An Analysis of Music Listening Behavior as it Relates to Addiction

A Senior Honors Thesis for the Department of Psychology

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Abstract

The current body of work on music and music listening's effects on brain and behavior suggests that a subset of the population is susceptible to a music listening addiction. This paper provides a framework for music listening addiction (MLA) as a neurological, physiological, and behavioral affliction similar to recognized substance and behavioral addiction disorders. A comparative analysis of the neurochemistries of addiction and music listening indicates areas of overlap. These shared neurochemical activations should theoretically manifest themselves in similar behavioral symptoms. However, a standardized method of quantifying MLA behavioral symptoms does not yet exist. The Music Listening Addiction Symptoms Test (MLAST), a questionnaire utilizing a self-report method of testing, was distributed amongst a sample population. The MLAST found evidence for the presence of MLA within the population, but it proved to be a poor means of analyzing the effects of MLA. Nevertheless, MLA seems to pose little danger to the individual while music is accessible. Alternative studies of music listening are proposed, and the implications of MLA for the individual and for society are discussed. With few inherently harmful effects, MLA may be viewed as a positive addiction. However, while it is not indicative of risky behavior in most situations, MLA can be significantly harmful and destructive and must be taken seriously. Further neurological and behavioral research is necessary for the continued development of the MLA framework.

Society is saturated with music. Whether it comes through handheld devices, radio antennae, computer speakers or direct performance, music is an omnipresent part of the human experience. Today's unprecedentedly easy access to music, brought about by technological advancements in recent decades, has resulted in music being an active or passive part in nearly all aspects of life: People listen to music while eating, working, commuting, exercising and socializing. Music also holds special significance in many religions, and it is a common means through which people develop individual identities and form interpersonal relationships. Music is incorporated into an astonishing amount of human activity, and for good reason: Music is generally understood to be one of the most pleasurable stimuli. This ever-present nature, which stems from the conscious application of music to multiple contexts, not only asserts music's societal significance, but also suggests that music may be more than a supplement to daily life.

In *How the Mind Works*, psychologist Steven Pinker refers to music as "a cocktail of recreational drugs that we ingest through the ear to stimulate a mass of pleasure circuits." (Pinker, 1997) Whether it comes in the form of a literary flourish, an artistic allusion or a scholarly paper, music is often likened to a drug because of its ability to provide the listener with intense pleasures and a variety of emotions. Recent neurological studies have found that listening to music not only results in the release of the pleasure-inducing neurotransmitter dopamine (Chanda & Levitin, 2013; Gebauer, Kringlebach, & Vuust, 2012), but it also affects several larger neurochemical systems in a similar way to cocaine and other reward-based stimuli (Salimpoor, Bosch, Kovacevic, McIntosh, Dagher, & Zatorre, 2013; Zatorre & Salimpoor, 2013). The music--drug analogy finds validation in these results, but overlooks a critical difference between music and drugs: That substances of abuse, and even non-substance sources of intense pleasure like gambling, are addictive and often harmful to the individual.

The body of work on music listening behavior is small compared to the work on gambling or substance abuse behavior. Few studies have analyzed music for a drug-like addictiveness, perhaps because a brief observation of modern life indicates that music is not harmful like a drug. One of the main differences between pleasure/reward and addiction is the "loss of flexibility and disability to make free decisions" (Esch & Stefano, 2004). Music seems to provide pleasure without these negative consequences, as most people do not appear to exhibit the same malignant symptoms as do recreational drug users or compulsive gamblers. However, a cursory glance does not provide a definitive conclusion. Previous studies of music listening behavior have consistently found a subset in the sample size that exhibits symptoms best associated with addiction or dependence (Cockrill, Sullivan, & Norbury, 2011; Florentine, Hunter, Robinson, Ballou, & Buus, 1998). These studies require further support, but if validated, their findings could have important consequences within the psychology community.

There are several avenues of research that can be studied with regard to music listening behavior. One approach is to identify the type of person that is most likely to exhibit unhealthy music listening behaviors. If one group is at higher risk than others are, it is important to identify the characteristics that create such a predisposition. For example, consider drugs of abuse. Most drug users do not become drug abusers or drug dependent (Koob & Moal, 1997). Former drug addicts[*] are at a greater risk of relapse into drug addiction than the average individual (Bickel & Yi, 2010). A significant amount of research has been dedicated to explaining this phenomenon, as well as unearthing the underlying hedonic, affective and emotional factors that make one

[*] Certain philosophies, with neurological findings to back their claims, argue that once an individual develops an addiction, that individual is and will always be addicted (Bickel & Yi, page 1). This has lead to debate over the validity of descriptions like 'former' and 'recovered' addict. For this research, a 'former' addict refers to a once addicted, but currently non-using individual.

vulnerable to addiction (Koob & Volkow, 2009). These factors, which are still highly scrutinized and largely theoretical, include personality type, genetic predisposition, history, stress, and life events (Cools & Robbins, 2004; Koob & Moal, 1997).

Further analysis of addiction-like music listening behavior must also examine the degree of risk the behavior poses to the individual. In other words, when and how can unhealthy music listening behavior become harmful? Such research will be especially relevant to the music therapy community, where music is often used as a substitute for abusive substances. Definitive research in this field must provide a greater depth of understanding on how individuals interact with music and insight into the contextual significance (i.e. the dangers) of an addiction-like music listening behavior.

The question stands: Can an individual become addicted to or dependent on music in the same sense as to recreational drugs or gambling? If so, what are the risks and ramifications of such an addiction-like behavior? Finally, how might this behavior be addressed, and what is its societal significance?

Defining 'Addiction'

What does 'addiction' mean? Clinically, it describes the harmful state associated with compulsive and habitual substance use or behavior (APA, 2013). However, the term has been deflated through its popularity, and today it is commonly used to reference a wide range of cases. With the mindset that anything can be an addiction if it is repeated enough times, contemporary culture has lost sight of the seriousness and severity of addiction. This paper is working in abandonment of the cultural stigmas and colloquialisms, instead opting for a clinical overview and examination of the multiple characteristics associated with addiction.

Addiction is a multimodal affliction. It manifests itself through mental, physical and behavioral features that are studied both individually and as an interconnected web. For example, the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-V*; American Psychiatric Association [APA], 2013) uses a mixture of physical and behavioral symptoms to quantify diagnosable addiction-related disorders. The scientific community agrees that addiction also involves a neurochemical change in neural subsystems (Holden, 2010; Redish, page 99). This study of addiction must therefore be approached from all three angles - mental, physical and behavioral.

The *DSM-V* contains a revised definition of addiction-related behavior that includes no mention of the word 'addiction' at all. This decision reflects an effort to avoid addiction's uncertain definition and pejorative, negative connotation (APA, 2013; O'Brien, 2010). The updated condition, termed 'substance use disorder', is a combination of the previous version's assessments of 'substance abuse' and 'substance dependence'. Per the *DSM-V*, "The essential feature of a substance use disorder is a cluster of cognitive, behavioral, and physiological symptoms indicating that the individual continues using the substance despite significant substance-related problems." Substance use disorder is accompanied by an underlying change in brain circuitry, and the most recent research has focused on how and where these changes occur. Ranging in levels of severity, substance use disorder is diagnosed through the demonstration of any two to three out of eleven symptoms. Symptom criteria cover four major categories: *impaired control*, *social impairment*, *risky use*, and *pharmacological criteria*. The eleven criteria are tolerance, withdrawal, continued use despite harm, loss of control, persistent desire to cut down [on use], salience (amount of time devoted to the substance), and reduced involvement in other activities. The case is 'Mild' if two to three symptoms are present, 'Moderate' if four to

five symptoms are present, and 'Severe' if six or more symptoms are present. In addition to combining the concepts of addiction and abuse, this revised definition also separates the disorder from the symptoms associated with obsessive-compulsive disorder, which previously consisted of similar behaviors (APA, 2013).

While the *DSM-V* is the standard diagnostic tool in the United States, its approach to quantifying addiction and dependence is one of several. The *International Statistical Classification of Diseases and Related Health Problems* (10th ed.; *ICD-10*; World Health Organization [WHO], 1992) classifies drug addiction as a subdisease under 'dependence syndrome.' This disorder, referred to as a "cluster of behavioral, cognitive, and physiological phenomena," is centrally defined by "the desire to take psychoactive drugs… alcohol, or tobacco" and is very similar to the *DSM-V* definition for substance use disorder. Dependence syndrome is diagnosed by the presence of at least three out of the six following symptoms: desire for the substance, difficulty in controlling substance-taking behavior, tolerance, physiological withdrawal, neglect of alternative pleasures or interests, and continued use despite harmful consequences (WHO, 1992). Both the *DSM-V* and the *ICD-10* allow for further specifications, such as 'currently abstinent,' 'currently abstinent, but in a controlled environment,' 'controlled dependence,' 'active dependence' and 'continuous use' (APA, 2013; WHO, 1992).

Despite the APA and WHO's avoidance of the word 'addiction', its use is still widely accepted by the scientific community. A 2007 piece of legislation embraced the word 'addiction,' proposing that the National Institute on Drug Abuse (NIDA) become the National Institute on Diseases of Addiction (U.S. Committee on Health, Education, Labor, and Pensions, 2007). This bill brought to light a decades-old debate that continues today. This concerns questions like whether a substance is "physically" or "psychologically" addicting, which

symptoms are the most dangerous and deserve primary treatment, and more. Director of NIDA Dr. Adam Leshner asserted the 'essence of addiction' to be "uncontrollable, compulsive drug seeking and use, even in the face of negative health and social consequences" (2001). Craving and the compulsive behaviors that ultimately lead to the degradation of the addict's life require immediate treatment, but certain treatments, i.e. morphine use for recovery, may need reexamination pending future findings.

While the behavioral aspects identified in the *DSM-V* are the most noticeable features of addiction-related disorders, there is more to addiction than meets the eye. Most institutions use a three-point approach to define addiction as a cycle of 'binge/intoxification', 'withdrawal/negative affect', and 'preoccupation/anticipation' (Koob & Volkow, 2009). Alternatively, the Institute of Medicine proposed a three-stage conceptualization of substance-taking behavior that consists of 'use' (the taking of drugs), 'abuse' (any harmful use) and 'dependence' (Institute of Medicine, 1996; Koob & Moal, 1997). These forms of categorical labeling allow for the application of a variety of measures to each stage of addiction, which can be helpful for treatment and research.

Addiction is unique from dependence and obsessive-compulsive disorder. The contemporary interchange of these terms results in an inaccurate portrayal and understanding of addiction. To fix this scattering of terminology, a joint committee developed a working set of definitions for dependence and addiction. This report asserts that physical dependence is an "expected, neuroadaptive consequence of chronic exposure to an agonist class of drug," while addiction is a "complex, multidimensional biopsychosocial phenomenon that occurs in at risk individuals when elective reward transitions into compulsive use" (Koob & Moal, 2005; Heit & Gourlay, 2009). Similarly, another researcher argued to stop the use of the word dependence

altogether, arguing that it only implies physiological dependence, which is different from the "psychological obsession of addiction" (Holden, 2010). Hence, while physical dependence manifests itself in the addiction cycle, it is only one aspect of addiction and is neither the sole nor the key feature of this condition (Koob & Volkow, 2009).

Behavioral Addictions: A closer look

While the APA and WHO classifications of addiction-related disorders originally diagnosed problems related exclusively to substance use, similar measures now diagnose behavior-related addiction disorders as well. Behavioral addictions, the most prominent of which is gambling, are inherently distinct from substance-related addictions in that behavioral addictions appear to spawn from noninvasive actions and activities, rather than drug use or 'invasive' activity. The *DSM-V* is the first edition of the APA manual to include behavioral addictions. This inclusion was spurred by brain imaging and neurochemical tests that have made a "pretty strong case that [gambling] activates the reward system in much the same way that a drug does" (Holden, 2010).

At present, pathological gambling, or 'gambling disorder' is the only APA-recognized behavioral addiction-related disorder. Gambling, in this context, is the act of placing something of perceived value, most commonly money, at risk in hopes of gaining something of greater perceived value (Bellegarde & Potenza, 2010). The diagnosis includes similar symptoms to that of substance use disorder. The nine symptoms characterizing gambling disorder include the need to gamble with increasing amounts of money to achieve desired excitement, restlessness and irritability when not gambling, and repeated unsuccessful efforts to control or cut back on one's gambling, among others (APA, 2013). Like drug addicts, gamblers report craving and highs in response to their stimulus of choice, they experience withdrawal and tolerance, and they score

high on measures of impulsivity (Bellegarde & Potenza, 2010; Holden, 2010; Petry, 2001; Steel & Blaszczynski, 1998).

Additional addiction-related behavioral disorders were proposed for inclusion in the DSM-V, including hyperactive sexual disorder and Internet addiction (Kafka, 2010; Block, 2008). Regarding these and other suggested behavioral addictions, the APA states, "Although some behavioral conditions that do not involve ingestion of substances have similarities to substance-related disorders, only one disorder—gambling disorder—has sufficient data to be included in this section" (APA, 2013). A strong argument against sex addiction and other proposed behavioral addiction disorders is the lack of qualifying scientific evidence; research has not shown reward circuitry to be operative in the same way as in addictive areas (Holden, 2010). More neurological data is needed to properly assess these conditions.

While the APA does not specifically list any other proposed behavioral addiction disorders, the 'sufficient data' clause serves as an acknowledgement to their possibility, pending reliable data on these topics. One proposed addiction disorder, 'Internet gaming disorder', is listed as a "condition warranting more clinical research" in the *DSM-V* appendix. The article acknowledges the Internet to be an integral and inescapable part of many people's lives. Preoccupation with online gaming, it states, manifests itself as a compulsion* that results in the "impairment or distress" of the individual, withdrawal symptoms and more. Neuroscience research has found that some gamers' neural pathways are triggered in the same "direct and intense way that a drug addict's brain is affected" (APA, 2013). This behavior prompts a neurological response that influences "feelings of intense pleasure and reward," the result of

* The manifestation of addiction out of compulsive behavior is one of a few major causal theories for addiction today (Koob & Volkow, 2009). See the *Neural and Behavioral Causes of Addiction* section for more information on this topic.

which, in the extreme, "is manifested in addictive behavior (APA, 2013)."[*] The APA cites its inclusion of Internet Gaming Disorder as encouragement for further research on the subject matter (APA, 2013; Holden, 2010).

Neural and Behavioral Causes of Addiction

In attempting to further understand addiction, recent research has transitioned focus from addiction-related behavior to associated causal factors in the brain. Neurological addiction studies have largely centered on neuroplasticity[*] within and around the limbic and executive systems, as these deal respectively with reward and control mechanisms. Such research revolves around the interaction of three specific areas within these neural systems: The amygdala, the nucleus accumbens and the prefrontal cortex (Bickel & Yi, 2010; Breiter & Rosen, 1999; Kalivas & Volkow, 2005). Scientists have proposed numerous behavioral causes to account for these changes. These behavioral theories, along with their associated neurological implications, are discussed below.

The amygdala, coined 'the impulsive system' by some addiction studies, signals pain and pleasure in the immediate, short-term period (Bechara, 2005). Such emotions result from internal and external 'emotionally-competent' stimuli that induce the release of certain neurotransmitters, e.g., dopamine, serotonin and noradrenaline, in the central nervous system (Bechara & Damasio, 2005). The short-term highs experienced from the release of these neurotransmitters are examples of 'positive reinforcement', as they provide a pleasurable reward to the individual. One framework for addiction suggests that positive reinforcement-based impulsive behavior shifts to negative reinforcement-based compulsive behavior as the motivation for the reward sensation

[*] The majority of this research comes from studies of male youths across the Asian continent (APA, 2013).

[*] The umbrella term 'neuroplasticity' refers to changes in neural pathways.

changes from optional/recreational to 'necessary' (Koob & Volkow, 2009). Withdrawal and tolerance are prominent factors in the reduction of induced pleasure from the same stimulus, but conditioned reinforcement, according to theory, results in a learned association between the stimulus-enhanced state and the stimulus itself (Hyman, Malenka, & Nestler, 2006).

Impaired decision-making is a major aspect of addiction. As a part of the executive system, the prefrontal cortex is largely responsible for actions related to executive function, such as the reconsideration of impulses through decision-making, willpower and strategic thinking in the long-term (Bickel & Yi, 2010). Damasio, Tranel, and Damasio (1991) found that damage to the ventromedial sector of the prefrontal cortices impairs decision-making behavior and emotional processing. The resultant somatic marker hypothesis proposed a systems-level neuroanatomical and cognitive framework for the influence of emotion on decision-making, by which emotional processes in the form of 'somatic markers' influence decision-making behavior (Damasio, 1996). These 'markers', theoretically existing in the prefrontal cortex, serve as associations between reinforcing stimuli and the state they induce.

The two-brain-system approach to addiction proposes that a change in the interaction between the 'impulsive' in the amygdala and the 'executive' in the prefrontal cortex results in the amplification of reward processing cues in the limbic system accompanied by a simultaneous inhibition of long-term decision-making and volition in the executive system (Bechara, 2005; Bickel & Yi, 2010; Jentsch & Taylor, 1999). Neurological research and findings have supported this framework.

Kalivas and Volkow (2005) found that cellular adaptations occurring in the nucleus accumbens* and prefrontal cortex promote compulsive stimulus-seeking behavior by decreasing the value of natural rewards and diminishing cognitive control. A three-stage biological model of addiction arose from this research. The first stage of addiction involves changes in cell signaling, where dopamine receptor stimulation prompts a cascading chain of events that lead to short-term neuroplastic changes in the reward system that persist for hours or days after initiation.

The transition to addiction occurs in the second 'stage', where long-term exposure to certain proteins results in alterations in the behaviors of dopamine and glutamate receptors in the nucleus accumbens. Glutamate is the major mediator of excitatory signals in the brain (Danbolt, 2001). As an inhibitory neurotransmitter, glutamate within the nucleus accumbens is believed to mediate reward-seeking behavior by modulating the release of dopamine (Bellegarde & Potenza, 2010). While dopamine release in the nucleus accumbens is required for the initiation of addiction, repeated use or exposure to the dopamine-releasing stimulus causes "gradual recruitment of the prefrontal cortex and its glutamatergic efferents to the accumbens," (Kalivas & Volkow, 2005) and there occurs a shift from dopamine- to glutamate- based behavior. The increased release of glutamate arises from neuroplastic adaptations that reduce inhibitory regulators and prevent proper glutamate maintenance in the nucleus accumbens. This shift reduces dopamine release and reception. Disruptions of dopamine transmission at receptor sites or along axonal routes decrease the reward value of dopamine (Bellegarde & Potenza, 2010; Nestler & Aghajanian, 1997). This explains addicts' reduced sensitivity to natural reinforcing

* The nucleus accumbens comprises half of the basal ganglia, and plays a central role in the reward system, especially as it relates to pleasure, motivation and reinforcement (Kalivas & Volkow, 2005).

stimuli. These cellular changes endure for several years, and are responsible for addicts' continued vulnerability (ibid.).

Addiction-related neurological changes occur across the nucleus accumbens and prefrontal cortex. Withdrawal from state-enhancing stimuli (during the second 'stage') results in dysmorphisms in the prefrontal cortex that lead to reduced cell signaling through certain transmitter receptors. The changes that occur from long-term exposure to 'addictive' stimuli inhibit the prefrontal cortex's ability to regulate impulses (Kalivas & Volkow, 2005). This reduced regulation in the executive, paired with the imbalance between stimulus-driven and natural rewards in the limbic system, explains the addict's single-minded pleasure-seeking/pain-reducing behavior.

Neurological Similarities of Substance and Behavioral Addictions

Individuals with substance use disorder and gambling disorder share several common neurological features that manifest themselves in many of the same behaviors and impairments. Both groups undergo similar, if not the same neuroplastic changes in both the executive and limbic systems. Concerning the executive, they experience decreased activation of the ventromedial prefrontal cortex during decision-making tasks, and tests of cognitive flexibility indicate that both groups take longer to adapt to new circumstances. Potenza (2008) found that pathological gamblers and cocaine addicts undergo diminished activation of the same brain regions when experiencing their respective urges and cravings.

Changes to reward circuitry in the limbic system equally occur in substance use and behavioral disorders. Addicted individuals are far more likely to make risky reward-related decisions than healthy individuals (Bellegarde & Potenza, 2010). Petry (2001) found that they both discount delayed rewards at abnormally high rates, a behavior that falls in line with the

impulsive/compulsive and two-brain-system frameworks.* Pathological gamblers, like addicts, also score highly for compulsivity related to decision-making and emotion (Bellegarde & Potenza, 2010). Both groups often share personality features, including impulsiveness and sensation-seeking. These shared neurological and resultant behavioral features suggest an indisputable similarity between behavioral and substance addictions.

Vulnerability/Predisposition to Addiction

The final barrier to understanding addiction lies in determining the characteristics that make certain individuals vulnerable or predisposed to addiction. The neurological and physiological similarities between individuals with gambling disorder and individuals with substance use disorder have led to several theories related to genetics, biology and more.

Overlaps between substance use disorder and gambling addiction in adolescents suggest that certain neurodevelopmental features make youths vulnerable to developing addictions. The mesolimbic dopamine system is strongest during adolescence, which may increase sensitivity to reinforcing stimuli. The brain regions that promote motivational drives are also "more effective at driving behavior during adolescence than during adulthood," according to Chambers and Potenza (2003). Research on developmental changes also focuses on the prefrontal cortex, which undergoes important maturational changes during adolescence (ibid.). The relative immaturity of this region during adolescence may contribute to adolescents' greater vulnerability to addiction (Bellegarde & Potenza, 2010).

* Pathological gamblers discount delayed rewards at higher rates than non-gamblers, and pathological gamblers with substance use disorder discount delayed rates at higher rates than pathological gamblers (Petry, 2001). This is evidence for similarity between the two conditions, but the further discounted value state when both are present suggests either that there are scaled degrees of addiction or that these conditions result in addictive behavior through different, coincidental paths.

Predispositions to substance use disorder and gambling disorder seem to arise from genetic and environmental factors. Family studies show a strong correlation between adolescent environment and neurodevelopmental predisposition, with adolescent exposure (such as parental gambling) resulting in a high correlated likelihood of addiction (Lesieur & Heineman, 1988). Genetic studies on addiction are in their early stages, but one study suggests that genetic factors may account for between 35% and 54% of the "liability for developing any symptoms" of, for example, pathological gambling (Bellegarde & Potenza, 2010; Eisen et al., 1998). A "genetic locus" involved in susceptibility to pathological gambling and substance use disorders seems evident. Molecular genetics studies suggest that polymorphisms in certain dopaminergic receptor genes linked to impulsivity may predispose individuals to addiction. Further genetic and molecular research can help identify the genetic mutations and environmental factors that contribute to vulnerability. Understanding the underlying causes of addiction at a neurological and environmental level will contribute to the development of effective treatments and prevention efforts.

Music Listening and Reward Circuitry: The Case for Music Addiction

Can music be addictive? Neurochemical changes, behavioral and physiological symptoms are the three major components to an addiction-related diagnosis. Breakthroughs in neuroscience have allowed researchers to hone their study of chemical activity in the brain, especially as it relates to reward circuitry. The wealth of cognitive similarities between gambling disorder and substance use disorder suggests the possibility of other behavioral addictions. Activities such as sex, eating and music listening affect the brain's reward system,[*] making them

[*] Research has ruled out the possibilities of sex and eating-related addictions because of their comorbidity: The presence of other neurological disorders or diagnosable problems rules out a diagnosable behavioral disorder.

prime targets for addiction research. Reports like those in Oliver Sacks' *Musicophilia* (2007) and other studies indicate that certain individuals display compulsive and addictive music listening behaviors with symptoms akin to those of gambling disorder and substance use disorder. A proposed 'music listening addiction' must display evidence of music-onset neuroplastic change that results in impaired control, social impairment, and risky use.

Neuroscience research shows that subjectively 'pleasurable' music plays a multivalent role in the brain, activating a complex series of reactions in the limbic, temporal and executive systems (Chanda & Levitin, 2013; Mas-Herrero et al., 2013). Spine tingling 'chills', often experienced in concurrence with emotions like pleasure, are used in music research for measurements of anticipation and emotional response. A positive correlation exists between dopamine release in the basal ganglia and the number of pleasurable 'chills' experienced by the listener (Salimpoor et al., 2011). This shows that intense pleasure experienced from music listening is directly associated with dopamine activity in the nucleus accumbens. Meanwhile, fMRI studies have found a deactivation of the amygdala while listening to pleasant music (Mas-Herrero et al., 2013; Blood & Zatorre, 2001).

Music is not an exclusively direct source of induced pleasure. The neurobiological role of music in reward circuitry is complicated by music's activation of multiple systems and subsystems. Music is considered to be a higher-order pleasure; recent studies suggest that the hedonic impact of music listening is driven by its "intrinsic ability to evoke emotions" (Mas-Herrero et al., 2013). The hedonic impact (reward sensitivity) of music emotional experience is unique to the individual, and both primary and secondary factors affect the way in which one is impacted by music. These include social attraction, physical movement (dance), singing, and more. In short, different types of music may invoke different types of pleasurable responses.

Chin and Rickard (2012) identified five sources of musical engagement: production, cognitive regulation, mood regulation, physical (dance and exercise), and social uses. Engagement through any one or more of these facets activates reward circuitry in different ways.

While the experience of musical pleasure varies from person to person, studies have found correlations between reward-seeking tendencies and individual differences in other reward-related areas such as personality (Mas-Herrero et al., 2013; Sandstrom & Russo, 2011). Openness to experience is positively correlated with several aspects of music. Those who score higher on this scale tend to be sensitive to art and experience a vast range of emotions and feelings. The ability to experience aesthetic chills, one of the physiological responses reported with pleasant music, is specifically related to the Openness trait (Mas-Herrero et al., 2013; McCrae, 2007). Studies have also found that individuals who experience anxiety when faced with negative or painful outcomes are also more likely to use music as a mood regulator (Chamorro-Premuzi & Furnham, 2007; Mas-Herrero et al., 2013). Zald and Zatorre (2011) theorized that pleasure of music might be mediated through two mechanisms: The positive engagement of the reward circuit and the inhibition of brain areas mediating negative affective states. This proposed structure offers an explanation to the high occurrence of music as a mood regulator: Music allows for the inhibition of negative states while also engaging in reward-related brain areas.

Advances in neuroscience have found evidence that music affects the same neurochemical systems of reward as addictive drugs. Using positron emission tomography (PET), Blood and Zatorre (2001) observed an associated activation of the nucleus accumbens with chill-inducing music that was not present with neutral music. Functional magnetic resonance imaging (fMRI) studies have investigated the neural subcomponents of pleasurable

music listening, finding a strong link between the orbito-frontal cortex and the mesocorticolimbic dopaminergic circuitry (Chanda & Levitin, 2013). Music-induced reward is therefore dependent on dopaminergic neurotransmission within a similar neural network as drug- and gambling-induced reward. A major limitation of many previous studies was an inability to directly investigate dopamine release during the processing of musical reward. Salimpoor et al. (2011) was the first study to provide direct evidence of a positive association between pleasure experienced when listening to music and dopamine activity in the reward system.

Research suggests that music listening also affects the regions that facilitate the learning of stimulus-response associations (Chanda & Levitin, 2013). The findings of concurrent dopamine release in the limbic system and associative learning in the executive system paints a portrait of pleasurable music as a state-enhancing positive reinforcer whose effects can be conditioned over time. One can therefore learn to associate the act of music listening with the rewarding effects of music listening. As musical taste is subjective and variant, so, too is this rewarding response specific to the individual. This association is supported by the increased use of music as a mood regulator in anxious individuals. Associative learning is one of the key aspects in the two-brain approach to addiction, so while these music-related associations are unique to each person, they support the proposed music addiction framework.

Music behaves very similar to drugs and gambling in the brain. Pleasurable music, like addictive drugs, shows evidence of an "appetitive phase related to anticipation" and a "consummation phase related to hedonic and reinforcing properties" (Chanda & Levitin, 2013; Zald & Zatorre, 2011). Music engages with the same pathways of the reward system as do addictive stimuli, and musical pleasure is dependent upon dopamine release. However, Mas-Herrero et al. (2014) argue that music might not be exclusively processed in the reward system,

and that it may be influenced by other areas like those involved in auditory processing. Some case studies show a loss of music's emotional impact resulting from brain damage not in reward-related structures. Recent research also suggests that assignment of reward value may be associated with a unique reward network as well as the recruitment of specific areas involved in the perception and cognition of the type of reward (ibid.). These findings underscore the need for further studies on the neurobiologies of pleasurable music and reward.

Music and Addiction: Existing Research

Previous research on music and addiction consists of questionnaire and deprivation studies that tested for the behavioral and physiological components of addiction. Two studies used similar adaptations of symptoms for substance use disorder, as defined by the then-latest *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; APA, 1994), to test for the possibility and prevalence of a music-related addiction amongst a population.

Florentine et al. (1998) theorized the existence of a "maladaptive pattern of music-listening behavior" similar to the behavior exhibited in substance dependence, per the *DSM-IV* (1994). This study specifically cited loud-music listening as addictive. Testing for incidence of a proposed 'maladaptive music listening' (MML) indicative of "something similar to the standard conceptualization of addiction behavior," the researchers developed a test in the form of a 31-prompt music listening questionnaire. The prompts for this questionnaire derived from the Michigan Alcoholism Screening Test (MAST) and the then-current APA publication. Individual questions were assigned weights based on pre-determined factors of applicability to symptomatic criteria. A positive screening of MML was based on a respondent's meeting or exceeding the criterion considered indicative of alcoholism for the MAST, and the criteria for substance dependence as defined by the *DSM-IV*. The latter criteria consisted of observable manifestations

of at least three out of seven symptoms, consisting of tolerance, withdrawal, loss of control, unsuccessful attempts to control use, great amounts of time spent involved with the substance, reduction of other activities because of substance use, and continued use despite knowledge of physical or psychological harm.*

Florentine et al. (1998) found a positive correlation between frequency of loud music listening and higher MML score. 8 out of 90 participants (9%) met the criteria for MML. In discussing these findings, the researchers made note of the limited amount of knowledge pertaining to music withdrawal. The *DSM-IV* (APA, 1994) notes that a nicotine addict will experience four or more withdrawal symptoms within the first 24 hours of nicotine deprivation. These symptoms consist of depressed mood, insomnia, irritability, anxiety, difficulty concentrating, restlessness, decreased heart rate, and increased appetite or weight gain. The research noted the remarks of three individuals who experienced symptoms such as depressed mood, irritability, moodiness, and lethargy when they stopped listening to loud music (Florentine et al., 1998). These symptoms disappeared when the individuals returned to listening to loud music. The results from this study provide evidence that some people may show music listening behaviors with addiction-like characteristics.

Similarly, Cockrill et al. (2011) hypothesized the potential for a MP3 player-related addiction. They explored the addictiveness of music consumption, defined by adaptations of *DSM-IV*-defined symptoms (APA, 1994), through a deprivation study and an independent

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* Per the *DSM-IV* (APA, 1994), …
Tolerance is defined as a need to markedly increase the substance to achieve the desired effect or a markedly diminished effect with continued use of the same amount of the substance.
Withdrawal is defined as a withdrawal syndrome or consumption of the substance to avoid withdrawal symptoms.
Loss of Control is defined as the substance being used often in larger amounts or over a longer period than intended.

questionnaire survey. In the deprivation study, twelve young adults withheld use of their MP3 players for one week. Reports found that most participants changed their routine to deal with this aural absence: Some individuals found music from alternative sources, while over half the participants believed certain parts of their lives would have been enhanced by their MP3 players. They experienced addictive symptoms such as craving and reduced interest in other activities as a result of not being able to use their MP3 players. One respondent to the deprivation study reported, "I missed my iPod and even cracked mid-week. I thought this would be simple and fun… didn't enjoy this thing but did learn more about me," while another wrote, "I never thought I used my iPod or iTunes so much… I really did not enjoy my workouts as much this week and work was more dull without my music" (Cockrill et al., 2011).

Adapting the *DSM-IV*'s symptoms for substance-related addiction (APA, 1994) to a music listening context, Cockrill et al. (2011), like Florentine et al. (1998), used a questionnaire survey to assess behavior. Prompts such as "Do you use your MP3 player/iPod for longer than you intended?" and "Does your job or study performance suffer because of iPod use?" related directly to addiction-related symptoms as they were assessed in the *DSM-IV* and are currently assessed in the *DSM-V* (APA, 1994; APA, 2013). The study concluded that music consumption manifested itself as an addictive behavior in a subset of the population, with researchers finding "a high level of addictive elements when it comes to MP3 player use" and a positive correlation between younger age and addictive symptoms (Cockrill et al., 2011).

While it was a lifestyle choice and means of enhancing daily life for most, some people experienced negative consequences in their lives and the lives of those around them. These negative consequences were the result of excessive music listening. Interestingly, Chinese males reported the most addiction-like symptoms. There was also a significant difference between

addiction and social impact, which implied that these were genuine differences. The researchers made note of collectivist versus individualist cultural differences as potentially skewing the ways in which individuals rated their behavior. Ultimately, Cockrill et al. (2011) concluded that MP3 consumption could be an addictive behavior with negative and unhealthy consequences on an individual's lifestyle, and that further research pertaining to the addictiveness of music consumption was needed to further assess the effects and significance of their results.

A Framework for Music Listening Addiction

The body of work on music and music listening's effects on brain and behavior suggests that a subset of the population is susceptible to a 'music listening addiction' akin to the music-related addictions proposed by Florentine et al. (1998) and Cockrill et al. (2011). This proposed 'music listening addiction' (MLA) complies with the multimodal definition of addiction as a mental, physical and behavioral affliction. MLA differs from the previous proposed addictions; whereas Florentine et al. (1998) studied loud music listening and Cockrill et al. (2011) studied MP3 player use, MLA refers specifically to the act of listening to subjectively pleasurable music. Rather than hypothesize the existence of MLA, this paper proposes a diagnostic framework for MLA and a test for one piece of that framework.

Under the proposed framework, MLA is defined by *uncontrollable, compulsive music seeking and use, even in the face of negative health and social consequences*. Previous research suggests that an estimated 8-12% of any population may be expected to exhibit symptoms. One hypothetical method of testing the symptoms of such a framework is through the adaptation of eleven addiction symptoms listed in the *DSM-V* (APA, 2013). A list of these symptoms can be found in Appendix A. These behavioral symptoms derive from a physiological need to listen to music, which finds its routes in neuroplastic changes.

Several safeguards and tests of internal validity can be exercised to ensure that such a questionnaire reflects accurate data. For example, Bellegarde and Potenza (2010) showed that the personality traits of impulsiveness and sensation-seeking are heavily prominent in addicts, and indicated that these features may be a means of testing for vulnerability to addiction. Impulsiveness and anxiety are facets of neuroticism as defined by the Big Five Inventory personality test (Srivastava, John, Gosling, & Potter, 1999), and excitement-seeking is a facet of extraversion. However, openness to experience is the most prevalent personality trait amongst individuals who prefer specifically listen to music for emotional regulation, so a mix of these three personality traits, would be expected along with behavioral symptoms of MLA. A personality test is one way of checking for internal validity.

It was hypothesized that these behavioral MLA symptoms can be accurately assessed through a questionnaire study. The 'Music Listening Addiction Symptoms Test' (MLAST) was developed to test for MLA, with a personality test used as a test of internal validity. The questionnaire was distributed amongst a sample college-aged population. The discussion section features an analysis of the questionnaire's findings, an assessment of MLA's impact and effect on society, and recommendations for future studies of MLA.

Method

Participants

This research intends to expand the current breadth of knowledge on music listening behavior by evaluating individuals' interaction with music as it relates to personality type and dependence. Participants were recruited via email and social media. Out of a total 330 participants, 61%, or 196 respondents (114 women, 78 men, 4 other, M_{age} = 20.22, age range: 18-24) provided valid and useable information. Demographic data including gender, ethnicity

and musical background were collected, as previous research suggests that differences in these characteristics may affect one's relationship with music (Cockrill et al., 2011).

To account for cultural and age-related differences, the participant pool was limited to current undergraduate students attending school within the United States. One hundred forty-one (72%) respondents attended Tufts University, while fifty-five (28%) respondents attended a different institution. One hundred sixty-one (82%) respondents reported having musical training, while thirty-five (18%) respondents lacked any musical training. Of those respondents with musical training, seventy-two (45% of the subgroup, 37% of total) were still playing an instrument and eighty-nine (55% of the subgroup, 63% of total) were not.

Materials and Procedures

This study was administered online in the form of a self-reported questionnaire. An introductory message was used to recruit students from Tufts University and other undergraduate institutions through e-mail and social media outlets. Participants accessed the questionnaire via a hyperlink in the introductory message's body. The study's opening page consisted of a consent form. Participants indicated their consent by selecting a button marked "Yes, I agree to participate." The questionnaire began on the following webpage.

The questionnaire, a version of which can be found in Appendix A, consisted of four main sections relating to demographics, music interaction, personality, and addiction. The demographics section collected general background data used for verification of the participant's eligibility and cross-demographic data comparison. Demographic data included age, gender, race/ethnicity, and current college or university.

The music interaction section collected data on participants' musical background. This included musical training, continuity of musical training, and average amount of musical practice

per week. This section also collected information regarding participants' relationship with music. This included the time of day and amount of time spent listening to music, preferred method of listening, preferred music styles, and situations in which one listened to music.

The personality section collected data on participants' personality types. This was measured through the 44-question Big Five Inventory (Srivastava et al., 1999). This utilizes a scale of 1-5, where a response of 1 indicates "strongly disagree" and a response of 5 indicates "strongly agree."

The final section on music listening behavior consisted of two subsections of questions. The first part provided participants with an opportunity to self-report the effect of their music listening behaviors on aspects of their lives. Some questions were specifically designed for college-aged students. For example, a yes-or-no question asked, "Are there certain situations in which you need to listen to music, e.g. when studying or going to sleep?" A follow-up prompted further, "Why do you think you have this need, and what impact has it had on your life?" Three other questions asked whether listening to music had ever had a negative effect on performance in school, social life, or family/private life.

A series of 31 questions and statements followed in the second part of the music listening behavior section, the MLAST. Designed to be indicative of a music listening addiction, many of these prompts were adapted from Cockrill et al.'s (2011) survey on MP3 player use. Additional questions were developed independently to account for specific symptomatic criteria. Participants answered prompts in this section using a 6-point scale, where an answer of "1" indicated *never*, "3" indicated *sometimes*, "5" indicated *always*, and "0" indicated *not applicable*. A debriefing statement with study and contact information was included at the end of the questionnaire.

Results

Analysis focuses on behavioral indicators of music listening addiction (MLA). Presence of MLA symptoms was assessed in two parts: Symptoms were collected and analyzed through the MLAST, and checked according to reported need to listen to music. Music listening need (MLN) was measured in responses to yes/no and open-answer questions that came before the MLAST.

Participants' responses to 29 out of the 31 prompts in the music listening behavior section of the questionnaire were summed, and composite scores over one standard deviation from the mean were highlighted as showing greater symptoms of MLA. Based on the MLAST, thirty-one participants (16%) indicated signs of MLA behavior (overall: $M = 60.70$, $SD = 17.58$; MLA: $M = 89.23$, $SD = 11.14$; Non-MLA: $M = 55.35$, $SD = 12.73$). For the purposes of analysis, these higher scoring participants were labeled the "MLA group," with the non-high scoring participants labeled the "non-MLA group." Refer to Appendix B for more information.

Individual average responses of the MLA group were analyzed. These responses were compared to the average responses of the non-MLA group, as well as amongst other responses in the same group. Nineteen average responses from the MLA group were significantly greater than the non-MLA group averages. These responses accounted for ten out of the eleven symptoms. A statistically significant different was not found on answers to three questions pertaining to '*a persistent desire or unsuccessful efforts to cut down or control music listening*.' This indicates that individuals do not perceive music listening or excessive music listening as harmful.

Amongst the MLA group itself, seven questions covering four MLA criteria garnered significantly higher responses than the average MLA group response ($M = 3.08$, $SD = 0.92$),

indicating an increased salience of the underlying symptoms. Three of these questions related to *withdrawal symptoms*, two related to *tolerance*, one related to *longer than intended activity*, and one related to *cravings*. Three prompts were significantly higher than both the average MLA group response and the average non-MLA group responses to those prompts. The average MLA group response was 3.08 (*SD* = 0.91, 1^{st} *SD* = 4.00). For the prompt, "I have a craving or strong desire or urge to listen to music," MLA group scores averaged 4.06 (*SD* = 0.93) compared to the respective non-MLA group scores (*M* = 2.39, *SD* = 1.24, 1^{st} *SD* = 3.63). For the prompt, "I must listen to music at some point during the day," MLA group scores averaged 4.29 (*SD* = 1.13) compared to the respective non-MLA group scores (*M* = 2.56, *SD* = 1.45, 1^{st} *SD* = 4.29). For the prompt, "Do you listen to music for longer than you intended?" MLA group scores averaged 4.00 (*SD* = 1.41) compared to the respective non-MLA group scores (*M* = 2.42, *SD* = 1.33, 1^{st} *SD* = 3.75).

Six MLA group average responses were significantly greater than the first standard deviation of the overall group response, indicating a significantly increased salience of the underlying symptoms in the MLA group. Two of these prompts related to *continued music listening despite it causing recurrent problems*, one related to *withdrawal symptoms,* one related to *great amounts of time spent in activities related to music listening*, one related to *cravings*, and one related to *reduced activities because of music listening*. MLA group members reported higher feelings of loss, restlessness and irritability, and withdrawal from situations when they had not been listening to music. They were more preoccupied by music, they were more likely to prefer to listen to music than spend time with others, and they were more likely to crave listening to music than were non-MLA group members.

Overall, four prompts had higher overall averages, MLA group averages, and non-MLA group averages, indicating a greater salience for those symptoms than other MLA symptoms for all participants. Three of these prompts related to *withdrawal symptoms* and one related to *tolerance*. The overall average for all prompts was 2.09 (*SD* = 0.79). The non-MLA group average for all prompts was 1.9 (*SD* = 0.78). The overall average for the *withdrawal symptom* prompt, "Do you think about music even when you are not listening to any?" was 3.34 (*SD* = 1.31; MLA: *M* = 4.32, *SD* = 0.79; Non-MLA: *M* = 3.32, *SD* = 1.31). The overall average for the *withdrawal symptom* prompt, "I feel that life without music would be boring, empty and joyless," was 3.79 (*SD* = 1.36; MLA: *M* = 4.52, *SD* = 0.77; Non-MLA: *M* = 3.65, *SD* = 1.41). The overall average for the *withdrawal symptom* prompt, "Listening to music makes boring activities more tolerable" was 4.14 (*SD* = 1.05; MLA: *M* = 4.61, *SD* = 0.67; Non-MLA: *M* = 4.05, *SD* = 1.08). The overall average for the *tolerance* prompt, "Do you listen to music to escape from negative thoughts or feelings?" was 3.01 (*SD* = 1.30; MLA: *M* = 4.00, *SD* = 1.10; Non-MLA: *M* = 2.82, *SD* = 1.25).

Responses concerning music listening need (MLN) were analyzed and cross-examined with participants' MLAST scores. One hundred two participants (52%) reported there being certain situations in which they needed to listen to music. There was no correlation between the MLA symptom scores and responses of music listening need (MLN), as can be seen in Figure 3. Specific situations of music listening need included several daily activities, such as commuting, bathing, studying, going to sleep, and exercising. Underlying reasons for such behavior were categorized into five groups. Participants responded that music helped to motivate them, focus them, provide a distraction, manipulate their mood, or 'other'. Many participants also indicated that they believed music had an overall positive impact on their lives, or that their use of music

contributed to the enhancement of their experiences. Some responses included mentions of other pleasurable activities done in conjunction with listening to music, such as singing and dancing. For example, one respondent reported it being "uplifting to sing along" to that person's favorite music.

Individual explanations for MLN were examined for indications of associative learning between music and emotion, along with individual behavioral symptoms such as craving. Thirty-seven responses (19%) indicated an association between music listening and emotion. There was no correlation between the MLAST scores and this association.

MLA group scores were cross-referenced with participants' open-answer responses MLN. Twenty-one participants (11%) indicated both MLA behavior and MLN. Ten (5%) of these twenty-one respondents' MLN explanations indicated associative learning between music and emotion. Of these, five responses specifically noted that music served a role in pleasure reinforcement. These participants' explanations for their music listening needs were unique from the other MLN categories of motivation, focus, distraction, and mood manipulation. Some reported not understanding their need for music or becoming depressed or disinterested without a musical stimulus. One participant reported, "…If I feel like current circumstances are too much for me to handle, I get the feeling that music is the only thing that surely won't let me down or judge me, and that I won't bother with my inability to handle things." Another wrote, "I have to listen to something at least once a day, regardless of situation," explaining: "If I don't, I get bummed out/depressed." A third respondent noted, "I sort of always need to be listening to music. If I'm not presently listening, I generally actively think about wanting to," but provided the caveat, "That being said, there are very few times in which I can't actually function without

music." This respondent also mentioned family background as having a significant impact on the respondent's relationship with music.

Some participants in the non-MLA group reported symptoms of MLA in their responses to the open-answer MLN questions. For example, one participant with an average MLA score of 55 reported, "I need to listen to music for at least some time every day, otherwise I feel like something is missing." This suggests the presence of significant withdrawal symptoms, which were found to be more salient that other symptoms in the overall population.

Few people responded to having academic/work, social, or family/private issues as a result of music listening. Thirty (15%) respondents reported music ever having a negative effect on performance in school, fourteen (7%) respondents reported a negative effect on social life, and 12 (6%) reported a negative effect on family/private life. There was no correlation between any of these three variables and MLAST score, as can be seen in Figures 5-7.

Personality type was measured through the Big Five Inventory, and correlations were examined between personality type and behavioral MLA scores. Of the 44 (22%) respondents measuring highest in extraversion, eight (18% of 44) reported symptoms of MLA. Of the 27 (14%) respondents measuring highest in extraversion, four (15% of 27) reported symptoms of MLA. Of the 33 (17%) respondents measuring highest in extraversion, zero reported signs of MLA. Of the 32 (16%) respondents measuring highest in neuroticism, three (9% of 32) reported signs of MLA. Lastly, of the 33 (17%) respondents measuring highest in openness, twelve (36% of 33) reported signs of MLA. The sample sizes for participants exhibiting greater extraversion and neuroticism were too small for an accurate correlative assessment between personality type and MLA.

In response to time spent listening to music per day, 42 (21%) participants reported 0-1 hour, 75 (38%) participants reported 1-3 hours, 47 (24%) participants reported 3-5 hours, 20 (10%) participants responded 5-7 hours, and 12 (6%) participants responded 7+ hours. 112 (57%) participants reported listening to music when they needed an escape.

Correlational data was tested for between MLAST score and other characteristics and behaviors. MLAST score and time spent listening to music on a daily basis were strongly correlated, $r(194) = .505$, $p < .01$. . This correlation can be seen in Figure 4. There was also a strong correlation between MLAST score and the number of activities performed while listening to music, $r(194) = .517$, $p < .01$. A statistically significant difference did not exist between MLAST score and gender or MLAST score and musical training. Increased time spent listening to music alone was not correlational to MLAST score, with 26% of participants reporting 70-80% of music listening time spent alone.

Discussion

In supporting the framework for a proposed 'music listening addiction' (MLA), the hypothesis expected the MLAST to provide an accurate and reliable assessment of MLA behavioral symptoms as defined by the framework. While the MLAST indicates the prevalence and prominence of MLA behavioral symptoms across a population, it does not provide a reliable assessment of MLA. As a self-reported questionnaire, the MLAST does not offer direct evidence of behavioral MLA, nor does it allow for further reworking of indicative symptoms based on its results. Since the theoretical framework for MLA is based off presupposed symptoms, any test of those symptoms should show consistency between MLA-related results and tests of internal validity. The MLAST does not display such consistency; hence, while its results demonstrate the

existence of MLA symptomatic behavior in the subset of a population, they are suggestive rather than definitive.

Confounding variables in this study include issues with data collection, time constraints, and test type. Participants were mainly recruited through social media such as e-mail and Facebook posts. While this was accompanied by emails to and announcements in undergraduate psychology classes, recruitment from any social media platform is restrictive and results in a skewed sample population. Nineteen participants took longer than sixty minutes to complete the questionnaire, while the other participants took an average of fourteen minutes (*SD* = 8:00) to complete it. While some of the nineteen participants completed the study in between one and three hours, others took multiple days to complete it. This and the inability to maintain constancy of condition are two significant environmental confounding variables in this study. Progressive error was counterbalanced for individual sections, but not across the study as a whole. Nearly 40% of the total 330 responses had to be ignored because those participants did not provide any responses to the music addiction section, which was presented at the end of the questionnaire. While the length of the survey was estimated to be between 10-15 minutes and the average response time was 14 minutes, a significant number of participants were evidently not motivated to complete the survey. Experimenter bias, especially concerning responses pertaining to anxiety and need, was controlled for via lack of experimenter presence, but this also resulted in the loss of a substantial amount of potential data. As this was an online survey, the responses were taken in good faith that respondents were truthful and honest. However, some responses were of a jocular nature. While these responses were already discounted, it is impossible to know whether other participants also failed to take the questionnaire seriously. These confounds illuminate the inherent problems with complex online questionnaires. Future studies of MLA should be

controlled for by a double-blind system where the participant and researcher do not know each other, and neither the participant nor the researcher knows the purpose of the study.

The discrepancies between this study's findings and previous music addiction-related findings suggest errors in this study's testing method. The lack of a correlation between the MLAST questions and responses to music listening need is troubling, considering need is a significant behavioral manifestation of MLA. Participants with average and low MLAST scores also reported needing music for emotional regulation, indicating the possibility of statistical errors in the MLAST scoring system or testing errors in the wording of individual prompts. Florentine et al. (1998) used a similar total number of 31 items to test for 'maladaptive music listening,' but a very different system of scoring assessment, with the assignment of weighted values to individual questions. Contrastingly, in Cockrill et al. (2011), responses were assigned to the behavioral symptoms they displayed, and addition was evaluated on tiers depending on the number of displayed symptoms. A reevaluation of the scoring method for the MLAST and a reassessment of its questions could reveal more information from the current data and help further the construction of a thorough framework for behavioral MLA-related evaluation.

These confounding variables should not obstruct the extraction and analysis of this study's findings. The results of the MLAST imply that certain individuals exhibit many of the behavioral symptoms of the proposed framework for MLA. The presence of these symptoms should indicate that certain people have a propensity or vulnerability to MLA. However, analyses of the MLAST and MLN results show that individuals do not view their 'needs' and addictive symptoms as problematic or harmful. Degrees of perceived harmfulness differ amongst individuals, as was indicated by Cockrill et al. (2011). This complicated the assessment of 'harmful' music listening effects. The majority of open-answer explanations referred to

interpersonal discrepancies in musical taste, resulting in a sense of separation, and music listening distracting individuals from work and other goals. In the extreme, these instances might manifest themselves as social isolation, alienation, or worsened grades, but such experiences were not evident from participants' responses. People do not view music listening as harmful to their general quality of life.

Members of the MLA group who reported strong needs for music display risky use of music as a means of escape. The use of music as an especially salient means of mood regulation amongst anxiety-prone individuals indicates that this minority of the participant pool, while small in representation, does exist in the greater populace. The use of music as a means of escape suggests that the underlying motivation to listen to music is to evade depressive feelings. Koob and Volkow (2009) proposed that addiction arises from a shift in positive reinforcement-based impulsive behavior to negative reinforcement-based compulsive behavior as the motivation for the reward sensation changes from optional/recreational to 'necessary' (Koob & Volkow, 2009). Further research on music and mood regulation must turn a critical eye toward those who use music as an escape because the continuous reinforcement of music as the primary means of avoiding, for example, depressive symptoms, could potentially result in the compulsive use of music to avoid depressive symptoms. A theoretical cascading cycle of needing increased amounts of music to stop feeling bad and to start feeling good would be a reliable indicator of MLA. Less than 10% of participants reported 'needing music to feel good', but those who did indicated strong addictive symptoms.

MLA group and non-MLA group members described music as having an undeniably positive effect on their lives, regardless of the context. This suggests that MLA symptomatic behavior does not have a negative impact on, nor does it detract from, the overall individual

experience. The positive effects of music are corroborated by studies on music and emotion, as well as the individual reports from Florentine et al. (1998), where loud music listeners who had been deprived of loud music stimuli experienced a reduction in proposed maladaptive music listening symptoms once they began listening to loud music again.

The MLAST cannot directly examine the effects of music deprivation. It is a survey of individuals' past and present responses to music stimuli, and its questions capture the conceptualizations of eleven theorized behavioral symptoms. The framework definition of MLA is *uncontrollable, compulsive music seeking and use, even in the face of negative health and social consequences*. The current findings show little indication of the definition's second half. Since individuals do not perceive these symptoms as malignant, the MLAST can only support MLA as *uncontrollable, compulsive music seeking and use*. The MLAST, therefore, is a poor means of examining the negative aspects of MLA; in other words, it tests for the presence of behavioral symptoms without testing the effects of those behavioral symptoms on the individual.

Addiction is easier to observe when in the absence, rather than in the presence of the stimulus. Kalivas and Volkow (2005) determined the "cardinal behavioral feature" of drug addiction to be continued vulnerability to relapse after years of drug abstinence, asserting that vulnerability comes from an intense desire for a stimulus and reduced capacity to control that desire. Repeated use of addictive stimuli induces reorganization of neural circuits that results in the establishment of behaviors characteristic of addiction. An afflicted individual craves the stimulus because he believes that is the only way of attaining what he desires - a physiological state. Cravings and other behavioral symptoms of addiction are observed best, therefore, when the individual is not using or affected by the addictive stimulus.

The results from the MLAST suggest that individuals experience greater negative symptoms in the absence of music than in the presence of music. However, the MLAST does not show whether individuals act upon these negative symptoms in such a way that would characterize a condition of addiction rather than physiological dependence. The difference between these two conditions, as stated earlier, is that dependence is an "expected neuroadaptive consequence" while addiction is characterized by compulsive use despite risk and harm (Koob & Moal, 2005). Individuals may have an ingrained linkage between music and pleasure, but if they are deprived of music for enough time, a dependency and related symptoms will go away, whereas an addiction and related symptoms will remain. A deprivation study can facilitate both the examination of behavioral symptoms in the absence of music and a subsequent reworking of the framework for MLA.

Proposal #1: Music Deprivation Study

One proposed means of testing the framework for MLA is a deprivation study. As previously mentioned, society is saturated with music. It is accessible through mobile devices, radios, social media, YouTube, and more. Testing for a possible music listening addiction is made difficult by this ever-present nature and easy attainability. It can more easily be done through a deprivation study similar to the one run by Cockrill et al. (2011). Through such an experiment, subjects would not listen to music for either one or two weeks, and their mood and behaviors would be observed. These extensive amounts of time are important to allow for any lingering effects of music to wear off, and for the musical absence to set in. Over 50% of participants reported feeling a need to listen to music at some point during the day. When this is understood as reflecting the desires for different physiological goal states, the question that arises is whether or not individuals find alternative means of fulfilling these desires, or if symptomatic

behaviors such as *cravings*, *reduced activities due to lack of music*, *withdrawal*, and *failure to fulfill obligations* increase in presence.

It is important to note this hypothesized alteration of MLA behavioral symptoms: The presentation of harmful behavioral symptoms is expected to occur due to lack of music, rather than presence of music. An addiction diagnosis, argues Kalivas and Volkow (2005), might relate to how importance is attached to stimuli that predict the availability of an addictive stimulus and how the brain determines behavioral output in response to those stimuli. Addictive drugs create sharp, marked 'highs.' Gambling creates 'highs', but in the United States, it is not a constantly accessible activity. Unlike these stimuli, music is universally accessible for many Americans. A deprivation study will show whether symptoms of MLA are present to a greater degree when music is unavailable, thereby preventing the individual from achieving desired physiological states, or when music is available and desired physiological states can be achieved.

An outline of the proposed deprivation study is provided. Participants would consist of undergraduate students looking to fulfill credits for an introductory psychology course.[*] Participants would be instructed to refrain from listening to music and to avoid situations where music is especially salient for one/two weeks' time. Upon their agreement to the study, participants would fill out a questionnaire assessing MLA behavioral symptoms and gathering information on participants' music listening behaviors, both overall and in the past week. As was done in Cockrill et al. (2011), participants would be prompted to write about their general mood

[*] Getting 50+ college students to refrain from listening to music is daring, but maintaining consistency within a single age group is an important facet of this study. Satisfying course requirements is a standard reward for participating in a study. Non-students would be less likely to participate with a reward, and a deprivation study using money might skew the results based on the presence of this external reward. That said, it may be interesting to see if there is a difference in MLA behavioral symptoms between students who receive monetary rewards and those who receive course credit.

and experience every day. However, instead of keeping a diary, participants would fill out an identical form; this standardization minimizes potential confounds. To test for changes, the study could simultaneously examine a control group with no music listening deprivation, or the same music-deprived group could be monitored for a set time once they began listening to music again. Not only would this deprivation study test for MLA behavioral symptoms, but it also would provide information important to the potential restructuring or reexamination of the theoretical MLA framework.

Developing an Accurate Neurological Framework

A major setback to the framework of MLA is a lack of relevant neurological data. MLA manifests itself as a neurological, physiological and behavioral affliction. Research, however, has thus far been primarily focused on finding evidence of a music-related addiction's existence through exploratory behavioral studies. These studies are exploratory because they seek evidence for a supposed condition; there is little reason to invest in expensive neuroimaging equipment without proof that MLA exists. *Proposal #1* is another such exploratory study, and if its findings support the behavioral framework for MLA, then there will be a greater impetus for neurological and physiological testing.

The neurological development of MLA is expected to be similar to the neurological development of gambling and drug addictions. However, as music affects a far greater and more complex neurological network than do these addictive stimuli, testing the activations of and interactions between the reward system and the executive system will be a complex and costly task. However, an understanding of the relationships between these neurological systems and a series of tests for neuroplastic change in the reward system are crucial to the continued development of an accurate neurological framework for MLA.

Complications to the Neurology of MLA

A major issue in the theoretical neurological development of MLA must be resolved. This concerns a discrepancy between the current neurological bases for substance and behavioral addictions and their application to MLA. Based on Kalivas and Volkow's (2005) findings, the transition from recreational and casual drug use to addiction is associated with "changes in neuron function" that accumulate with repeated administration and diminish over days or weeks after discontinuation of drug use. The absence of the addictive stimulus is therefore fundamental to the development of an addiction.

This necessary absence poses a problem for the understanding of music listening as an addiction. Music, per this study's findings, was listened to on a daily basis by over 70% of the population, with 38% of respondents listening to music for 1-3 hours daily and 24% of respondents listening to music for 3-5 hours daily. It is therefore possible that the continuous presence of music in our daily lives actually prevents the development of a music listening addiction. While situations may occur wherein an individual wants to, but cannot listen to music, this absence does not compare to drug use or gambling, both of which are also far more expensive to sustain than music listening. Drug use, in addition to being an expensive activity, is also generally bad for one's health in large quantities, whereas music, per this study's findings, does not seem to have a negative impact on physical health when listened to in large doses.

If this study's findings are accurately representative of the population, then most people choose to listen to music on a frequent basis. Music is rarely absent in people's lives. This calls into question the external validity of any deprivation study because people rarely abstain from listening to music for the long temporal periods used in *Proposal #1*'s multi-day and multi-week deprivation studies.

The relationship between time lapse and addiction poses another issue, this one having to do with the lack of neurological research concerning the effects of music deprivation on neuroplasticity in the brain. How much time is needed for the effects of music deprivation to take place on a neurological, physiological, and behavioral level? Even with drugs, there is little continuity between frequency of drug administration and the transitions between Kalivas and Volkow's (2005) stages of addiction. The present study found a positive correlation between time spent listening to music and signs of MLA. Listening to music on a more frequent basis means that one spends less time in the absence of music. However, this does not mean that the amount of time spent without music had a significant effect on higher frequency of music listening and other behavioral symptoms. *Proposal #1* uses weeks to measure the development of behavioral MLA symptoms, but it could be that some people begin to develop symptoms within hours of musical absence. This is especially true for members in the MLA group, where the prompts "I must listen to music at some point during the day," "I have a craving or strong desire or urge to listen to music," and "Do you listen to music for longer than you intended" garnered especially high responses. A multi-level deprivation study testing for the development of MLA behavioral symptoms over different amounts of time will show whether a temporal aspect is worth evaluating on a deeper level.

The effects of a deprivation study are best examined on a neurological level. MLA group respondents who reported statements like "If I don't [listen to music], I get bummed out/depressed" may have a greater biological vulnerability to stimulus-based neuroplastic change, and as such may actually be at risk for developing a music listening addiction. The factors involved in this vulnerability would be temporal-based; certain neurobiological adaptations in at-risk individuals could make it so that music need only be absent for a few hours

in order for the changes in Kalivas and Volkow's (2005) proposed stages of addiction to take place.

Proposal #2: Music Deprivation Neurological Study

Neurological research is needed to better assess the effects of the absence of music on the reward system. A neuroimaging study of individuals deprived of music will provide crucial details on the effects of the absence of music on the brain. Signs of a propensity for music listening addiction may include induced changes in cell signaling, as well a higher presence of glutamatergic receptors in the nucleus accumbens. The onset stage of addiction, characterized by induced changes in cell signaling, specifically involves the induction of "immediate early gene products, such as cFos" (ibid.). These promote short-term neuroplastic changes that last between hours and days. Specific neuroimaging of the amygdala, nucleus accumbens, and the prefrontal cortex during a deprivation study akin to that in *Proposal #1* may shed light on the neurological effects of a prolonged musical absence, along with a better understanding of what a 'prolonged absence' entails.

Implications of MLA and its Societal Import

The proposed framework for MLA requires more information on the temporal aspects of music deprivation on the brain. If the deprivation studies indicate a significant increase in MLA symptoms during more-than-normal abstinence from music, then it can be confidently assumed that the frequent listening behaviors of most individuals prevent them from developing music listening addictions. Through a strange twist of fate, this means that frequent listening to music may actually preclude the key neurological changes characteristic of substance and gambling addictions from taking place.

While few individuals may actually be addicted to music, the fact that music activates circuits involved in different types of addictive behaviors, in conjunction with this study's findings, suggests that the propensity for a music listening addiction exists amongst a subset of the population. The notion that music listening, a means of positive reinforcement in the reward system that poses little risk or harm to the majority of the population, regardless of excessive practice, can also be addictive has important implications, as well as practical applications to both drug/addiction therapy and addiction research.

A growing number of studies praise music for its many positive psychological and physiological effects. Music has positive effects on reward, motivation, pleasure, stress, arousal, immunity, and social affiliation (Chanda & Levitin, 2013; Sandstrom & Russo, 2010). Music has been used therapeutically to improve mood symptoms and depressive symptoms (Mas-Herrero et al., 2013). Pleasurable music listening may also be helpful in drug and addiction therapy. Since music listening activates the same reward system as addictive stimuli, it may be possible for music listening to be employed as a substitute for addictive drugs or gambling. This substitution would take advantage of the addiction-related neuroplastic changes by ideally turning pleasurable music into the addictive, reinforcing stimulus. The benefits of such a treatment are that music 'therapy' is cheap, noninvasive, it has minimal side effects, and it is inexpensive. Initial research on the use of music listening as a means of providing drug addicts non-drug-induced emotions was studied by Baker, Gleadhill, and Dingle (2007). Their research on music therapy in the treatment of substance use disorder was met with positive results. Music therapy facilitated the experiencing of predominately positive emotions, and these emotions were experienced to either a moderate or high degree. Moreover, participants reported that music

therapy was beneficial in allowing them to experience emotions without the need for substance use.

Music is a 'natural' high, and while the substitution of addictive drugs or gambling for pleasurable music does not directly solve the problems inherent to addiction, it does solve the problems inherent to gambling and drug addictions. Since pleasurable music listening offers fewer risks and dangers than compulsive drug use and pathological gambling, a music listening addiction is far safer and healthier than a drug or gambling addiction. Music, when listened to even on an extremely frequent basis, is both beneficial and relatively harm-free. In this sense, music listening addiction can be viewed as a positive addiction. While neuroimaging and behavioral studies should confirm the differences and similarities between the effects of pleasurable music and addictive drugs in the activation of the addict's reward system, current research suggests an overlap in neural activation that could be useful in drug and addiction therapy.

Further insight into music's role in reward circuitry may be very beneficial to addiction research. Gambling addicts have a higher propensity for drug addiction. Similarities between music listening and such addictive stimuli therefore beg the question, "Can MLA or a predisposition to MLA be indicative of a predisposition to drug addiction and gambling addiction?" If so, then MLA may have a beneficial indicative presence, with behavioral MLA symptoms being used as warnings of more dangerous vulnerabilities. Hence, preventative measures can be used before further addictions or risky behaviors occur.

Concluding Remarks

While MLA poses few overall dangers to the individual, its presence has important implications to anyone who qualifies for a positive diagnosis. Regardless of music's relative

harmlessness, a predisposition to any addiction-related affliction implies deeper biological or neurological vulnerabilities to addiction. A person with MLA is at higher risk of developing other addictions based on brain chemistry alone. For their individual safety and well-being, at-risk individuals should be aware of their own behavioral symptoms, know the signs for other addictions, and act in such a way as to ensure their vulnerabilities remain mere vulnerabilities.

As with any multimodal addiction, MLA should be taken very seriously. While it is not indicative of risky behavior in most situations, MLA can be significantly harmful and destructive in certain contexts. As was previously mentioned, a minor subset of the sample population reported needing music specifically to feel good. One respondent reported needing to listen to something at least once a day, regardless of the situation. In explaining this need, the respondent wrote, "If I don't, I get bummed out/depressed." This is potentially an instance where the impetus to listen to music comes from negative reinforcement, or the desire to reduce negative feelings, rather than positive reinforcement, or the desire to increase positive feelings. The use of music as a primary mood regulator should be considered 'risky' when music is being listened to in order to escape from negative thoughts and feelings, because music is, in this case, a temporary bandage.[*] What happens when the music stops? What if an individual's primary means of music access is cut off, like in the loss or damage of an iPod? The danger of MLA lies in what happens when the musical stimulus is no longer available, and how an individual will respond to this absence. A healthy individual would adapt to the now music-less environment and be able to seek other forms of pleasure while music was inaccessible. An at-risk individual would have trouble adapting, seek out music in a compulsive manner, and experience anxiety, discomfort,

[*] This suggests a possible comorbidity of MLA with anxiety and depression disorders.

and negative feelings, among other symptoms. Another respondent noted needing to listen to music when feeling immensely stressed out. In explaining this need, the respondent wrote:

> "I trust people shallowly and can usually rely on myself for deep emotional support, so if I feel like current circumstances are too much for me to handle, I get the feeling that music is the only thing that surely won't let me down or judge me, and that I won't bother with my inability to handle things. When I'm really stressed or sad, I listen to music, and I feel a lot better and more independent later. It enables me to feel refreshed instead of constantly on edge."

This is also indicative of the harmful effects of MLA because it implies the use of music as a primary means of ignoring situations and escaping negative feeling. Music has several positive and beneficial effects, but the propulsion to listen to music, when based on negative, rather than positive reinforcement, is harmful, and an example of how MLA can be dangerous if left unchecked.

Music holds an extraordinarily special place in society. It has powerful hedonic effects, activating multiple neural systems that work together and separately from each other to induce emotion and many other neurological and physiological responses. Much is understood about music's effect on emotional response and regulation, but at the same time, there is still much to be learned. Chanda and Levitin (2013) remarked, "Studies of the neurochemistry of music may be the next great frontier." A deeper understanding of the neurobiology of pleasurable music will aid in the continued development of a framework for a neurological, physiological, and behavioral music listening addiction.

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Appendix A

Music Listening Addiction Behavioral Symptoms

#	Description
1	Loss of control (music is listened to for longer than intended)
2	There is a persistent desire or unsuccessful efforts to cut down or control music listening
3	A great deal of time is spent in activities necessary to obtain or listen to music
4	Craving, or a strong desire or urge to listen to music
5	Recurrent music listening resulting in a failure to fulfill major role obligations at work, school, or home
6	Continued music listening despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the behavior
7	Important social, occupational, or recreational activities are given up or reduced because of music listening
8	Recurrent music listening in situations in which it is hazardous
9	Music is listened to despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by the behavior
10	Tolerance
11	Withdrawal

Table 1. MLA behavioral symptoms, adapted from the *DSM-V* (APA, 2013).

Music Listening Addiction Symptoms Test (MLAST)

#	Description	Symptom
1	Does your work or study performance suffer because of music listening?	5
2	I listen to music to avoid unwanted conversations or contacts.	6
3	Do you sometimes hide how long you have been listening to music?	1
4	I spend a great deal of time in activities necessary to obtain or listen to music.	3
5	Do you feel restless, frustrated or irritated when you cannot listen to music?	11
6	Do you prefer to listen to music instead of spending time with others?	7
7	Do you listen to music for longer than you intended?	1
8	Do you neglect your daily obligations (work, studies or family life) because you prefer to listen to music?	5
9	I feel withdrawn from situations when I am not, or have not been listening to music.	6
10	I have given up or reduced important social, occupational, or recreational activities to listen to music.	7
11	Have you ever tried and failed to cut back on time spent listening to music?	2
12	Without music, I feel lost.	6
13	Do you think about music even when you are not listening to any?	11
14	I feel that life without music would be boring, empty and joyless.	11
15	Does your family complain that you are listening to music too much?	5
16	Listening to music makes boring activities more tolerable.	3
17	I am often preoccupied by music.	3
18	I must listen to music at some point during the day.	10
19	Listening to music gives me an excuse to ignore people I do not want to talk to at a particular moment.	7
20	I need to listen to music (in increasing amounts) in order to achieve a desired state.	10
21	Are you short of sleep because you listen to music?	9
22	I need to listen to music to alter my mood.	4
23	Do your friends complain that you ignore them when you listen to music?	6
24	Do you think you should listen to music less frequently?	2
25	I lie to conceal the extent to which I listen to music	2
26	Are you unable to pay other bills because of spending too much on music/downloads?	8
27	Do you listen to music to escape from negative thoughts or feelings?	4
28	Listening to music helps me to 'block out' unwanted conversations.	7
29	I have a craving or strong desire or urge to listen to music.	4

Table 2. The MLAST tests for presence of MLA behavioral symptoms through self-reporting.

Appendix B

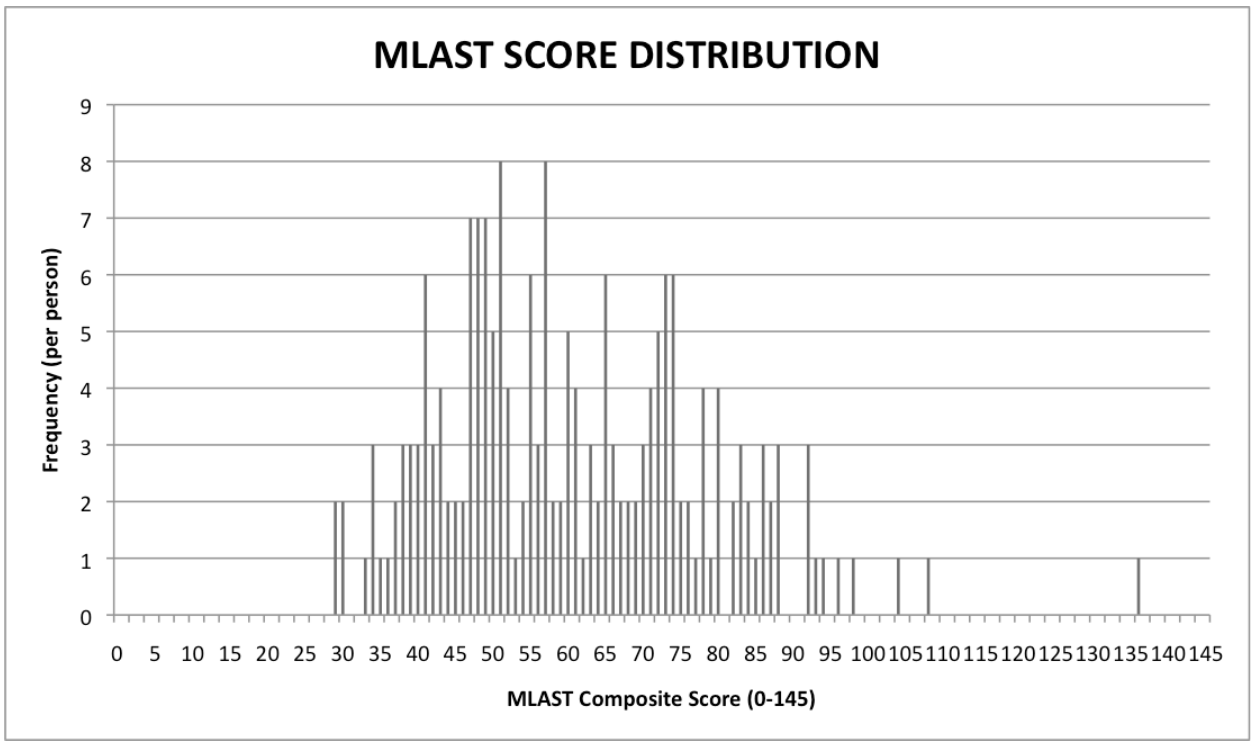


Figure 1. MLAST composite score distribution over a potential range of 0 to 145; average was 60.70 (*SD* = 17.58).

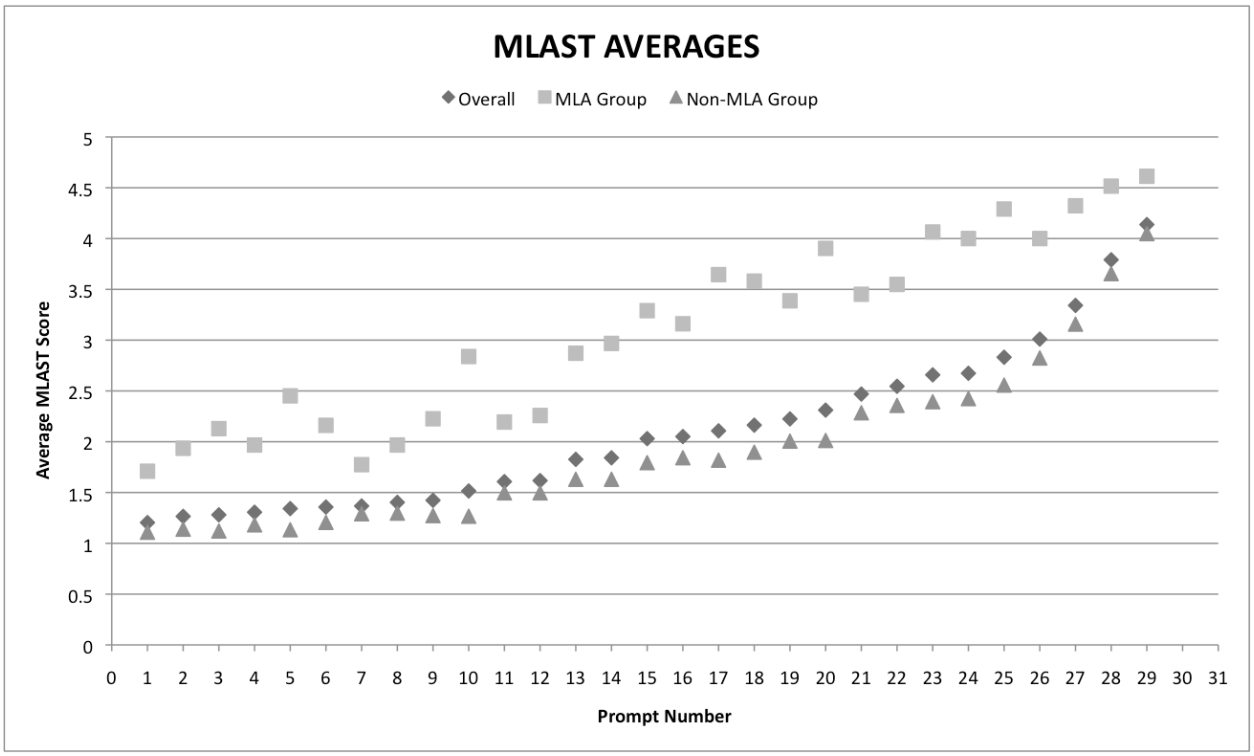


Figure 2. MLAST averages for total participant pool, MLA group, and Non-MLA group.

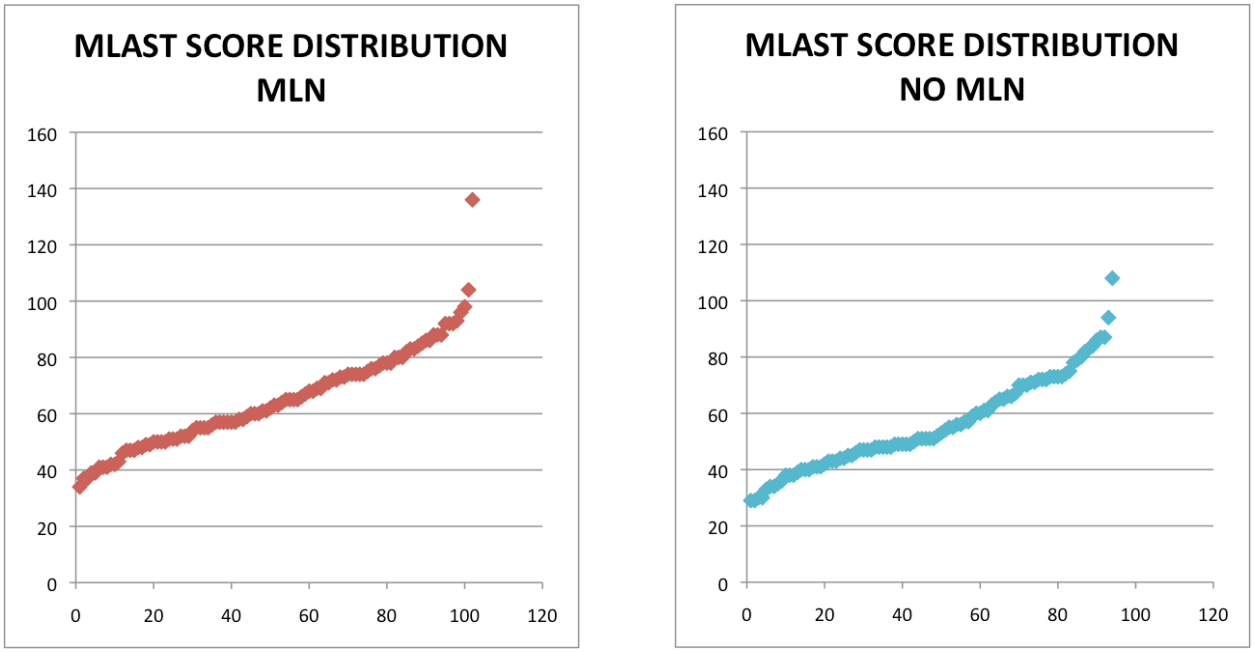


Figure 3. MLAST composite score was not correlated with reported music listening need.

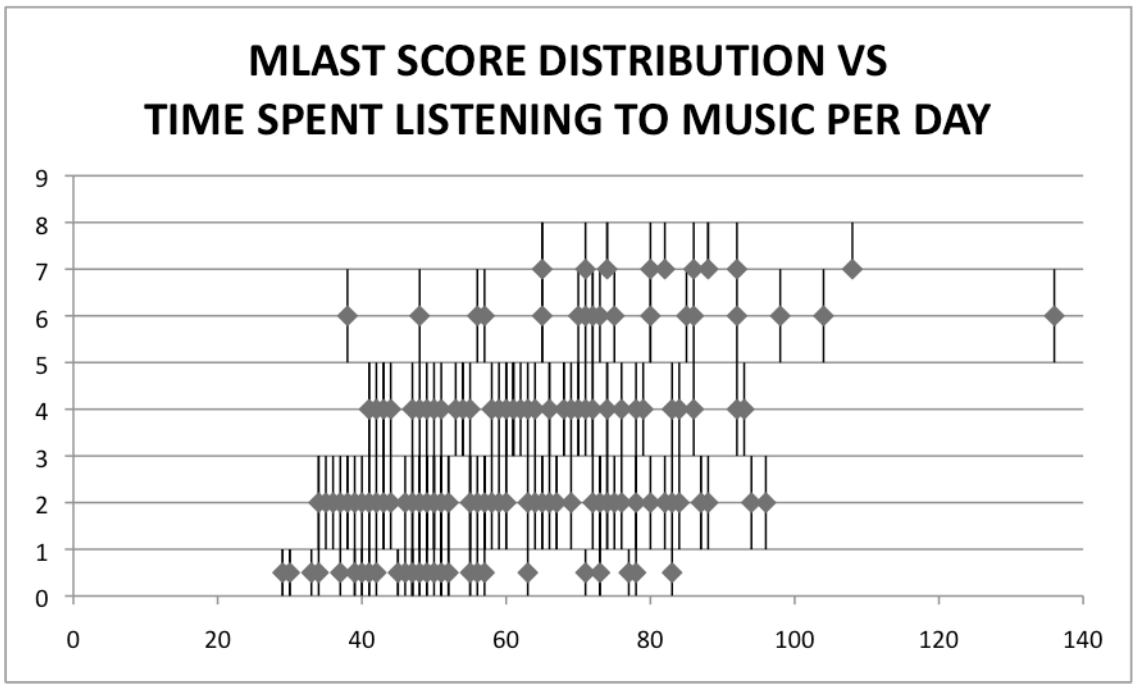
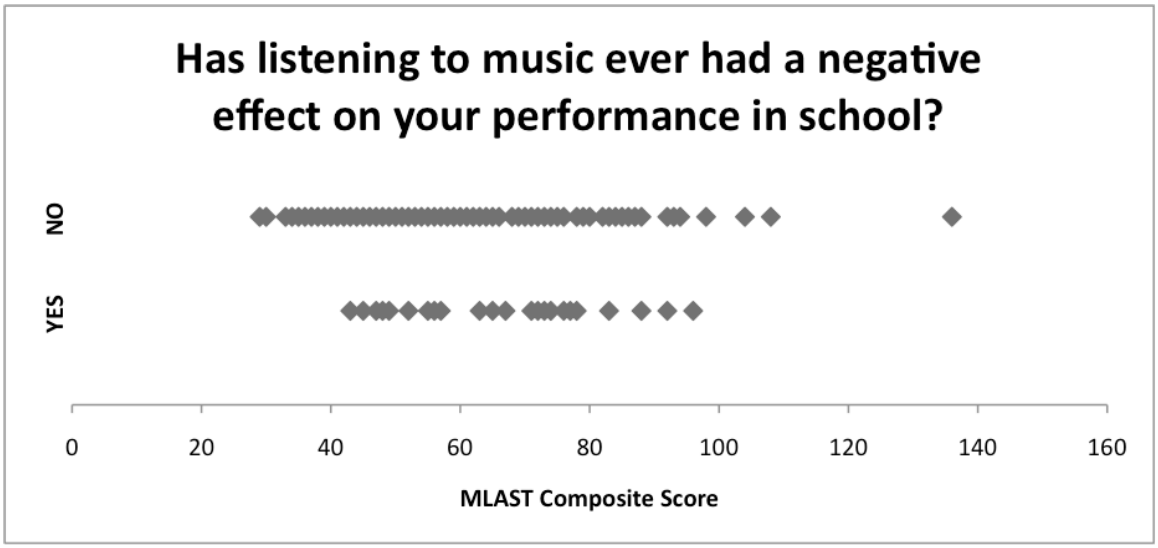
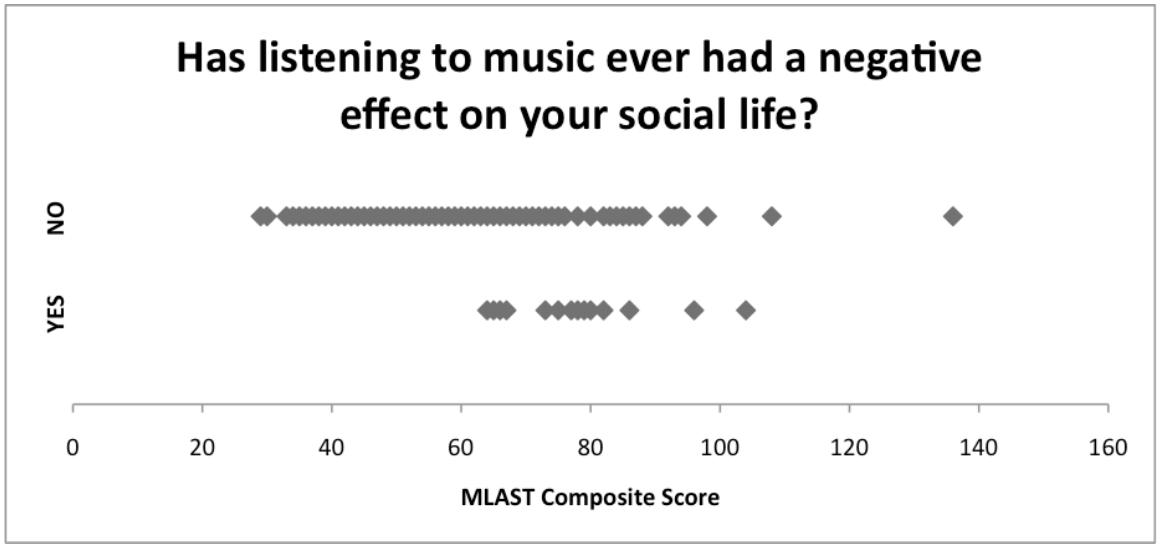
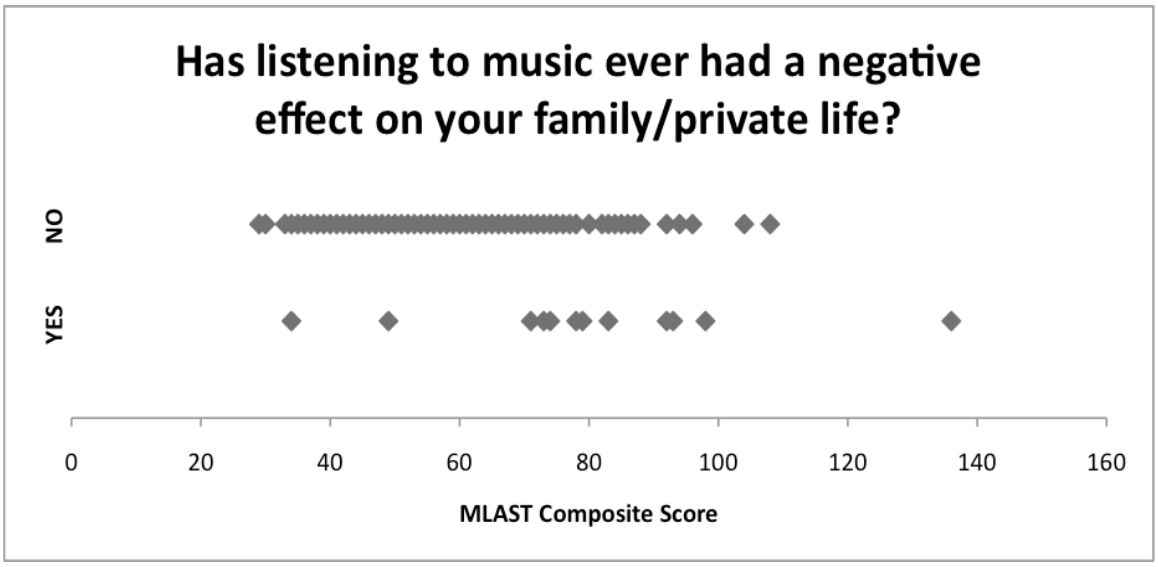


Figure 4. MLAST composite score and time spent listening to music on a daily basis were strongly correlated.







Figures 5-7. MLAST composite score was not correlated with reported negative effect on quality of life.