9. Frisson – Thrills from Chills

The experience of musically induced "shivers" is often reported as a notable or peak emotional response while listening to music (see, for example, Sloboda, 1991; Gabrielsson & Lindström, 1993, 2003). The response might be described as a pleasant tingling feeling, associated with the flexing of hair follicles resulting in goosebumps (technically called piloerection), accompanied by a cold sensation, and sometimes producing a shudder or shiver. Dimpled skin is evident, especially in the region of the back of the neck and upper spine, often including the shoulders, scalp and cheeks, and sometimes extending to the entire back, belly, groin, arms, chest, or legs (Panksepp, 1995). This experience may last from less than a second to 10 seconds or longer. Longer responses usually involve one or more "waves" of spreading gooseflesh. The experience is phenomenologically pleasurable and accessible to conscious awareness. Grewe et al. (2007, 308) note that the occurrence of such "shivers" is significantly correlated with judgments of the pleasantness of music works. Some reports mention that the response may be accompanied by smiling, laughing, weeping, lump-in-throat, sighing, breath-holding, or heart palpitation. For the purposes of this chapter, we will focus exclusively on the prototypical response involving topical (skin-related) sensations.

Researchers have proposed a number of different labels for this response, including *thrills* (e.g., Goldstein, 1980, Konenči et al., 2007), *chills* (e.g., Grewe et al., 2007, Guhn et al., 2007), and *frisson* (Sloboda, 1991; Huron, 2006). Gunther Bernatzky of the University of Salzburg has suggested the term *skin orgasm* – a term also recommend by Panksepp (1995). However, this latter term has gained few adherents. In the interests of precision, we will follow Sloboda's suggestion and employ the French loan word, *frisson*. Listeners can find music “thrilling” without necessarily experiencing gooseflesh. The term “chills” is best reserved for the phenomenological feeling of coldness, which, like piloerection, may be considered characteristic symptoms of the frisson response.

Apart from music, gooseflesh (piloerection) can be evoked in many other situations. Gooseflesh can occur when experiencing fear (such as hearing an unknown sound while walking alone in a dark alley), when viewing disgusting photographs, during orgasm, or in response to fingernails scratching a blackboard (Halpern, et al., 1986). Of course gooseflesh is a common response when we are cold, but paradoxically, it can also arise when immersing ourselves in a hot bath. Gooseflesh can also be evoked by physical contact with another person, when experiencing a sudden insight (such as an unexpected solution to a problem), while observing an inspiring moment in a competitive sport, or when experiencing great natural beauty, such as viewing a large canyon (Goldstein, 1980).

Notice that the experience of gooseflesh can be either pleasant or unpleasant. The term “frisson” however, applies only to the pleasure-inducing form. Simply put, “frisson” might be defined as “pleasurable piloerection” or “enjoyable gooseflesh.”

10. Individual Differences

Not everyone experiences music-induced frisson. Avram Goldstein (1980) carried out a survey of 45 employees of a research center unconnected to music. Achieving a 100% return rate, 21 (47%) reported never having experienced a music-induced “thrill.” Similarly, Grewe et al. (2007) found that only 21 of 38 participants (55%) reported music-induced “chills.” After careful pretesting of stimulus materials, Konenči et al. (2007) were able to reliably induce “thrills” in only 35% of an undergraduate student sample. By contrast, 90% of the music students included in Goldstein's study reported having experienced music-induced “thrills.” It appears that only about half of the general population may be familiar with the experience. It may be that the capacity to experience music-induced frisson encourages certain people to pursue a career in music.

Panksepp (1995) and others have observed that music-induced frisson is more likely to be reported by female listeners compared with male listeners. In addition to gender differences, personality differences have been observed by Grewe, Nagel, Kopiez, and Altenmüller (2007). As measured using the Sensation Seeking Scale (Litle & Zuckerman, 1986), "chill responders" are less adventurous or thrill-seeking. That is, reactive listeners are less likely to enjoy physical risk-taking, such as skydiving or riding rollercoasters. One might say these listeners are "more sensitive" or "thin-skinned." Grewe and his colleagues also found that the more reactive listeners have greater familiarity with classical music, identify more with the music they prefer, and are more likely to listen to music in concentrated (rather than background) situations. In short, susceptibility to music-induced frisson is correlated with musical interest.

Listeners who experience music-induced frisson are typically able to point to particular moments in a work when the frisson is evoked (Sloboda, 1991). This specificity has naturally attracted researchers to search for musical features that might be responsible for the frisson. These efforts have been confounded, however, by poor inter-listener consistency (e.g. Blood & Zatorre, 2001). Early on, investigators discovered that musical works that evoke frisson for the experimenter often fail to evoke frisson in other listeners. Asking participants to bring their own frisson-inducing music reinforced this discovery: when participant-selected music is employed as stimuli, listener's inevitably experience more frisson in response to their own music than to music brought by other participants. Moreover, when different listeners experienced frisson in the same work, the points of frisson can differ.

This effect led some researchers to conclude that familiarity may be a key to music-induced frisson. However, this observation is confounded by the reliance on participant-selected music; if asked to bring a piece of music that causes you to "shiver," participants are likely to choose pieces that they particularly love, and well-loved pieces are apt to be highly familiar. Consider a gustatory parallel. If asked to bring a dish of your most favorite food to a potluck dinner, what is the likelihood that you will find a dish brought by someone else that you like even better than your own favorite dish? If people attending a potluck dinner tended to prefer their own culinary offering to those of others, one would not be justified in claiming that familiarity is the most important aspect of taste. Guhn, Hamm and Zentner (2007) addressed this possible confound by measuring the familiarity of different works *not* selected by the participants. They found a correlation of zero between the frequency of frisson responses and familiarity. This suggests that listeners become familiar with works that *a priori* cause them to experience frisson, not that frisson arises due to increasing familiarity.

11. Causes of Frisson

In light of the high proportion of nonresponders and given the high individual variability between responders, the best efforts to identify potential causes of frisson have involved careful pre-selection of experimental participants. When selected according to high self-reports for musical sensitivity, Guhn, Hamm and Zentner (2007) were able to show a high degree of inter-subjective consistency in the location of frisson responses as determined by self-report and skin conductance measures. In addition, Guhn and his colleagues found that heart rate responses are also highly correlated between such subjects. Even when a participant doesn't exhibit a frisson response, heart rates are still highest at moments when frisson responses are evoked for other participants. This suggests that sympathetic arousal may be a necessary, though not sufficient, component of frisson.

Among researchers, there is considerable agreement about acoustical and musical correlates of frisson (Blood & Zatorre, 2001; Craig, 2005; Guhn, et al. 2007; Grewe, et al. 2007; Sloboda, 1991; Panksepp, 1995, 1998; Rickard, 2004). The most important acoustic correlate is a rapid large change of loudness, especially a large increase in loudness (*subito forte*). A less robust acoustic correlate appears to be the broadening of the frequency range (i.e., the addition of low bass and/or high treble). Musical correlates include the entry of one or more instruments or voices, the return of a melody, theme, or motive, an abrupt change of tempo or rhythm, a new or unprepared harmony, abrupt modulation, or a sudden change of texture. Music deemed “sad” (slow tempo, quiet dynamic, minor key) is roughly twice as likely to evoke frisson compared with “happy” music (Panksepp, 1995).

Notice that two common elements can be found in this list of features. First, adjectives such as abrupt, rapid, sudden, new, and unprepared suggest that the precipitating musical events may be surprising or unexpected. A second common theme is high energy, such as increased loudness or the addition of sound sources. Notice also that slow, quiet passages (such as commonly found in sad music) provide an especially contrasting background against which unexpectedly energetic events may be highlighted.

12. Examples

These frisson-inducing properties are evident in the two musical examples shown in Figures 4 and 5. Figure 4 shows a passage reported by Panksepp (1995) that displayed a high probability of evoking frisson responses in his undergraduate listeners. The frisson-evoking tendency of this passage has been replicated in Huron's lab, and has also been attested by theorist

Zohar Eitan. The passage is from Pink Floyd's *The Final Cut* and occurs roughly 2'50" into the recording; only the vocal melody is transcribed. The most obvious feature of this passage is the dramatic increase in loudness. The transcribed dynamic markings (*pp* and *ff*) are arbitrary; after listening to the recording, many listeners might wish to argue that the true dynamic markings are closer to *ppp* and *fff*. The initial phrase is sung in nearly a whispered voice, whereas the subsequent phrase is sung in a shouting voice. Even if you are not a Pink Floyd fan, the effect is striking.

PLACE FIGURE 4 NEAR THIS POSITION

Figure Caption: Vocal melody from Pink Floyd's *The Final Cut*. One of the frisson-inducing passages reported in Panksepp (1995).

Figure 5 shows a more complicated frisson-inducing passage identified by one of the respondents to Sloboda's (1991) survey. The passage, from Arnold Schoenberg's *Verklärte Nacht* ("Transfigured Night"), exhibits the same *subito forte* dynamic contrast evident in *The Final Cut.* In addition, the passage exhibits harmonic and rhythmic surprises coinciding with the onset of the D-major chord at the beginning of measure 229. In the key of G minor, the D-major chord is the dominant: a progression from E-flat major (*VI*) to *V* would be a relatively common progression. However, in approaching this passage, there is no hint of G minor, and the E-flat chord is minor rather than major. Consequently, for Western-enculturated listeners, the D-major chord would be harmonically unexpected. The advent of this chord also involves an element of temporal surprise. Prior to measure 229, the chord onsets have been systematically avoiding the downbeat. In approaching measure 229, the sense of meter has been significantly eroded for listeners so although the D-major chord occurs on the downbeat, this moment is no longer expected for most listeners. In short, the frisson-inducing moment coincides with a combination of temporal surprise, harmonic surprise and abrupt increase in loudness. For at least one listener, we know that this passage evokes marked shivers running up and down the spine.

PLACE FIGURE 5 NEAR THIS POSITION

Figure caption: Piano reduction of bars 225-230 from Arnold Schoenberg's *Verklärte Nacht* – a passage identified by one of John Sloboda's respondents as reliably evoking a frisson ("chills") response.

The passages shown in Figures 4 and 5 are comparatively simple, and so they should not necessarily be regarded as representative of frisson-inducing passages in general. Nevertheless, Figure 4 suggests that an abrupt increase in dynamic level may be sufficient to generate musical frisson, whereas Figure 5 suggests that unexpected dynamic, metric, and harmonic violations in combination may contribute to the evoking of frisson.

13. Physiological Correlates

Apart from behavioral studies, the frisson response has also attracted physiological studies, including observations of skin conductance, heart rate, neurochemical changes, and hemodynamic changes. As we will see, physiological studies have important repercussions for theories attempting to account for the source of frisson responses.

Gooseflesh or piloerection is positively correlated with heart rate, although peak heart rate is not a good predictor of frisson responses (Guhn, et al., 2007). Frisson is more strongly correlated with increases in skin conductance response (Craig, 2005; Guhn, et al., 2007; Rickard, 2004) and some researchers have used SCR as an independent check on participant-reported frisson.

Neurochemical changes associated with frisson were investigated by Goldstein (1980). Goldstein administered naloxone, an opiate receptor antagonist, to healthy volunteers. Naloxone is highly effective in blocking the activation of μ-opioid receptors in the brain, with only slightly less antagonistic action for κ- and δ-opioid receptors. As a result, naloxone is able to block or significantly attenuate the positive feelings that normally accompany the release of endogeneous opioids such as endorphins. Goldstein used a double-blind protocol in which members of a control group were injected with an inert saline solution. Of the 10 volunteers who received naloxone, three reported a significant reduction in music-induced “thrills” to participant-selected music.

Goldstein's study implies two conclusions. First, the results are consistent with the view that music-induced frisson can lead to the release of endogenous opiates (such as endorphins), commonly associated with the experience of pleasure. At the same time, the results seem equivocal: only three of ten volunteers showed any effect. If we assume that only about half of the population experience music-induced frisson, the mixed results might be attributable to the considerable individual variation in frisson responsiveness observed by Goldstein and others.

Neurohemodynamic changes associated with frisson have been investigated by Anne Blood and Robert Zatorre (2001). Blood and Zatorre carried out PET scans of volunteers listening to participant-selected music. They found that frisson responses coincided with increased blood flow in the nucleus accumbens, the left ventral tegmental area, the dorsomedial midbrain, the insula, thalamus, anterior cingulate, the supplementary motor area and bilateral cerebellum. Decreased blood flow was observed in the amygdala, left hippocampus, and the posterior cortex. This hemodynamic pattern has been found by other researchers to be characteristic of euphoric or pleasurable experiences (Breiter et al., 1997). In addition, increased activity in the thalamus and anterior cingulate are associated with increased attention.

14. Theories of Music-Induced Frisson

Two theories have been proposed that attempt to account for the origin of music-induced frisson: Jaak Panksepp's *Separation Distress* theory, and David Huron's *Contrastive Valence* theory. Both theories rely on evolutionary arguments linking affective experience to physiological changes.

14.1 Panksepp's Separation Distress Theory

Jaak Panksepp (1995, 1998) has proposed a theory of music-induced frisson whose foundation is the reactiveness of caregivers to the distress calls of offspring. Few experiences are more traumatic than the separation of mother and child, doe and fawn, ewe and lamb, or hen and chick. When visual contact fails, offspring typically rely on distress calls as a way of signaling their location. In order for the distress call to be effective, caregivers must be responsive. Given the biological importance of nurturing and protecting offspring, one would expect distress calls to have a powerful motivating (that is, emotional) effect on caregivers.

While providing food and protection are the foremost tasks of any parent, the most common behavior simply involves reassuring offspring of the parent's presence. For most animals, physical contact (so-called “comfort touch”) provides such reassurance. The contact between caregiver and offspring typically results in a mutual increase in skin temperature. In human language, social comfort is often described using thermal metaphors, such as “warm personality” or “cold shoulder.” When a caregiver perceives a distress call, Panksepp suggests that feelings of coldness or chill may provide increased motivation for social reunion. Panksepp and Bernatzky (2002) have suggested that frisson-inducing musical passages exhibit acoustic properties similar to the separation calls of young animals.

Following up on Panksepp's suggestion, Beeman (2005) has assembled various analyses related to the acoustics of human infant cries. As a starting point, it is worth noting that human hearing is not equally sensitive at all frequencies. Although the nominal range of hearing is commonly reported as spanning the range 20-20,000 Hz, the operative range is smaller. Moreover, due to resonances in the pinna and ear canal, the threshold of hearing is much more sensitive in the region between about 1,000 and 6,000 Hz. Within this region, sensitivity is most acute in a narrow region between 3,000 and 4,000 Hz. We can detect a 3,500 Hz tone that has less than half the energy of a just-detectable 1,000 Hz tone (Fletcher & Munson, 1933).

Beeman (2005) noted that human infant cries show an energy peak in the region between 3,000 and 4,000 Hz. When babies cry, they produce considerable energy in the region where human hearing is most sensitive. Other research has established that the sound of a crying baby is highly distressing for adult listeners (Drummond et al., 1999; Lester, 1978; Lester & Boukydis 1992). Apart from the presumed cognitive motivations, there are straightforward sensory reasons why a crying baby attracts our attention. Moreover, when the crying doesn't stop, there are good reasons why adults might find the sound so relentlessly disturbing.

Infant cries aren't the only sounds that show a high energy peak in the ear's most sensitive region. The adult human scream also displays a disproportionate amount of energy in the broad region between 1,000 and 6,000 Hz where human hearing is best. This is true of screams produced by both males and females. When men scream, they break into falsetto voice, generating a fundamental frequency that is considerably higher in frequency than the normal male modal voice. A human scream is the sound humans can hear at the greatest distance.

Beeman (2005) has also noted that this auditory sensitivity is exploited by professional singers. Sundberg (1972, 1987) discovered that operatic singers are able to concentrate considerable acoustic energy in the so-called “singer's formant.” In one study, for example, Sundberg measured the spectral resonances in recordings by the famous tenor, Jussi Björling. Sundberg found that Björling's voice produced an especially strong resonance in the region around 3,000 Hz (Sundberg, 1972, 1977). Studies by other researchers have confirmed the existence of the singer's formant. For example, Johnstone and Scherer (1995) measured the spectral resonances in recordings of the Slovakian soprano, Edita Gruberová, and found high energy peaks in the region between 2,900 and 4,100 Hz.

The singer's formant is variously described by vocal teachers as “acoustic ping” or *squillo*. As pointed out by Beeman, production of the singer's formant is one of the principal aims of professional operatic training.

Of course many listeners report that they dislike the sound of the Western operatic voice. Opera-haters often say that the singers sound “hysterical” or over-wrought. Professional writers tend to be reserved when criticizing opera, but amateurs writing on the web are more frank. In the words of one web writer: “I don't like opera because people scream all the time” (www.pencollectors.com/projects.htm, 2007/12/16). For these listeners, it is possible that the acoustic similarities between operatic *squillo* and screaming is just too close.

Panksepp notes that not everyone is equally responsive to distress calls. A crying baby may evoke strong nurturing instincts in its parents, but strangers are more likely to find the sound annoying. The strongest nurturing emotions are evoked when an adult has *bonded* with its offspring. A key factor in bonding is familiarity, and Panksepp suggests that familiarity with a given musical work has an effect similar to parental bonding. As a result, music-induced frisson is more likely to arises with familiar music (1995, 202).

By way of summary, Panksepp's theory suggests that the emotional power of the frisson response lies in the receptiveness and sensitivity of the auditory system to infant distress calls. Since the principal caregivers in most species are mothers, females would be expected to be more attentive to separation distress calls, and so would be expected to be more reactive to music-induced frisson.

14.2 Huron’s Contrastive Valence Theory

While Panksepp's separation distress theory appears to provide a good account of music-induced frisson, difficulties arise in trying to extend the theory to other forms of frisson. Recall that piloerection can arise in many circumstances. For example, apart from music, pleasant piloerection can arise when immersing ourselves in a hot bath, when a potential lover first touches our hand, when observing an inspiring moment in a competitive sport, when experiencing a sudden insight (such as an unexpected solution to a problem), when riding a rollercoaster, or when experiencing great natural beauty. Unpleasant piloerection can arise when experiencing fear or when we are cold. When exposed to disgusting photographs, the resulting piloerection may be described by viewers as “making my skin crawl.” What does music-induced frisson share in common with other forms of pleasurable piloerection, and what differentiates the positive from negative gooseflesh feelings?

Huron's (2006) theory attempts to place music-induced frisson in a larger context of pleasant and unpleasant piloerection. Gooseflesh undoubtedly originates as a thermoregulatory response: raised hair provides a good insulator – although the effectiveness is much less in relatively hairless humans. But piloerection is also used in aggression displays and as a response, when afraid, to discourage attack by others. When threatened, for example, a cat with arch its back and make its hair stand on end. Throughout the animal kingdom, a common response to fear is to attempt to appear larger.

Whether part of an aggression display or defensive display, fear-induced piloerection appears to be an *exaptation* – a pre-existing physiological response that is “borrowed” for other purposes. Although principally intended to regulate temperature, gooseflesh can also be evoked by fear, panic, or aggression. But what distinguishes the pleasant and unpleasant forms of piloerection? Why does an abrupt loud sound in *The Final Cut* provoke an enjoyable moment of frisson, while an unexpected loud sound in a dark alley merely provokes a hair-raising moment of terror?

In the ITPRA theory, a distinction is made between the *reaction* and *appraisal* post-outcome responses. These responses differ both anatomically and functionally. The fast reactive response is restricted to the brain stem, whereas the slow appraisal response also involves the neocortex (LeDoux, 1996). Because brain-stem pathways involve fewer synaptic connections they respond much faster than pathways traversing through the cortex. This neuroanatomical difference is reflected functionally in the two responses. Reaction responses (such as the startle reflex) are defensive in function; these fast-onset responses tend to assume a worst-case scenario and so most of these responses prove to be over-reactions. The appraisal response represents a more leisurely (and accurate) assessment of situations.

In the ITPRA theory, reaction responses respond to any cues suggestive of danger or alarm. Appropriate acoustic cues include loud sounds (suggestive of high energy events in the environment), and sounds that resemble human alarm signals (such as adult screams or infant crys). As noted earlier, another potent fear-inducing situation arises from surprise. Surprise always indicates a biological failure. Although it is possible to be “pleasantly surprised” (see below), the failure to anticipate an outcome means that the individual is not well prepared for the future.

A classic illustration of the effect can be observed in a surprise party. When a person is unexpected surprised by her friends, the first response is one of terror: the eye-lids are retracted producing a wide-eyed appearance, and the jaw drops resulting in a classic “terror” expression. But within half a second, this moment of fear is transformed into happy celebration as the individual recognizes her friends and the positive social meaning of the event. A quick defensive reaction response is followed by a slower (inhibitory) cognitive appraisal.

The overall feeling state evoked by events appear to be strongly influenced by contrast. If we initially feel bad and then feel good, the good feeling tends to be stronger than if the good experience occurred without the preceding bad feeling. Conversely, if we initially feel good and then feel bad, the bad feeling tends to feel worse (e.g., McGraw, 1999). The five components of the ITPRA theory provide many possible interactions that might lead to such “contrastive valence,” but the most pertinent here is the contrast between the quick reaction and slower appraisal responses.

This contrast allows us to account for the difference between pleasant and unpleasant piloerection. When we feel cold, the experience is simply unpleasant, so the resulting shivers are felt as bad. However, when descending into a warm bath, the quick negative reaction to the rapid change of skin temperature is dismissed by the slower appraisal that judges the temperature to be welcome. When we are unexpectedly touched by a stranger, our reaction is wholly negative. But when the unexpected touch comes from a prospective lover, the initial shock of surprise is quickly displaced by a highly positive appraisal with a memorably large contrast in feelings from bad to good. Approaching the edge of a canyon, our initial reaction is one of danger. But standing securely on the cliff edge, the cortex concludes that there is no threat. Wrestling with a difficult problem, an unexpected moment of insight replaces a period of stressful rumination with a sudden feeling of achievement. The terror of riding a rollercoaster is held at bay by the cortical conviction that "I'm not going to die." Hearing a loud, scream-like, or unexpected sound, sets off reactive alarm bells. But a cortical appraisal inevitably concludes that "it's just music."

In all of the cases of frisson, an initial negative response is superceded by a neutral or positive appraisal, and the contrast between the two responses results in an overall positive feeling. Fear, panic, or anger may all lead to piloerection. But the ensuing cortical processes form their own judgments about the situation. When the appraisal response concurs with the reaction response, the sense of fear, panic, or anger is amplified. But when the appraisal response contradicts the reaction response, the cortex belatedly inhibits the fast subcortical responses and in the process transforms the negatively valenced feelings into something positive.

Notice that the evoking of frisson depends on the individual's susceptibility to experiencing fear. Those "thick-skinned" individuals who are less responsive to fear would be less likely to experience fear-induced piloerection, and so less likely to experience frisson. Since males commonly score higher on measures of sensation-seeking, they are less susceptible to fear, and so may be less likely to experience frisson than females.

An important question raised by this contrastive valence theory is how frisson might be reliably evoked when a given listener hears a passage repeatedly. If piloerection is a response to fear or panic, won't musical familiarity ultimately dull the response? While repeated stimulation normally leads to habituation, an exception occurs in the case of defensive responses, such as pain. Recall that the function of fast responses is primarily defensive. Defensive responses must always be ready, even in a world full of false alarms. In order for defensive responses to remain effective, they must be resistant to habituation or unlearning. The principal way that biology deals with false alarms is not by desensitizing defensive reflexes, but by adding inhibitory circuits that suppress inappropriate defensive behaviors after they have already begun. While slower than the reaction responses, appraisal circuits often begin the process of inhibition within about 500 milliseconds. As a result, fast reaction responses are typically short lived and rarely reach conscious awareness. Our brains and bodies engage in frequent skirmishes with ghostly dangers while we remain blissfully unaware. It is this resistance to habituation and unlearning that allows the music to retain its emotional power. In short, the frisson experience is reliable for the same reason that a familiar deceptive cadence continues to sound deceptive. Responses arising from veridical familiarity differ from schematic responses.

Recall that in Blood and Zatorre's (2001) PET study of music-induced frisson, they found *decreased* activity in the left and right amygdalas. Since the amygdala is the principal brain structure associated with fear, if piloerection is activated by fear, one might have expected the amygdala to show increased activity. However, according to the contrastive valence interpretation, the key component to frisson is strong cortical *inhibition* after an initial burst of fear, panic or anger. In observing the decreased activity in the right amygdala and the left hippocampus/amygdala, Blood and Zatorre suggested "activation of the reward system by music may maximize pleasure, not only by activating the reward system but also by simultaneously decreasing activity in brain structures associated with negative emotions." (2001, 11823). Since positron emission tomography provides little temporal resolution, we might expect any initial amygdala activity to be drowned-out by a sustained period of inhibition.

This summary provides a cursory introduction to Huron (2006), whose theory includes two other strong emotions, laughter and awe. While large violations of expectation may produce pleasurable gooseflesh, they can also lead to outburst of laughter, or to the expansive breath-holding characteristic of awe. In Huron's theory, all three originate as negatively valenced affects that are transformed through contrastive valence, into notably positive experiences.

15. Conclusion

The feeling of shivers running up and down one's spine is widely reported as one of the most memorable and pleasurable experiences induced by music. Apparently, not all listeners experience musical frisson, and so one wonders whether the phenomenon contributes to whether a person becomes a music lover. However, even for the most passionate aficionado, music-induced shivers is a relatively rare event, and so is unlikely to provide the main attraction or motivation for music listening.

Apart from its value as one of life's treasures, frisson provides an especially fruitful phenomenon for the study of music and emotion. Music listening is a notoriously passive activity. When observing listeners, there is little to distinguish the listener who is lost in musical rapture from the one who is utterly bored. Evoked emotions provide few observables. In rare circumstances, a listener might weep, laugh, smile, or sigh. But apart from body-swaying or foot-tapping, there is little gross behavior to observe. Although metabolic behaviors (such as heart rate or EEG) may be relatively easy to measure, the resulting data are often difficult to interpret or poorly correlated to important affective experiences. Frisson is an exception. Craig (2005) has noted that gooseflesh can be directly observed on the forearm of listeners. Amazingly, this simple response is directly linked to a deeply felt (and aesthetically valued) musical experience. Frisson is important in music-related emotion research because it provides a relatively easily observed behavior that has obvious affective significance. We anticipate that frisson will continue to be attractive topic of research in the field of music and emotion.