neural organization. Members of all three groups tend to be unusually attracted to music, but what they are hearing and perceiving remains open to debate. Individuals with Williams syndrome, characterized by low IQ and deficits in spatial ability, reasoning, and numeracy, show relatively intact language and musical abilities, yet are often just as attracted to odd sounds (such as motors, fans, and water running) as they are to symphonies and pop songs. Individuals with autism spectrum disorders, in spite of an attraction to music and a sometimes eidetic memory for sound ("phonographic memory") appear to be insensitive to many of the nuances in musical emotion.

Another rare but unique aspect of pitch processing is some people's capacity for absolute pitch. Possessors of absolute pitch can name a note when it is heard in isolation, provided they have knowledge of the labels assigned to musical notes (A-G, or do-re-mi); there are also ways of identifying absolute pitch experimentally in the absence of labels. Absolute pitch possessors do not require the anchor of another note for pitch identification by means of calculating musical intervals (relative pitch). Some musicians have acquired a strong representation for an isolated musical tone (usually the tone to which they are accustomed to tuning their instrument). They use this memorized tone to calculate other notes using relative pitch, and this phenomenon is called quasi-absolute pitch.

The benefits of musicianship have long been hailed for their potential effects on cognition. Childhood music lessons have a small but long-lasting positive correlation with IQ and with academic performance. Recent studies have provided the first concrete evidence that playing a musical instrument significantly enhances the brain stem's sensitivity to speech sounds. Preliminary work on rhythmic training suggests that it may help to ameliorate dyslexia. Correlational studies further suggest that a mastery of instrumental music may lead to a positive self-concept, but carryover effects to other domains have not yet been demonstrated. Brain imaging studies suggest that early training has its greatest effect on neural systems involved in sensorimotor integration and timing.

## Emotion and Expectation

Music represents a dynamic form of emotion, and the conveying of emotion is considered to be the essence, if not the purpose, of music, and the reason that most people report spending large amounts of time listening to music. Recently, much study has been focused on the biological underpinnings of musical emotion, particularly the involvement of neural reward systems. This phenomenon has been studied through investigating the chill response, a physical sensation up the spine that can occur as a result of conscious music listening. It varies from individual to individual, and is based on a number of factors, such as structural components and loudness of the music, as well as character/personality organization and musical experience. When people listen to music that they report consistently gives them chills, blood flow increases to those centers of that brain that are implicated in reward, emotion, and arousal: the amygdala, nucleus accumbens, and ventral tegmental area. These regions modulate levels of dopamine. In addition, activation is observed in the hypothalamus, insula, and cerebellar vermis.

The experience of pleasant, or consonant, music also activates orbitofrontal, subcallosal cingulate, and frontal polar cortical areas. The hippocampus has been found in positron emission tomography studies to activate during pleasant music, and the parahippocampal gyrus, also implicated in emotion processing, has been found to activate during unpleasant, or dissonant, music.

Much of our emotional reactions to music are believed to be caused by the meeting and violating of musical expectations. Listeners track the progression of music over time, noting the pitches and rhythms employed, and form subconscious predictions about what will occur next. A musical piece that we find pleasing strikes the balance between meeting those predictions some of the time and violating them in interesting ways the rest of the time. These predictions may involve statistical maps of which notes are most likely to follow certain melodic and harmonic progressions, and the tracking of such tonal movement is now thought to involve regions in BA47, BA44, and the rostral portion of the ventromedial superior frontal gyrus and the right orbitofrontal gyrus.

There exists a widespread belief in Western culture that major keys are associated with positive affect, or happiness, while minor keys are related to negative affect, or sadness. In fact, this occurrence turns out to be largely a product of musical exposure and learning and is thus culturally dependent. It has been shown that other musical systems (e.g., Middle Eastern, Indian) do not share these associations.

## Hemispheric Specialization

Early reports stated that music is predominantly a right-hemisphere activity and language a left-hemisphere activity (in neurologically intact right-handed listeners). This is now considered to be an oversimplification, in part because of the distributed nature of specialized processing mechanisms acting on the individual musical attributes previously listed. It is now known that music listening, performing, and composing engage regions throughout the brain, bilaterally, and in the cortex, neocortex, paleo- and neocerebellum. Laterality effects do exist, however. For example, magnetoencephalography (MEG) responses to deviations in the memorized lyrics of tunes are stronger in the left hemisphere, whereas the perception of violations of expected notes are governed by the right hemisphere. The act of learning music causes a left hemisphere shift as naming processes become involved.

Pitch and rhythm have been found to be neurally separable. The processing of melodic, but not rhythmic information of music is neurally isolated in the auditory association cortex of the superior temporal gyrus, as documented by lesioned patients. Based on evidence from brain-damaged patients, Isabelle Peretz and Max Coltheart suggest a theoretical model of functional architecture whereby music processing modules, grouped into pitch organization and temporal organization, represent an interactive and separable system of music processing. Timbre appears to invoke distinct neural circuitry as well, bilaterally in the temporal lobes. Recent evidence suggests that timbre maps, similar to tonotopic pitch maps, may exist in the cortex.

## Music Preferences and Individual Differences

Measures of personality and individual differences have been shown to correlate with taste in music; the correlations are relatively small, but both significant and robust. Using the Big Five personality inventory and a cross-section of songs representing the major genres and subgenres of Western tonal music, certain consistencies have emerged. Although such research is still in its early stages, extraverted individuals tend to like music that is characterized as energetic and rhythmic. Individuals who rate high on factor 5, openness to new experience, show no correlation with such music, but rather with music that is described as reflective and complex. Upbeat and conventional music correlates with factor 2, agreeableness.

Several hypotheses exist as to why musical taste might be related to personality. In some cases, people may prefer and seek out styles of music that reflect and reinforce aspects of their personalities. Research suggests that personality influences how individuals think, feel, and behave. For example, that people with high levels of extraversion seek out situations that allow them to be talkative and sociable. In contrast, more introverted people tend to seek out environments where they have limited contact with other people, especially people they don't know. Just as people seek out and create social environments that reinforce aspects of their personalities, so too might people seek out auditory or musical environments that reinforce aspects of their personalities. Those who are normally extraverted, for example, may help to maintain their self-identity and energy level by listening to energetic music. Because music is a part of social identity in contemporary society, people may also seek out music that they believe will create a desirable impression of them. Adolescents, in particular, use music as a badge to communicate their status and affiliation with a particular peer group. Finally, many individuals report using music for mood induction. This further underscores the role of music in emotional regulation, and its role in maintaining fundamental aspects of well-being.

The study of music perception and cognition has informed fundamental issues in cognitive psychology and cognitive neuroscience, providing a window into higher cognitive function. As a universal human activity, music's evolutionary roots are no doubt very old, and the development of the brain, mind, and culture would have occurred alongside changes in the way we create, perform, listen to, and use music in everyday life. Although far more experimental psychologists study visual processes than auditory processes, the nature of mental representations for music—their vividness, relatively early formation in infants, and durability—allows for the scientific study of cognition from an alternative perspective, using ecologically valid stimuli that are meaningful to many human experimental participants.

*Daniel J. Levitin and Anna K. Tirovolas*

***See also*** Auditory Scene Analysis; Emotional Influences on Perception; Melody Perception; Sound Reproduction and Perception; Timbre Perception

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## MUSIC IN FILM

*Music and film* are both based on communication of meanings through time. The emotional, mood, and perceptual effects of music in film can reinforce visual and textual components or act independently of the dramatic elements as a counterpoint to dramatic visual/textual elements, and thus create satire or irony. The study of these effects involves measuring subject response to combinations of music and film and determining goodness of fit, changes in affect or emotional response, and changes in attention or memory. Measurement has often been achieved by rating scales, based on variations of the semantic differential, an approach using bipolar opposite words in three factors, such as good-bad (evaluative), active-passive (activity), and strong-weak (potency), thus operationalizing dependent variables, such as affect, meaning, and emotion. Independent variables have included the use of visual elements alone, musical elements alone, and their combination for comparative analysis. This entry considers research on the interaction between music and visual elements of film.

Sandra Marshall and Annabel Cohen conducted an early series of experiments on how music affects subject characterization of animation figures relative to musical combinations. Animations of a small triangle, large triangle, and small circle were combined with strong and weak composed music prototypes. The weak music, in C major with high tessitura (pitch/frequency range), was contrasted with strong music, in Aeolian minor in low tessitura. Subject ratings on evaluative, potency, and activity scales were collected for the animation alone, the music alone, and combinations thereof. Results indicated that the large triangle had the highest activity and potency ratings and the lowest (most unpleasant) evaluative ratings. They found that ratings of the animation alone were altered by combination with the music, particularly as the small triangle increased in activity with strong music. Based on these results, Marshall and Cohen proposed the congruence-associationist model (CAM). Congruence is the consonant (appropriate) connection of ratings of the visual and musical elements. The proposed model of association (e.g., big triangle = strong, fast and minor music = strong) and time congruence, loosely connected to tempo and accent, led to a greatly expanded model by Cohen that includes text, speech, visual surface, music surface, and sound special effects, elements in relation to short-term and long-term memory. Most of these elements remain unexplored in experimental research as of this writing.

Scott Lipscomb and Roger Kendall conducted an experiment focused on whether the composer's intent in combining music and film was communicated to the perceiver. Five excerpts from the film *Star Trek IV* (music by Leonard Rosenman) were presented in their original combination of music and visuals and in all crossed combinations. Subjects were asked to rate the degree of fit in