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Resting physiological arousal is associated with the experience of music-induced chills

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ABSTRACT

In the study of emotion and autonomic nervous system functioning, resting physiological arousal is usually considered a negative characteristic. The present study examined the relationship between resting physiological arousal and positive emotional experience linked to psychophysiological arousal. We assessed resting physiological arousal using markers as high skin conductance level and low respiratory sinus arrhythmia, measured just before participants listened to their favorite music. Participants reported the sensation of chills (goose bumps, shivers) by pressing a mouse button while listening. The results indicated that individuals with resting physiological arousal frequently experience music-induced chills, which evoked unambiguous pleasurable feelings and an increase in skin conductance response. The current results, and the previously demonstrated relationship between resting physiological arousal and negative emotionality linked to psychophysiological arousal (e.g., anxiety, panic), suggest that resting physiological arousal may reflect sensitivity to psychophysiological arousal with both intense positive and negative emotions.

1. Introduction

Interest in the relationship between autonomic nervous system function and human emotion has steadily grown (Kreibig, 2010). The autonomic nervous system has two branches: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). Autonomic nervous system activity towards SNS activation and PNS withdrawal indicates physiological arousal, while SNS withdrawal and PNS activation are typically associated with relaxation. Numerous studies have explored stable individual differences for both SNS and PNS functioning, and these differences have shown reliable associations with emotional responses (e.g., Appelhans and Luecken, 2006; Lorber, 2004).

A growing body of literature suggests that tonic PNS withdrawal is associated with individual differences in negative emotionality. It is known that respiratory sinus arrhythmia (RSA) involves regular patterns of heart rate fluctuations that are linked to the breathing cycle, and modulated by PNS (or vagal) activity (Thayer and Lane, 2000, 2009). Previous findings suggested that resting RSA has been associated with emotional regulation capabilities. Since vagal influence can rapidly alter heart rate, individuals with a high resting RSA are able to swiftly modulate their cardiac activity and regulate their emotional response in accordance with situational demands. The resultant high resting RSA is indicative of physiological flexibility and a greater capacity for adaptive regulation and social engagement (Porges, 2007; Thayer and Lane, 2000). Conversely, individuals with lower RSA have been shown to exhibit negative emotional traits, such as anxiety disorders, panic disorders, and hypervigilance, all of which may result from a lack of physiological flexibility and adaptive regulation (for a review, see Acharya et al., 2006; Appelhans and Luecken, 2006; Kemp and Quintana, 2013). Moreover, some studies have indicated that individuals affected by persistent anxiety or panic symptoms show higher resting skin conductance level (SCL) than healthy controls (Doberenz et al., 2010; Roth et al., 2008). SCL, we note, is a typical index of SNS activity. Therefore, high resting SCL (SNS activation) and low resting RSA (PNS withdrawal) — that is, resting physiological arousal — may be associated with psychiatric disorders, and are considered to be negative characteristics.

However, resting physiological arousal may reflect sensitivity to a strong emotional response associated with psychophysiological arousal rather than negative emotionality. Some studies suggest that negative mood is not correlated with resting physiological arousal (Oveis et al., 2009; Wang et al., 2013), and may be not related to it. These findings suggest that, in the relationship with resting physiological arousal, negative moods may differ from other forms of negative emotionality, such as anxiety and panic disorders. One of the differences between negative mood and psychiatric disorders is the strength of the emotional

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experience. While negative moods are considered weak-intensity affective states, people affected by anxiety and panic experience persistent anticipatory negative thoughts and intense emotional disturbances (Doberenz et al., 2010; Gonzalez-Bono et al., 2002). Furthermore, the experience of anxiety and panic has been almost unanimously characterized by physiological arousal (Kreibig, 2010). These differences between forms of negative emotionality may imply that resting physiological arousal is related to individual differences in strong emotional activation associated with psychophysiological arousal. Although resting physiological arousal was not associated with subjective emotional arousal in Frazier et al. (2004), it may be related to the experience of psychophysiological arousal.

Is resting physiological arousal related to positive emotional experience rather than merely negative emotional experience? Positive and negative variations are basic aspects of emotions, and have opposite natures (Russell, 1980, 2003). Since the negative emotional aspects of resting physiological arousal have been noted in a number of studies as stated above, it may seem strange to suggest that resting physiological arousal may be associated with positive emotions. However, it is well known that people experience psychophysiological arousal during both intense positive and negative emotional responses (Kreibig, 2010). If resting physiological arousal reflects the sensitivity of strong emotional experiences linked to psychophysiological arousal, it would be not contradictory if it were related to both positive and negative emotions. To date, it is not clear whether resting physiological arousal is related to positive emotions linked to psychophysiological arousal. To further elucidate the relationship between resting physiological state and emotion, it is necessary to assess whether resting physiological arousal is also associated with strong positive emotional experiences linked to psychophysiological arousal.

One indicator of strong positive emotion linked to psychophysiological arousal is a music-induced chill (Zatorre and Salimpoor, 2013). The phenomenon of chills is described as goose bumps, or shivers down the spine (for a review, see Huron and Margulis, 2010). Chills typically result from alterations in the thermoregulatory system, such as those produced by cold air or illness, but are also known as a response to strong emotional experiences (Maruskin et al., 2012; Panksepp, 1995). In empirical research, many studies have examined such emotionally derived chills in response to music (Benedek and Kaernbach, 2011). Although chills are sometimes experienced in response to movies or books, music appears to be the stimulus most commonly linked to them (Goldstein, 1980; Silvia and Nusbaum, 2011). Music-induced chills are not experienced by all people; individuals who do experience them, however, tend to do so consistently during moments of strong emotional response (Grewe et al., 2007; Sloboda, 1991). Previous studies on music and emotion have repeatedly suggested that people who report music-induced chills experience psychophysiological arousal largely due to an increased amplitude of skin conductance response (SCR) (e.g., Egermann et al., 2011; Guhn et al., 2007; Rickard, 2004). Moreover, in participants who experienced chills while listening to their favorite music, the chills were accompanied by strong pleasant feelings and emotional arousal (Blood and Zatorre, 2001; Salimpoor et al., 2009, 2011). Although previous studies showed that openness to experience, one of the Big Five personality traits, is associated with music-induced chills (McCrae, 2007; Nusbaum and Silvia, 2011; Silvia and Nusbaum, 2011), it has not yet been determined whether physiological variables are related to the chills.

The present study examined the relationship between resting physiological arousal and music-induced chills. We measured resting SCL and RSA to assess tonic physiological arousal and chill-related SCR, in order to assess the experience of psychophysiological arousal. Given our assumption that resting physiological arousal reflects sensitivity to strong emotional response linked to psychophysiological arousal, we predicted that individuals with resting high SCL and low RSA would frequently experience musical chills that induced strong positive emotions associated with psychophysiological arousal.

2. Methods

2.1. Participants

Participants were recruited during a university psychology class. In the class, the frequency with which participants experienced chills while listening to music was assessed with the following two questions: “While listening to music, how often do you get goose bumps?” and “While listening to music, how often do you feel shivers down your spine?” The questions contained a Likert response format that ranged from 0 (not at all) to 10 (nearly always). Scores were averaged to yield an overall chill score (Cronbach's $\alpha = .77$). We selected participants who reported experiencing chills while listening to music at least once, although the range of chill frequency varied ($M = 4.3$, $SD = 2.5$, max $= 9.5$, min $= 1.0$). Thirty-two college students (18 women and 14 men) gave written informed consent and participated in the experiment. Participants ranged between 18 and 20 years of age ($M = 18.8$, $SD = 0.8$). Participants were required to be in good general health to participate in the study. We confirmed that participants did not have a history of neurological, psychiatric, or cardiovascular disorders, or chronic medical conditions through oral assessment. All participants were instructed to abstain from coffee or alcoholic beverages the night before physiological response measurement. Participants were compensated with money (about $8) and course credit.

2.2. Materials

In the present experiment, we allowed each participant to select his or her favorite music and then used those selections as stimuli. Generally, strong positive emotion is difficult to evoke in experimental settings, so experimenter-selected music is less likely to induce chills. However, self-selected music is more likely to facilitate this response in the laboratory (Grewe et al., 2007; Rickard, 2004). Similar to the method used by Zatorres and colleagues (Blood and Zatorre, 2001; Salimpoor et al., 2009, 2011), control stimuli were selected for each individual using a paradigm in which one individual's chill-associated music was used as another person's non-chill-associated music. This allowed us to analyze data comparing the same sets of stimuli. Furthermore, this method ensured that chill responses would not likely have been the result of psychoacoustic properties (e.g., rapid increase in loudness, Nagel et al., 2008) and allowed us to examine individual differences in chill response.

Each of the 32 participants selected three pieces of music that had previously elicited a pleasant chill response, and these 96 pieces of music were used as stimuli in the present experiment. The experimenter used the self-selected music of one participant as the experimenter-selected music for another participant. For example, if music set A (three pieces of music) evoked chills in participant 1, and music set B (three pieces of music) evoked chills in participant 2, then music set B served as the psychoacoustic control for participant 1, and music set A served as the psychoacoustic control for participant 2. We collected the paired data using this matching procedure. In the procedure, a musical piece was used once as self-selected music and again as experimenter-selected music; thus, 96 pieces of music were used twice in the experiment. Each participant listened to 6 pieces of music (three self-selected and three experimenter-selected music pieces); these 96 pieces of music, played twice (i.e., 192), were divided evenly between the 32 participants. In this way, we collected 16 pairs of data from 32 participants. In addition, to best control for a potential chill response to experimenter-selected music, we asked participants prior to the experiments to name their three favorite artists apart from those who performed their self-selected music. We subsequently ensured that the three experimenter-selected music pieces assigned to a given participant did not overlap with his or her six favorite artists (the three artists who performed the self-selected music, and three reported favorite artists).