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Cardiovascular and respiratory responses during musical mood induction

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Abstract

Music is used to induce moods in experimental settings as well as for therapeutic purposes. Prior studies suggest that subjects listening to certain types of music experience strong moods and show physiological responses associated with the induced emotions. We hypothesized that cardiovascular and respiratory patterns could discriminate moods induced via music. 18 healthy subjects listened to 12 music clips, four each to induce happiness, sadness, and fear, while cardiovascular and respiratory responses were recorded using an electrocardiogram and chest strain-gauge belt. After each clip subjects completed a questionnaire. Subjects consistently reported experiencing the targeted mood, suggesting successful mood induction. Cardiovascular activity was measured by calculating time domain measures and heart rate changes during each clip. Respiratory activity was measured by total, inspiration, and expiration lengths as well as changes in mean respiration rate during each clip. Evaluation of individuals' patterns and mixed-model analyses were performed. Contrary to expectations, the time domain measures of subjects' cardiovascular responses did not vary significantly between the induced moods, although a heart rate deceleration was found during the sadness inductions and acceleration during the fear inductions. The time domain respiratory measures varied with clip type: the mean breath length was longest for the sad induction, intermediate during fear, and shortest during the happiness induction. However, analysis using normalized least mean squares adaptive filters to measure time correlation indicated that much of this difference may be attributable to entrainment of respiration to characteristics of the music which varied between the stimuli. Our findings point to the difficulty in detecting psychophysiological correlates of mood induction, and further suggest that part of this difficulty may arise from failure to differentiate it from tempo-related contributions when music is used as the inducer.

Keywords: Music; Mood; Cardiovascular and respiratory responses

1. Introduction

A large literature, in both healthy and psychiatric individuals, has investigated the psychological, biological, and neural correlates of mood. Experiments in this literature have explored the effects of mood on overall health, immune system function, memory, attention, and perception (Cacioppo et al., 2000). However, in the context of a laboratory achieving successful emotional induction may be very difficult since induction techniques are limited by ethical and experimental feasibility. Musical mood induction is an attractive option to induce moods in experimental settings since subjects consistently report experiencing strong emotions in response to music (Juslin and Sloboda, 2001). Music has been used for mood induction in a wide variety of experiments, both alone and combined with other stimuli (for review, see Gerrards-Hesse et al., 1994). For example, music has been used in combination with reading self-referential statements (Mayer et al., 1995; Richell and Anderson, 2004), with lighting (Davey et al., 2003), to study autobiographical recall (Setliff and Marmurek, 2002), salivary cortisol levels (Clark et al., 2001; Hucklebridge et al., 2000), and emotional face judgments (Bouhuys et al., 1995). A growing literature has also investigated the changes in the brain that arise from inducing strong moods via music (reviewed in Lewis, 2002). For instance, music excerpts that were pleasurable for specific individuals were associated with reliable activation of emotion-related processing regions of the brain (Blood and Zatorre, 2001). These and other findings have supported that idea that music is processed in a special way by

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the brain (Peretz, 2001) and can tap powerfully into the neural circuitry that generates emotional responses.

It is generally accepted that large and reliable changes in physiological states are associated with emotional responses, regardless of the manner in which the emotional response was induced. There is consensus that such physiological changes are a reliable correlate of certain psychiatric disorders, including anxiety and panic disorders and depression (Berntson and Cacioppo, 2004; Berntson et al., 1998; Grossman, 1983; Wientjes, 1992). However, whether specific physiological patterns for each unique normal emotional state exist is controversial (e.g. Collet et al., 1997; Hagemann et al., 2003; Levenson and Ekman, 2002). A meta-analysis and literature review by Cacioppo et al. (2000) highlighted the inconsistent results found in studies searching for distinct emotion-specific patterns of physiological activity, but indicated that autonomic activation may be greater in negative than positive valenced states. Two psychophysiological measures thought to index emotional states are respiration and cardiovascular patterns.

1.1. Respiration patterns

A number of studies have suggested that the experience of emotional states is accompanied by respiratory changes (reviewed in Boiten et al., 1994; Ritz, 2004; Wientjes, 1992). One of the most well-established connections is between anxiety-related states and respiratory changes (e.g. Bass and Gardner, 1985; Grossman, 1983; Wientjes, 1992). Wientjes (1992) suggests that hyperventilation may be a normally occurring passive coping response in situations of pain, apprehension, anxiety, or fear. Stressful or effortful mental tasks also can increase respiration rate, and respiratory disregulation is associated with several diagnostic groups, including depression, panic disorder, and anxiety (Boiten et al., 1994; Wientjes, 1992). Evidence that voluntary alteration of respiration patterns can change subjective emotions (such as by reducing anxiety in a stressful situation) also suggests interactions between emotion and respiration (Bass and Gardner, 1985; Boiten et al., 1994; Grossman, 1983).

Other research has probed for specific respiratory patterns for basic emotions. Bloch et al. (1991) quantitatively and qualitatively described unique patterns of respiration for each of six different emotion types (joy/laughter, sadness/crying, fear/anxiety, anger/aggression, erotic love, and tenderness) in trained actors. Particular patterns of respiration accompanied specific emotions; for instance fear/anxiety correlated with frequent pauses, increased respiratory rate, increased respiratory rate variability, and increased inspiration time relative to expiration time. Wientjes (1992) describes four breathing patterns associated with emotional states: rapid and shallow respiration in tense anticipation/anxiety, rapid and deep respiration in excitement/arousal/fear/anger/joy, slow and shallow respiration in passive grief/depression, and slow and deep respiration during sleep/deep relaxation. In an experiment using autobiographical recall mood induction Collet et al. (1997) found significant differences in instantaneous respiratory frequency between emotional states: shortest mean breath lengths occurred during happiness, whereas the longest mean breath lengths were found in surprise, anger, disgust, and intermediate breath lengths occurred during fear and sadness. Boiten (1998) studied respiration changes during moods induced by emotional movie clips and found significantly shorter inspiratory duty cycle, shorter post-expiratory pause length, and greater total breath length variability for the positive films when compared to the negative films. These data indicate that respiratory measures may provide a sensitive correlate of emotional experiences induced in a variety of ways.

1.2. Heart rate variability patterns

Heart rate variability may provide another measure of mood, although whether heart rate variability patterns are distinct for each emotional state is debated. A number of studies reported increased heart rate during anger, fear, and sadness (Collet et al., 1997; Levenson, 1992; Levenson et al., 1990), while others reported increased heart rate during anger, fear, and sadness compared to happiness (Ekman et al., 1983; Levenson and Ekman, 2002). Heart rate during disgust has been reported to be lower than during anger, fear, and sadness (Levenson et al., 1990). Schwartz et al. (1981) found emotion-specific (happiness, sadness, anger, and fear) changes of diastolic and systolic blood pressure and heart rate while subjects performed autobiographical recall mood induction. Palomba et al. (2000) measured heart and respiration rate during viewing films designed to elicit either a threat/anxiety, disgust (surgery/mutilation), or neutral state, and reported an increase in respiration rate while viewing all films, an increase in heart rate during the threat/anxiety film, and a slight decrease during the disgust and neutral films.

Other researchers have not found evidence of differences in heart rate between specific emotions, but rather an increased heart rate across all emotions compared to a neutral state (e.g. Neumann and Waldstein, 2001; Prkachin et al., 1999). Sinha et al. (1992) found changes in blood pressure and vascular resistance between emotional states but not in heart rate. Stemmler (1989) did not find respiration or heart rate differences between emotional conditions (fear, anger, happiness, control, induced by real-life task manipulation and autobiographical recall), although differences were reported in other psychophysiological measures (also Gendolla et al., 2001).

1.3. Coordination of respiration with external signals

It is known that respiration is influenced by factors other than physiological requirements, in addition to factors that induce emotions. For example, respiration has been shown to coordinate to rocking frequency in newborns (Sammon and Darnall, 1994), steps while walking (Loring et al., 1990), passive leg movement (Gozal and Simakajornboon, 2000), and bicycle peddling (Kohl et al., 1981). This coordination may occur without conscious awareness (e.g. Haas et al., 1986; Kohl et al., 1981). Haas et al. (1986) recorded subjects'