Proceedings of the 3rd International Conference on Music & Emotion (ICME3), Jyväskylä, Finland, 11th - 15th June 2013. Geoff Luck & Olivier Brabant (Eds.)

THE EFFECTS OF NICOTINE ON MUSIC-INDUCED EMOTION

Theresa Veltri*, Renee Timmers*, Paul Overton†

*Department of Music, University of Sheffield, England
†Department of Psychology, University of Sheffield, England
TMVeltri2@sheffield.ac.uk

Abstract

Nicotine is an available drug widely self-administered in the context of music (e.g. pubs, clubs). Furthermore, nicotine effects one's physiology, which allowed us to test the effects of these physiological changes on the emotional experiences of music. We hypothesized that because nicotine changes one's physiology it may also change one's affective arousal in response to music. To test this, non-smokers were administered nicotine gum at either 2mg, 4mg, or placebo level. Participants then listened to 4 musical excerpts: happy, sad, neutral, and self-selected chill-inducing. After each listening, participants rated their emotional responses on 6 intensity scales: arousal, pleasure, happy, sad, familiar, and liking. Although nonsignificant, results showed a trend, as nicotine levels increased pleasure and happy intensity ratings correspondingly decreased. Future research may be interested in testing these effects in dependent and nondependent smokers.

Keywords: music, emotion, nicotine

1. Music and nicotine as sources of pleasure

Despite that music lacks the canonical features of pleasure induction, such as biological necessity, secondary reward, or addictiveness, we know that listening to music is indeed pleasurable. In a series of studies by Dube and Le Bel (2003) music was consistently rated as one of the top ten activities found to be pleasurable. Among the four categories of pleasure found (physical, social, intellectual, and emotional) music was categorized as a form of emotional pleasure.

Damasio (1999) suggests that pleasures arising from social and physical antecedents may stem from evolutionary goals. For example, the social pleasure of a strong family bond helps protect the family, while the physical pleasure of sex perpetuates the species (Berridge & Kringelbach, 2008; Levitin, 2008). However, pleasures arising from intellectual and emotional antecedents may be more convoluted, and seen as 'pleasures of the mind' (Dube & La Bel, 2003). For example, emotional pleasures require complex appraisal and consist of both positive and negative emotions. Furthermore, an experience of emotional pleasure is likely to begin with joyful anticipation before the antecedent is encountered (Dube & La Bel, 2003), a claim corroborated with musical stimuli (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). Categorizing music as an emotional pleasure may help explain why it does not demonstrate a biological necessity, but is still considered pleasurable.

Although music may be classified as a non-biological form of pleasure it is shares the same cerebral pathway as other, more biological antecedents of pleasure (Gebauer, Kringelbach, & Vuust, 2012). That is, music activates the dopaminergic system of the brain and it is this system which is associated with the wanting of rewards, such as food, sex (Berridge &

Robinson, 1998; Wise, 2006), and gambling (Shizgal & Arvanitogiannis, 2003).

Music also activates the brain structures most associated with pleasure. Blood & Zatorre (2001) and Menon & Levitin (2005) found that listening to highly pleasurable music activated the limbic and paralimibic regions of the brain, areas particularly implicated in reward (Rodriquez de Fonseca & Navarro, 1998). These studies also found activation in the mesolimbic pathway including the ventral striatum, nucleus accumbens, ventral tegmental area, and amygdala (Blood & Zatorre, 2001; Menon & Levitin, 2005; Mitterschiffthaler, Fu, Dalton, Andrew, and Williams, 2007). The mesolimbic system is particularly responsible for assessing the value of a potential reinforcer of reward (Adinoff, 2004). Another system, the mesocrotical pathway, which is connected to the mesolimbic pathway and is also involved in reward assessment, was found to be activated via the orbitofrontal cortex and anterior cingulate cortex (Blood & Zatorre, 2001: Menon & Levitin, 2005; Mitterschiffthaler et al., 2007). These brain areas are well established for their involvement in the release of dopamine (Berridge & Robinson, 1998) and in the experience of pleasure (Berridge & Kringelbach, 2008). For example, they are activated in response to highly pleasurable activities such as euphoria and drugs of abuse (Blood & Zatorre, 2001; Menon & Levitin, 2005).

Nicotine is also a source of pleasure as evidenced by its addictive qualities (Dani, Ji, & Zhou, 2001; Balfour, Wright, Benwell, & Birrell, 2000). For example, smoking has a cessation rate of only 20% (Balfour et al., 2000). In laboratory conditions nicotine elicits reinforcing behavior, such as intravenous self-administration of the substance and place preference (Corrigall, 1999; Di Chiara, 2000).

As with other addictive substances nicotine enhances reward from brain stimulation (Dani, Ji, & Zhou, 2001). Nicotine increases reward by activating nicotinic acetylcholine receptors (nAChRs) located in the ventral tegmental area (VTA) of the midbrain. These receptors produce neuronal excitation via the release of glutamate neurotransmitters. Glutamate neurotransmitters then activate the dopamine neurons of the VTA, which in turn cause dopamine to be released in the nucleus accumbens (Koob & Markou, 2013). This cascading process is known as the mesolimbic dopamine pathway. It is responsible for the reinforcing properties of rewarding behavior (Koob & Markau, 2013), and is crucial for drug reward (Volkow, Wang, Folwer, Tomasi, & Telang, 2010; Wise, 2009). As such, stimulation of this 'reward' pathway modulates the experience of pleasure and creates a rush or 'high' (Adinoff, 2004). Nicotine and music share the mesolimbic pathway as both are rewarding stimuli, demonstrating their commonalities in eliciting reward for those who engage in their activities.

2. Interactions between emotion and physiology

The relationship between emotion and physiology is complex. Research has demonstrated the ability of each domain to influence the other (Dibben, 2004; Khalfa et al., 2002). Emotions are coupled with physiological responses via the autonomic nervous system (ANS). A function of the ANS is to activate bodily systems to support action (Ron & Amir, n.d.). Therefore, the ANS plays a critical role in emotion, producing visceral sensations that shape subjective emotional experience. The most common emotions to be investigated are anger, fear, sadness, disgust, and happiness, and are typically induce in volunteers via film clips or personalized recall (Kreibig, 2010). Although contradictions exist, induction of these emotions have shown to increase heart rate, skin conductance, and respiration rate (Aue, Flykt, & Scherer, 2007; Ax, 1953; Boiten, 1996; Collet, Vernet-Maury, Delhomme, Dittmar, 1997; Gross, Fredrickson, Levenson, 1994). Other emotions are more associated with deactivation of the ANS. For example, a decrease in heart rate is found in studies of affection and certain types of sadness (e.g. non-crying, imagery-induced) (Eisenberg, Fabes, Bustamane, Mathy, Miller, & Lindholm, 1988). Furthermore, respiration rate decreases when relief or anticipatory pleasure is elicited (Kreibig, 2010, Vlemincx et al., 2009).

The influence of emotion on physiology has been demonstrated with musical stimuli as well. Khalfa and colleagues (2002) musically

inducing participants with four emotions, fear, happiness, sadness, and peacefulness, and measured their corresponding skin conductance response (SCR). Fear and happiness were associated with higher SCR magnitudes compared to sadness and peacefulness. This was explained by the high arousal rate of fear and happiness, which is further explained by SCR's sensitive to changes in arousal (Bradley & Lang, 2000; Winton, Putnam, & Krauss, 1984). This arousal effect has also been demonstrated using slides of affective pictures and environmental sounds (Bradley & Lang, 2000; Lang, Bradley, & Cuthbert, 1998).

Contrastingly, physiology can be used to inform emotions. Scherer and Zenter (2001) suggest that peripheral feedback can influence the intensity and valence of felt emotion. That is, each emotion tends to have its own distinguishable set of bodily changes (Philippot, Chapelle, & Blairy, 2002). For example, anger increases heart rate, breathing rate, and blood pressure (Kreibig, 2010). Therefore, activation of a particular set of body changes (e.g. an increase in heart, breathing rate, and blood pressure) may have the ability to give rise to the emotion with which it is coupled (e.g. anger) (Damasio, 1994). In this way, individuals can use their body state to inform them of their emotions (Dibben, 2004). This process is known as peripheral feedback (Philippot, Chapelle, & Blairy, 2002; Damasio, 1994) and is suggested to help enhance the emotional characteristics of stimuli (Ron & Amir, n.d.).

In a seminal study Schachter and Singer (1962) injected either epinephrine (adrenaline) or a placebo into 184 university students. The epinephrine caused a rise in heart rate, blood pressure, blood flow, and respiration rate. Only one third of the participants were informed about the effects of epinephrine, the others were either deceived, being told the injection was used to test their eyesight, or were left ignorant of its side effects. The students were then placed into either a euphoric or angry social situation. Results show that those students who had been deceived (misinformed or left ignorant) about the injection and had been exposed to the euphoric social condition reported the most intense experiences of euphoria. This suggests that the deceived subjects, who had no explanation for their arousal state, labeled their physiological state of arousal based on their appraisal of their social situation. Although Schachter and Singer (1962) has been criticized for methodological limitations (Mezzacappa, Katkin, & Palmer, 1999) it demonstrates that arousal has the potential to influence the intensity of an emotional experience.

In a more recently study, Dibben (2004) demonstrated the ability of peripheral feedback to influence music-induced emotion. This was accomplished by inducing physiological arousal via a short uphill walk. Immediately proceeding the exercise participants listened to four music excerpts, one from each quadrant of the circumplex model of emotion (Russell, 1989), and rated the intensity of the emotions they perceived and felt. When comparing the exercising group with a relaxation group it was found that the exercising group, those with higher arousal, gave higher intensity rating for felt emotion, suggesting arousal to influence the emotions experienced in response to music.

3. Interactions between nicotine and music

Nicotine in known to influences physiology by increasing heart rate, blood pressure and skin conductance (Tro, 2009). Since nicotine can influence physiology and in turn, physiology can inform emotions via peripheral feedback (Schachter & Singer, 1962) it may be that nicotine can effect responses to emotional stimuli.

Furthermore, nicotine has been suspected of increasing the reinforcing properties or reward value of other stimuli (Balfour et al., 2004; Donny et al., 2003), which suggests that nicotine may enhance music-induced emotion. That is, nicotine has two effects on reinforcement. Firstly, it is a primary reinforcer as the intake of nicotine results in pharmacological actions which strengthen or 'reinforce' an individual to continue the use of the drug. Research has demonstrated that in animals and humans nicotine increases the frequency of behaviors which are necessary for nicotine administration (Palmatier et al., 2006). For example, humans and animals will learn to per-

form an action (e.g. lever press) in order to receive intravenous nicotine infusions (Corrigall & Coen, 1994). Secondly, because nicotine releases extracellular dopamine in the nucleus accumbens, which is part of the pleasure pathway, it also increases the reinforcing properties of other stimuli (Balfour et al., 2004; Donny et al., 2003). As a consequence of this increase in dopamine there may be an increase in the pleasure experienced from other behaviors performed concurrently or immediately after nicotine intake (Attwood, Penton-Voak, & Munafo, 2009). Indeed, animals increase their response rate to food, alcohol, and cocaine subsequent to nicotine administration (Bechtholt & Mark, 2002; Clark, Lindgren, Brooks, Watson, & Little, 2001).

This may suggest then that upon the intake of nicotine and subsequent action of music listening, two emotional results may occur: (1) an individual may experience an increase in the intensity of music-induced emotion and (2) and an individual may experience an increase in pleasure.

4. Research aims and current study

The first aim of the current study is to understand the basis for music-induced emotion. Music is known to influence physiology (Menon & Levitin, 2005; Rickard, 2004). However, it is unknown whether these physiological changes are important in determining an individual's emotional response to music. Because nicotine can cause similar physiological changes as music (Benowitz, Porchet, Sheiner, & Jacob, 1988) it is possible to use nicotine as a tool to induce a heightened physiological state of arousal in the listener, then examine the effect of this induction on emotional responses to music.

A second aim of this study is to understand if, and how, nicotine effects music-induced emotion by bridging two lines of established research: (1) the effect of nicotine on physiology and (2) the effect of physiology on emotion. This will help us to understand why smoking cigarettes and listening to music often co-exist. For example, smoking and music listening are frequently observed together at pubs, clubs, and music festivals. Do drugs and music have similar effects on the brain and behavior? Does simultaneous consumption of nicotine and music listening result in extreme pleasure or reward?

Although there may be social reasons for why cigarette smoking and music listening are coupled, we anticipate that physiological reasons also play a role. We expect nicotine administration to contribute to and enhance affective arousal in response to music listening by temporarily increasing physiological arousal and increasing alertness to sounds (Baldeweg, Wong, & Stephan, 2006; Benowitz et al., 1988; Gilbert, 1979). This is based on previous research demonstrating nicotine to increase arousal (Benowitz et al., 1988), and arousal to intensify music-induced emotion (Dibben, 2004).

5. Method

Participants were 44 non-smokers, 17 male and 28 female, with an mean age of 22 years, ranging from 17 to 51 years (*SD* = 6.51). Participants were staff and students of varying levels of study from the University of Sheffield, England. Although no participants were professional musicians, 65% had musical performance experience to at least a high school level. Non-smokers were defined as individuals who smoked less than 7 cigarettes in a life time and who scored a maximum of two on the Fagerström Test for Nicotine Dependence (Heatherton, Kozlowski, Frecker, Fagerstom, 1991). Participants were paid £5 for their time. Informed consent was obtained prior to experimentation. The research protocol met the ethical requirements of the University of Sheffield Department of Psychology.

6. Materials

Materials for this study included 10 excerpts (4 happy, 4 sad, 2 neutral) based on 2 preliminary surveys. The surveys verify (1) that each excerpt induced its intended emotion and (2) identify excerpts which were the most emotionally intense example of their emotion category. Surveys were administered online to approximately 100 volunteers. The first survey requested participants to listen to 18, 1 min

excerpts of popular music and to rate their emotional response on three 7-point scales: (1) pleasantness (unpleasant-very pleasant), (2) arousal (sleepy-energetic), and (3) liking (not at all-very much). A follow-up survey was needed for the selection of sad and neutral music. This survey followed similar procedures to the previous one, but used six intensity scales instead of three: arousal, pleasure, happy, sad, familiar, and liking.

Participants were asked to self-select a 2 min excerpt of music known to consistently and reliably bring them to chills and to either email this music prior to experimentation or to bring this music with them at the time of their experiment.

The nicotine gum (2 mg and 4 mg) was Boots NicAssist ice mint flavored gum. The chewing gum was Wrigley's Extra peppermint flavored gum, used because it was of similar size, shape, and color to the nicotine gum.

7. Procedure

First, baseline levels of mood were taken where participants rated their current mood on four intensity scales: (1) arousal, (2) pleasure, (3) happy, and (4) sad. Next, they were administered either one of two dosages of nicotine (2mg, 4mg) or a placebo and asked to chew the gum for 25 minutes. After 5 min of chewing they were given a piece of chewing gum to mask the flavor of the nicotine. During the 25 min chewing task participants were engaged in two distraction tasks, a 15 min reading task and a 10 min writing task. After 25 min participants discarded all gum and were checked for side effects using the Subjective Treatment Emergent Symptom Scale (Guy, 1976). They then rate their current mood using the same scales as before. Next, volunteers listened to 4 music excerpts (happy, sad, neutral, chill-inducing). After each listening subjective ratings of intensity were taken on six emotion scales: arousal, pleasure, happiness, sadness, familiarity, and liking. Song order was played at random to account for ordering effects.

8. Result

A GLM multivariate analysis was used to assess the mood ratings taken directly before and immediately after the intake of nicotine gum. Overall, we found a significant difference in mood ratings (arousal, pleasure, happy, sad) for those ratings taken before and after the administration of nicotine gum/placebo, F = 3.07, p = < 0.036. However, there were no significant differences found between these ratings and gum conditions, F = 0.51, p = 0.84.

Of the four mood ratings that were measured before and after the intake of gum (arousal, pleasure, happy, sad) three were shown to significantly increase after the intake of gum/placebo. Arousal was marginally significantly higher after the intake of nicotine gum/placebo, F = 4.014(1,26), p = 0.056. Also, pleasure was rated significantly higher after the intake of nicotine gum/placebo, F = 7.654(1,26), p = 0.01. Lastly, happy was rated significantly higher after the intake of nicotine gum/placebo, F = 5.529(1,26), p = 0.027. Sadness ratings were not shown to be significantly different before or after the intake of nicotine gum/placebo, F = 1.234(1,26), p = 0.277.

Next, a GLM multivariate analysis was used to compare the three gum conditions (2 mg, 4 mg, placebo) to test whether participants experienced any adverse effects due to the intake of nicotine. Examining the pair-wise comparisons we found no significant differences between any of the gum conditions and any of the four adverse effects. Difficulty in pay attention (M = 3.648, SE = 0.351) was not significantly different between the dosage conditions, F(2, 27) = 0.608, p = .552. Stomach aching (M = 1.435, SE = 0.160) was not significantly different between the dosage conditions, F(2, 27) = 0.590, p = .561. Feeling dizzy (M = 2.815, SE = 0.350) was not significantly different between the dosage conditions, F(2, 27) = 0.527, p = 0.596. Lastly, feeling shaky (M = 2.278, SE = 0.282) was not significantly different between the dosage conditions, F(2, 27) = 0.090, p = 0.914.

Lastly, a GLM repeated measures analysis was used to examine if music and nicotine interacted to effect participants' intensity ratings. From the initial analysis we realized that

the self-selected chill-inducing music created a ceiling effect as all intensity ratings were extremely high for this category of music. Furthermore, chill-inducing music substantially differed from the happy, sad, and neutral music because it was self-selected and so highly familiar. Therefore, we performed the analysis again, omitting the ratings for chill-inducing music.

Although results of the reanalysis are nonsignificant, the linear contrast estimates showed a trend for pleasure and happy ratings. When looking at the pleasure ratings we saw a nonsignificant probability level, $p = 0.079$. We then examined the mean pleasure ratings for each dosage condition, which are available in Table 1. We found a trend showing that as nicotine intake increased pleasure ratings decreased.

We also looked at the happy ratings, also finding a nonsignificant probability level, $p = 0.076$. We then examined the mean happy ratings for each dosage condition, which is available in Table 1. We found a trend showing that as nicotine intake increased pleasure ratings decreased.

Table 1. Means of Pleasure and Happy Ratings

Rating	Condition	*M*	*SE*
Pleasure	Placebo	4.73	0.20
	2 mg	4.67	0.20
	4 mg	4.2	0.20
Happy	Placebo	4.41	0.20
	2 mg	4.08	0.20
	4 mg	3.84	0.23

9. Discussion

This study aimed to understand why music and nicotine often co-exist. We hypothesized that because nicotine can change one's physiology it may be able to change one's affective arousal to music-induced emotion. However, our results do not support this hypothesis. Although we saw a significant increase in participants' arousal, pleasure, and happy ratings from before to after the intake of nicotine gum, there was no significant difference found between each of the dosage conditions. It could be that nicotine, regardless of dosage, increased arousal, pleasure, and happy ratings, but that a placebo effect was strong enough to cause no significant differences between the dosage conditions. Previous research has shown placebo to result in an increased positive mood (Perkins, Sayette, Conkin, Caggiula, 2003).

We also checked whether participants experienced any adverse effects due to the intake of nicotine. We found no significant differences between any of the dosage conditions and any of the adverse effects. This confirms that for the 2 mg and 4 mg dosage conditions participants did not experience any negative side effects significantly different from those of the placebo condition. Because it is common for non-smokers to feel some adverse effects from nicotine (Guy, 1976), these results may imply that participants were unaffected by the amount of nicotine administered.

Our other results, although nonsignificant, showed a trend suggesting that as nicotine increased pleasure and happy ratings for music decreased. These results suggest that as nicotine levels for non-smokers increased the intensity they felt for music-induced pleasure and happiness correspondingly decreased. Unfortunately, this finding is in complete opposition to our hypothesis. However, previous literature has noted this phenomenon. Gilbert (1979) noted the paradox of nicotine increasing physiological arousal yet simultaneously reducing self-reports of emotion experiences. The decreases in pleasure and happiness are not thought be a consequence of nicotine's side effects as these were checked and found to not correspond to nicotine dosage. However, it is possible that this result is due to nicotine's ability to increase tranquility (Firth, 1971) and to decrease measures of aggression and anxiety (Nowlis, 1965).

A limitation of this study is the low participation, as there were only 44 participants. The trend between an increase in nicotine and a decrease in pleasure and happy ratings suggests the need for more participants, especially non-students. This may help results increase

to significant levels and encourage more generalizable findings. A major limitation of this study was the use of only non-smokers. A follow-up study may be interested in examining dependent and nondependent smokers who are familiar with nicotine and as such respond to its emotional, physiological, and cognitive effects differently than non-smokers.

10. References

Adinoff, B. (2004). Neurobiologic processes in drug reward and addiction. *Harvard Review of Psychiatry, 12(6),* 305-320.

Attwood, A., Penton-Voak, I., & Munafo, M. (2009). Effect of acute nicotine administration on ratings of attractiveness of facial cues. *Nicotine & Tobacco Research, 11(1),* 44-48.

Aue, T., Flykt, A., & Scherer, K.R. (2007). First evidence for differential and sequential efferent effects of stimulus relevance and goal conduciveness appraisal. *Biological Psychology, 74, 347–*357.

Ax, A.F. (1953). The physiological differentiation between fear and anger in humans. *Psychosomatic Medicine, 15,* 433–442.

Baldeweg, T., Wong, D., & Stephan, K. E. (2006). Nicotine modulation of human auditory sensory memory: Evidence from mismatch negativity potentials. *International Journal of Psychophysiology, 59(1),* 49-58.

Balfour, D. J., Wright, A. E., Benwell, M. E. & Birrell, C. E. (2000). The putative role of extrasynaptic mesolimbic dopamine in the neurobiology of nicotine dependence. *Behavioural Brain Research, 113,* 73-83.

Bechtholt, A. & Mark, G. (2002). Enhancement of cocaine-seeking behavior by repeated nicotine exposure in reats. *Psychopharmacology (Berl), 162,* 178-185.

Benowitz, N. L., Porchet, H., Sheiner, L., & Jacob, P. (1988). Nicotine absorption and cardiovascular effects with smokeless tobacco use: Comparison with cigarettes and nicotine gum. *Clinical Pharmacology & Therapeutics, 44,* 23-28.

Berridge, K.C. & Kringelbach, M.L. (2008) Affective neuroscience of pleasure: Reward in humans and other animals. *Psychopharmacology 199(3),* 457-80.

Berridge, K. C. & Robinson, T. E. (1998). What is the role of dopamine in reward: Hedonic impact, reward learning, or incentive salience? *Brain Research Reviews, 28(3),* 309-369.

Blood, A. & Zatorre, R. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences of the United States of America, 98(20),* 11818-11823.

Boiten, F.A. (1996). Autonomic response patterns during voluntary facial action. *Psychophysiology, 33,* 123–131.

Bradley, M.M. & Lang, P. J. (2000). Affective reactions to acoustic stimuli. *Psychophysiology, 37,* 203-215.

Clark, A. Lindgren, S., Brooks, S. P., Watson, W., & Little, H. (2001). Chronic infusion of nicotine can increase operant self-administration of alcohol. *Neuropharmacology, 41,* 108-117.

Collet, C., Vernet-Maury, E., Delhomme, G., Dittmar, A. (1997). Autonomic nervous system response patterns specificity to basic emotions. *Journal of Autonomic Nervous System, 62,* 45–57.

Corrigall, W. A. (1999). Nicotine self-administration in animals as a dependence model. *Nicotine & Tobacco Research, 1(1),* 11-20.

Corrigall, W. & Coen, K. (1994). Nicotine self-administration and locomoor activity are not modified by the 5-HT3 antagonists ICS 205-930 and MDL 72222. *Pharmacology, Biochemistry, and Behavior, 49,* 67-71.

Damasio, A. (1999). *The feelings of what happens: Body and emotion in the making of consciousness.* New York: Harcourt Brace.

Dani, J., Ji, Daoyun, & Zhour, F. (2001). Synaptic plasticity and nicotine addiction. *Neuron, 31,* 349-352.

Dibben, N. (2004). The role of peripheral feedback in emotional experience with music. *Music Perception, 22(1),* 79-115.

Di Chiara, G. (2000). Role of dopamine in the behavioural actions of nicotine related to addiction. *European Journal of Pharmacology, 303,* 295-314.

Donny, E. C., Chaudhri, N., Caggiula, A. R., Evans-Martin, F. F., Booth, S., Gharib, M. A., Clements, L. A., Sved, A. F. (2003). Operant responding for a visual reinforcer in rats is enhanced by noncontingent nicotine: Implications for nicotine self-administration and reinforcement. *Psychopharmacology, 169,* 68-76.

Dube, L. & Le Bel, J. (2003). The categorical structure of pleasure. *Cognition and Emotion, 17(2),* 263-297.

Eisenberg, N., Fabes, R.A., Bustamante, D., Mathy, R.M., Miller, P.A., Lindholm, E. (1988). Dif-

ferentiation of vicariously induced emotional reactions in children. *Developmental Psychology, 24,* 237–246.

Firth, C. (1971). Smoking behavior and its relation to the smoker's immediate experience. *British Journal of Social and Clinical Psychology, 10,* 73-78.

Frankenhaeuser, M., Myrsten, A-L., & Post, B. (1970). Psychophysiological reactions to cigarette smoking. *Scandinavian Journal of Psychology, 11,* 237-245.

Frodi, A. M., Lamb, M. E., Leavitt, L. A., Donovan, W. L., Neff, C., & Sherry, D. (1978). Fathers' and mothers' responses to the faces and cries of normal and premature infants. *Developmental Psychology, 14(5),* 490-498.

Gebauer, L., Kringelbach, M. L., & Vuust, P. (in press, 2012). Musical anticipation: Integrating perception and emotion in a predictive coding framework. *Psychomusicology.*

Gilbert, D. G. (1979). Paradoxical tranquillity and emotion-reducing effects of nicotine. *Psychological Bulletin, 86(4),* 643- 662.

Goldstein, A. (1980). Thrills in response to music and other stimuli. *Physiological Psychology, 8,* 126-129.

Gross, J.J., Fredrickson, B.L., Levenson, R.W. (1994). The psychophysiology of crying. *Psychophysiology, 31,* 460–468.

Guy, W. (1976). ECDEU Assessment Manual for Psychopharmacology (revised). Department of Health, Education, and Human Welfare Publication No. (ADM) 76-338, Rockville, MD.

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerstrom, K. (1991). The Fagerstrom Test for Nicotine Dependence: A revision of the Fagerstrom Tolerance Questionnaire. *British Journal of Addiction, 86,* 1119-1127.

Khalfa, S., Isabelle, P., Jean-Pierre, B., & Manon, R. (2002). Event-related skin conductance responses to musical emotions in humans. *Neuroscience Letter, 328,* 145-149.

Koob, G. F. & Markou, A. (2013). The neurobiology of nicotine dependence and co[morbid psychiatric disorders. [Powerpoint slides]. Retrieved from https://docs.google.com/viewer?a=v&q=cache:Jo_HJp3IC_EJ:archives.drugabuse.gov/meetings/apa/ppt/koob1.ppt+&hl=es-419&gl=uk&pid=bl&srcid=ADGEESjkdxmxqGiQuqehr2kQq7ePO23mWzZ5GnW6deNot2RzcgK5wweUDFFwtHInz9Gq_f7glEXOOZqL-gkdN2Jnm2SWQs6ROKiOVVQFbTgn6WoJJGcBK5oe2xJ6T9HY3i1OMhb92bON&sig=AHIEtbTRaFhdPERsGs4wFT6UR7A9_Igf9Q

Lang, P. J., Bradley, M. M. & Cuthbert, B. N. (1998). Emotion and motivation: Measuring affective perception. *Journal of Clinical Neurophysiology, 15(5),* 397-408.

Levitin, D. (2008). The World in Six Songs: How the Musical Brain Created Human Nature. New York, USA: Dutton.

Menon, V. & Levitin, D. (2005). The rewards of music listening: Responses and physiological connectivity of the mesolimbic system. *Neuroimage, 28(1),* 175-184.

Mezzacappa, E. S.., Katkin, E. S., & Palmer, S. N. (1999). Epinephrine, arousal, and emotion: A new look at two-factor theory. *Cognition and Emotion, 13,* 181-199.

Mitterschiffthaler, M. T., Fu, C., Dalton, J., Andrew, C., & Williams, S. (2007). A functional MRI study of happy and sad affective states induced by classical music. *Human Brain Mapping, 28,* 1150-1162.

North, A. C. & Hargreaves, D. J. (1997). Liking, arousal potential, and the emotions expressed by music. *Scandinavian Journal of Psychology, 38,* 45-53.

Nowlis, V. (1965). Research with the Mood Adjective Check List. In S. S. Tomkins & C. E. Ikard (Eds.), *Affect, cognition and personality.* New York: Springer.

Palmatier, M., Evans-Martin, F., Hoffman, A., Caggiula, A., Chaudhri, N., Donny, E., Liu, X., Booth, S., Gharib, M., Craven, L., Sved, A. (2006). Dissociating the primary reinforcing and reinforcement-enhancing effects of nicotine using a rat self-administration paradigm with concurrently available drug and environmental reinforcers. *Psychopharmacology, 184,* 391-400.

Perkins, K., Sayette, M., Conkin, C., & Caggiula, A. (2003). Placebo effect of tobacco smoking and other nicotine intake. *Nicotine & Tobacco Research, 5(5),* 695-709.

Philippot, P., Chapelle, G., & Blairy, S. (2002). Respiratory feedback in the generation of emotion. *Cognition and Emotion, 16,* 605-627.

Rickard, N. (2004). Intense emotional responses to music: A test of the physiological arousal hypothesis. *Psychology of Music, 32,* 371-388.

Rideout, B. E. & Taylor, J. (1997). Enhanced spatial performance following 10 minutes exposure to music: A replication. *Perceptual and Motor Skills, 85,* 112-114.

Rodriquez de Fonseca, F. & Navarro, M. (1998). Role of the limbic system in dependence on drugs. *Annals of Medicine, 30(4),* 397-405.

Ron, S. & Amir, N. (n. d.). *The psychophysiology of emotion* [PowerPoint slides]. Retreived from http://www.slideworld.org/viewslides.aspx/The-psychophysiology-of-emotion-Samuel-Ron-and-Noa-ppt-2107166

Salimpoor, V., Benovoy, M., Larcher, K., Dagher, A., & Zatorre, R. (2011). Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. *Nature, 14(2),* 257-264.

Schachter, S. & Singer J. (1962). Cognitive, social and physiological determinants of emotion state. *Psychological Review, 69,* 379-399.

Shizgal, P. & Arvanitogiannis, A. (2003). Neuroscience: Gambling on dopamine. *Science, 299,* 1856-1858.

Stéphanie, K., Peretz, I., Blondin, J., Manon, R. (2002). Event-related skin conductance responses to musical emotions in humans. *Neuroscience Letters, 328(2),* 145-149.

Tong, J., Knott, V., McGraw, D., & Leigh, G. (1974). Alcohol visual discrimination and heart rate: Effects of dose, activation and tobacco. *Quarterly Journal of Studies on Alcohol, 35,* 1003-1022.

Tro, N. J. (2009). *Chemistry in focus: A molecular view of our world* (4th ed.). Belmont, CA, USA: Brooks/Cole Cengage Learning.

Vlemincx, E., Van Diest, I., De Peuter, S., Bresseleers, J., Bogaerts, K., Fannes, S., Li, W., Van den Bergh, O. (2009). Why do you sigh: sigh frequency during induced stress and relief. *Psychophysiology, 46,* 1005–1013.

Volkow, N. D., Wang, G., Fowler, J. S., Tomasi, D., & Telang, F. (2010). Addiction: Beyond dopamine reward circuitry. *Proceedings of the National Academy of Sciences Early Edition,* 1-6. Retrieved from http://www.pnas.org/content/early/2011/03/11/1010654108.full.pdf

Winton, W. M., Putnam, L. E. & Krauss, R. M. (1984). Facial and autonomic manifestations of the dimensional structure of emotion? *Journal of Abnormal Psychology, 97,* 487-491.

Wise, R. A. (2006). Role of dopamine in food reward and reinforcement. *Philosophical Transaction of the Royal Society, 361,* 1149-1158.

Wise, R. A. (2009). Roles for nigrostriatal- not just mesocorticolimbic – dopamine in reward and addiction. *Trends Neuroscience 32,* 517-524.

Zentner, M., Grandjean, D., & Scherer, K. R. (2008). Emotions evoked by the sound of music: Characterization, classification, and measurement. *Emotion, 8(4),* 494-521.