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The sound of music: The influence of evoked emotion on recognition memory for musical excerpts across the lifespan

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THE SOUND OF MUSIC:
THE INFLUENCE OF EVOKED EMOTION ON RECOGNITION MEMORY FOR MUSICAL EXCERPTS ACROSS THE LIFESPAN

by

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Socioemotional Selectivity Theory (Carstensen, 1999) posits that as people age, they selectively focus on positive aspects of emotional stimuli as opposed to negative as a way of regulating emotions. Thus, older adults remember positive information better than negative. This hypothesis has been tested extensively with visual stimuli, but rarely with auditory stimuli. Findings from this study provide support in the auditory domain. In this study, 135 younger, middle-aged, and older adults heard consonant (pleasant) and dissonant (unpleasant) musical excerpts. Participants were randomly assigned to either a Study Only condition, in which they heard excerpts and studied them for later recognition, a Rate Only condition, in which they rated the excerpts and were tested later in a surprise recognition test, or a Rate and Study condition, in which they rated and studied the excerpts for later recognition. Results indicated that younger, middle-aged and older adults remembered consonant (pleasant) musical excerpts better than dissonant (unpleasant) musical excerpts overall and provide support for the hypotheses of the Socioemotional Selectivity Theory.

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CHAPTER 1

INTRODUCTION

Emotions exert a strong influence on cognition. Emotions are defined by Fox (2008) as "A relatively brief episode of coordinated brain, autonomic, and behavioral changes that facilitate a response to an external or internal event of significance for the organism." The basic components of emotion are subjective experience, expression and physiological response (Carstensen et al., 2006). According to LeDoux (2002), emotions help organize brain activity. When a discrete emotion system is active (e.g. fear, sadness, happiness, anger), other emotion systems are generally inhibited. For example, consider a threatening situation. The amygdala sends signals to the sensory thalamus, directing attention to potential dangers. Other signals are sent to memory formation areas, directing the creation of memories regarding the situation for further use. Arousal networks are also contacted and directed to release neurotransmitters throughout the brain. The amygdala also sends direct signals to the body, readying muscles for the "fight or flight" response. In this way, emotions influence information processing from the environment. Most individuals would agree that being sad or depressed makes it more difficult to pay attention during cognitive tasks, especially at work. In addition, individuals who are extremely happy may demonstrate attention difficulties by focusing on the object of their happiness and disregarding other issues, which should demand their attention.

Consider a study by Pessoa et al. (2011), which investigated inhibitory performance using fearful and happy stop faces. Participants viewed a computer screen and were told to press a button with their right hand to indicate a circle or a square under the "go" condition. For the "stop condition", participants again indicated a circle or square by a button press, but when a picture of a face was presented, they were instructed to withhold their responses. The expressions on the presented faces were happy, sad or neutral. Participants were asked to respond as quickly and accurately as possible. A total of 180 different face pictures from the Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flyket & Ohman, 1998), the Ekman set (Ekman & Friesen, 1976), the Ishai-NIMH set (Ishai, Pessoa, Bikel & Undergerleider, 2004), and the Nimstim Face Stimulus Set (Tottenham et al., 2009) were used. In the stop (inhibition) condition, response times were faster for faces with an emotional expression than for faces with a neutral expression. These results indicated that cognition was directly affected by the emotions induced and are supported by a meta-analysis conducted by Lench, Flores, and Bench (2011) in which an overall medium-sized effect of discrete emotion on cognitive performance was reported. Older adults exhibited better cognitive performance within the context of emotional information relative to the presence of non-emotional contextual information (Carstensen & Mikels, 2005).

Music has significant effects on emotions and is an integral part of our lives, even when we are not aware of its presence. From Musak at the grocery store or mall, to background music on television and in movies, to the ever-present iPod, music is pervasive. Listening to music produces physiological changes (Krumhansl, 1997) as well as modulates pain (Roy et al., 2008). Studies of music-induced emotions indicate that people use music as a tool to manage and express emotions (Chan et al., 2009). Music therapy has been used as a tool to moderate anxiety in patients preparing to undergo brain surgery (Walworth et al., 2008). Twenty-seven patients admitted to a hospital for surgical procedure of the brain were randomly assigned to either a control group receiving no music therapy or an experimental group receiving music therapy either pre-operatively or post-operatively. The study occurred over 23 months with participants ranging in age from 8-73 years. The patients completed a self-report Visual Analog Scale (VAS) measuring anxiety, mood, pain, perception of hospitalization or procedure, relaxation and stress.

Pain medication administration and length of hospitalization were documented. On the morning of their scheduled surgeries, patients completed the VAS form. Patients in the experimental group received 20-30 minutes of music therapy immediately after completing the form. The therapy consisted of music preferred by the patient. On the days following surgery, patients in the experimental group completed the VAS form prior to and after receiving music therapy. Patients in the control group completed the VAS form daily during their hospital stays. Results indicated a positive effect of live music therapy on patients' anxiety, perception of hospitalization, relaxation, and stress levels during recovery from cranial surgery.

Listening to music also induces emotions based on pleasant or unpleasant ratings of melodies. Melodies that are consonant in nature often are rated as pleasant while those that are dissonant are rated as unpleasant (Costa, et al., 2004). Consonant melodies are those that are centered around a specific key signature (for example, the key of C) while dissonant melodies are not centered around a specific key. Often, but not always, dissonant music is composed based on a mathematical pattern based on the twelve chromatic tones and sounds very dissonant to listeners. Consonant and dissonant musical excerpts will be used as stimuli for the current study as a basis for contrasts between pleasant and unpleasant auditory stimuli.

Examination of attention to positive and negative material by younger and older adults has demonstrated evidence for the Socioemotional Selectivity Theory (Carstensen, 1992). Carstensen posited that older adults become more focused on positive information as opposed to negative information. This focus translates into better emotion regulation on the part of older adults. Carstensen hypothesized that older adults understand that time, for them, is limited. Therefore, they seek to promote positive interactions with close social contacts (friends and relatives) over the information gathering style of younger adults, who are motivated by the goal of exploring the world and their place in it. This better emotion regulation translates into a positivity effect and has been demonstrated in studies utilizing visual stimuli. Varying the positive/negative valences of pictorial stimuli has been extensively used to examine cognitive performance differences in younger and older adults (Mikels, et al., 2005; Mather & Carstensen, 2003). However, auditory stimuli have rarely been used to examine these differences. The current study examined differences in emotional memory between younger, middle-aged and older adults using consonant and dissonant (auditory) musical stimuli.

Younger (18-25 years), middle-aged (45-60 years) and older (over 65 years) adults were asked to listen to consonant and dissonant musical excerpts. Participants were randomly assigned to one of three groups. The Rate Only group was asked to rate the pleasantness or unpleasantness of the excerpts. The Study Only group was asked to study and remember the melodies, but not rate them. The Rate and Study group was asked to rate the pleasantness and unpleasantness of the melodies and remember them for later testing. During the recognition phase, participants were asked to designate each stimulus as “remember”, “know”, “guess”, or “new”, with those designated as “remember” being recognized from the previous hearings, along with something they felt or thought during the previous hearings, “know” if they recognized the stimulus but did not remember anything they thought or felt, “guess” if they thought they might have heard the stimulus earlier and “new” if the stimulus was new. Younger, middle-aged and older adults were expected to find the stimuli salient, based on studies that have demonstrated that emotional stimuli are better recalled than non-emotional stimuli (Leclerc & Kensinger, 2008).

I hypothesized that participants in each age group would rate the consonant excerpts as “pleasant” and the dissonant excerpts as “unpleasant” based on findings by Costa, Fine and Bitti (2004). Participants were asked to determine emotions expressed by musical excerpts and were also asked to judge the aesthetics of the music in terms of pleasant-unpleasant ratings. The melodies that adhered to strict keys (i.e., were consonant) were rated as being “pleasant” while those that did not adhere to a particular key (i.e., were dissonant) were rated as being “unpleasant” (Costa et al., 2004). I further hypothesized that overall, younger adults would display better recognition memory for all the stimuli, with particularly better recognition memory for excerpts termed “unpleasant” based on Socioemotional Selectivity Theory, as they remember negative information more accurately than positive (Charles et al., 2003). I hypothesized that memory deficits would be observed in middle-aged adults for all excerpts, based on Salthouse (2009). Participants between the ages of 18-60 were examined across several cognitive abilities. He reported a linear decline in scores occurred beginning near age 30 that continued across the lifespan. Therefore, middle-aged adults in this sample were expected to show some evidence of memory deficits relative to young adults. Further, I hypothesized that adults in this age range (45-60 years) would demonstrate better memory for excerpts rated as “pleasant” as opposed to those rated as “unpleasant” based on the Socioemotional Selectivity Theory. Older adults (over 65 years), were expected to demonstrate less efficient memory overall. However, again based on the Socioemotional Selectivity Theory, participants in this age range were expected to demonstrate enhanced memory for excerpts rated as “pleasant” as opposed to those rated as “unpleasant” for the excerpts that they did recognize. Older adults may be more skilled in directing their attention to positive information than younger adults, facilitating the encoding of the pleasant, consonant excerpts, with younger adults retaining better memory for the unpleasant, dissonant excerpts because of their inexperience in terms of directing attention (Urry & Gross, 2010). Lima and Castro (2011) examined changes in emotion recognition of music across the adult life span and discovered that middle-aged adults demonstrated a decline in responsiveness to music designated as sad and scared. This finding also extended to those in the older adult age group. Most studies to date have compared younger (18-25 years) and older adults (over 65 years) but few have included a middle-aged group (45-60 years). I included a group of middle-aged participants in order to further examine if the differences observed by Lima and Castro were also apparent when the task requires evoked emotion as opposed to recognized emotion.

Verbal and visual stimuli have often been used to examine emotion and cognitive aging but the use of auditory stimuli has been limited. Music was chosen as the nonverbal, auditory stimuli for the current study because it has often been associated with emotion. Roy et al. (2008) examined the effects of listening to pleasant and unpleasant music while experiencing thermal pain and discovered that, compared to a silent condition, excerpts rated as “pleasant” produced significant reductions in experienced pain. In a study of undergraduate students, Ladinig and Schellenberg (2011) examined emotional intensity and individual differences in experiences with unfamiliar music. Participants rated excerpts of unfamiliar music on perceived complexity, liking, intensity of emotional response, and emotion felt. More intensely felt emotional responding was positively related to higher liking ratings; a feeling of happiness in response to the music was positively related to liking the excerpts while the feeling of sadness was negatively related to liking the excerpt. Participants also rated faster excerpts and those in a major key as being more liked compared to slower excerpts and those in a minor key.

The influence of emotion on cognitive functioning has been the focus of research in recent years and provides further justification for using music to explore the relations between emotion and cognitive function across the lifespan. The use of musical stimuli that is varied in emotional valence to examine age differences in memory ability is especially appropriate and will be considered in the literature review that follows. The neuroscience of aging and emotion, as well as emotional regulation in aging influences of music on emotion will also be addressed in the literature review.

Literature Review

Neuroscience of aging.

Physical, functional, and cognitive changes occur in the brain with aging. Based on neuroimaging studies, decreases in volume in the caudate, cerebellum, hippocampus, and prefrontal areas as well as a decline in grey and white matter are observed in older adults (Park & Reuter-Lorenz, 2009) and are related to decreases in cognitive functioning in older adults. In addition, the numbers of white matter hyperintensities (WMHs), areas of high intensity on brain scans which usually reflect an abnormality of signal from the white matter area, increase with age. Increases in the numbers of WMHs are thought to be the source of age-related slowing of behavior. In addition to decreases in volume and increases in WMHs, the number of dopamine receptors in the brain declines with age. These declines may be in part responsible for the slowing of perceptual speed and episodic memory task performance observed with age.

HAROLD Model. Cabeza (2002) introduced the HAROLD (Hemispheric Asymmetry Reduction in OLDer adults) model to explain differences observed (e.g., Reuter-Lorenz, 2002) in prefrontal activity of the brain in younger and older adults. During episodic memory encoding and retrieval tasks completed during positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), Tulving et al. (1994) noted activity in the left prefrontal cortex was present during encoding and activity in the right prefrontal cortex during retrieval in young adults. This model became known as the HERA, Hemispheric Encoding/Retrieval Asymmetry, model (Nyberg, Cabeza, & Tulving, 1996, 1998), with refinement of the HERA model being proposed by Habib, Nyberg and Tulving (2003). Adults in the same scanning paradigm did not display this type of activation, but, instead, displayed a pattern of little activation of the prefrontal cortex during encoding and a bilateral pattern of activation during recall. The pattern of less prefrontal activation of older adults during encoding of material but bilateral prefrontal activation of the prefrontal cortex during recall has been titled the HAROLD model (Hemispheric Asymmetry Reduction in OLDer adults) by Cabeza. Reuter-Lorenz et al. (2000) found evidence to support the HAROLD model by examining a group of younger (18-30 years) and older (62-75 years) females on two working memory tasks. One task was a verbal-storage task in which participants were shown four letters, which they stored in memory for three seconds and then indicated whether or not a probe letter matched any of the four. In a spatial-storage task, participants saw three target locations on a screen and then indicated whether a target location matched a probe location. Younger adults displayed a pattern of greater activation in the left hemisphere for verbal materials and greater right hemisphere activation for spatial materials. Older adults displayed a pattern of bilateral activation for both types of memory, providing support for the HAROLD model discussed by Cabeza (2002).

Neuroscience of emotion.

Emotions are defined as “discrete and consistent responses to an internal or an external event which has a particular significance for the organism” (Fox, 2008) and are biologically based. The emotion of interest, joy/happiness, anger, disgust, and fear are natural kinds, meaning that they have evolved over time, have consistent properties that are observable, and have significant similarities (Izard, 2007).

Because the amygdala is the receptor for much of the sensory input of the brain (Nolte, 2009), it is thought to be one of the major areas concerned with the processing of emotions (Fox, 2008). The amygdala is part of the limbic system and is located in the medial temporal lobe. The amygdala receives basic sensory input as well as input in the form of levels of physical and emotional comfort and discomfort. Emotional responses are initiated through outputs to the ventral striatum, hypothalamus, and brainstem and contributions to emotional experience are made by outputs to the limbic cortex (Nolte, 2009).

Good et al. (2001) used voxel-based-morphometry (VBM) to examine age differences in grey and white matter in a large sample of normal adults, ranging in age from 17-79 years. An anatomical template was first created using subgroups of participants matched for age and handedness. The fMRI images to be studied were then registered to the template image. The scans were segmented into grey matter, white matter, and CSF areas and smoothed. Separate grey and white matter templates were created and segmentation of the image was completed and normalized. A global decline in grey matter with age was reported, with the rate of decline being steeper in males than in females with the superior parietal gyri, pre- and post-central gyri, insula/frontal operculum, right cerebellum and anterior cingulate being particularly affected. However, the lateral thalami, hippocampi, entorhinal cortex, and, of particular interest for this study, the amygdalae, demonstrated little change in volume. Because the amygdala is significantly implicated in emotional processing (Fox, 2008), preservation of volume of this area with aging would predict that emotional processing abilities may be relatively spared with age.

Winecoff et al. (2011) examined the neural mechanisms underlying emotional processing of cognitive reappraisal in younger (19-33 years) and older adults (59-73 years) using visual stimuli. Participants first completed a battery of tasks (Henninger et al., 2010) as well as a recall memory test consisting of a series of 16 words and executive function tests (e.g., working memory). After the cognitive test battery, participants were trained on an emotion regulation task in which they viewed images from the International Affective Picture System (Lang et al., 2005) and were instructed to think of themselves as a detached, unemotional third party (i.e., the reappraisal condition). During an fMRI scanning session, 60 positive images trials (half "experience", half "reappraise"), 60 negative images trials (half "experience", half "reappraise") and 30 neutral images trials were presented. Both age groups displayed increased activation of the prefrontal cortex and decreased activation of the amygdala in the reappraisal condition. Older adults displayed decreased activation of the lateral prefrontal cortex, specifically the left inferior frontal gyrus (LIFG), during the reappraisal condition as compared to younger adults. These changes predicted performance during the reappraisal condition.

Winecoff et al., (2011) suggested that the LIFG plays an important role in the ability of older adults to regulate emotion. Both younger and older adults displayed a decrease in activation of the bilateral amygdalae in the negative condition related to cognitive ability. The authors further hypothesized that both younger and older adults utilize a similar network for emotion regulation because no age differences in reappraisal-related activation in the dorsolateral and dorsomedial prefrontal cortex or changes in functional connectivity between the amygdala and the lateral prefrontal cortex were observed. This finding might be indicative that neural changes are more a matter of age-related cognitive decline rather than a direct effect of age.

Additional studies provide support that changes in the activation of the amygdala occurs across age groups with emotional stimulation. Younger adults (18-29 years) and older adults (70-90 years) viewed randomly ordered positive, negative, and neutral pictures during event-based fMRI scanning to examine differences in amygdala response. During the scanning, they rated their subjective emotional arousal by pressing a button on a device, with 1 being the least arousing and 4 being the most arousing. The average overall arousal ratings did not differ between younger and older adults with negative pictures being rated as the most arousing, positive pictures next and neutral pictures being the least arousing. Younger adults rated the negative pictures as more arousing than did the older adults but the ratings of positive pictures did not differ between the two groups. Examination of the amygdala revealed a greater change in activation for the positive pictures than for the negative pictures in older adults. Younger adults did not experience a significant difference in activation between positive versus negative pictures. However, a greater change in activation was observed for the negative pictures relative to the positive in the older adults. The authors indicated that the reduced activity of the amygdala in the older adults implied that they were able to diminish encoding of the negative pictures, resulting in a later diminished memory for the negative pictures. They further proposed that the results of their study indicated a shift of response to the type of emotional stimuli had occurred rather than a general decline in amygdalae function.

Leclerc and Kensinger (2008) examined structural age-related differences in emotional processing in a cross sectional study. Younger (19-31 years) and older (61-80 years) adults were asked to examine 324 pictures (108 positive, 108 negative and 108 neutral) of items and to make a keypress as rapidly as possible for the items that would fit inside a file cabinet drawer. Older adults made slower decisions, but there was no age difference in accuracy. Two patterns of neural activation in the prefrontal cortex were noted, with a dorsomedial prefrontal region being modulated by stimulus arousal and a ventromedial region being modulated by stimulus valence. The regions modulated by stimulus arousal displayed an interesting reversal pattern for the groups. Activity in the ventromedial prefrontal cortex/anterior cingulate region was greater for younger adults for negative relative to positive items. In contrast, activity was greater for positive relative to negative items for older adults. Leclerc and Kensinger (2008) hypothesized that the area actively processes emotional valence throughout the lifespan but that the nature of the response appears to change, allowing for the positivity bias frequently displayed in behavioral research with older adults.

In another study involving visual stimuli, younger and older adults were presented with negative, positive and neutral pictures while in an fMRI scanner under two conditions (Ritchey et al., 2011). In the deep task condition, participants were asked to analyze each picture based on its meaning and interpretation. In the shallow condition, participants were asked to analyze the pictures based on features such as colors and lines. Participants were instructed to use either the deep or shallow analysis when viewing the pictures. The left and right amygdalae were activated across all trial types and across all ages, indicating that there were no age-related differences in emotional activation. Younger adults displayed a greater difference in activation of the visual cortex than older adults in response to emotional stimuli compared to neutral stimuli. No differences were observed for older adults across the stimulus types (i.e., activation for neutral stimuli was comparable to that for emotional stimuli). In addition, during the semantic elaboration task, greater activation of the medial prefrontal cortex and the ventrolateral prefrontal cortex for positive stimuli was noted for the older adults. This is consistent with the age-related differences in emotional processing observed by Leclerc and Kensinger (2008). Findings also indicated that individual differences in executive functioning predicted positive valence effects in older adults, demonstrating a link between executive function and elaborative processing of emotional stimuli. Finally, stronger activation between the medial prefrontal cortex and ventral striatum was noted in older adults for positive trials while younger adults showed greater activation in this area for negative trials. These areas have been indicated in deeper processing of self-referential processing, specifically autobiographical memory processing, in older adults.

Older adults may therefore more fully process emotionally valenced stimuli, especially based on of the personal relevance of the stimuli.

Waldinger, Kensinger, and Schulz (2011) utilized visual stimuli to examine a group of older adults (64-89 years) enrolled in a longitudinal study of adult development. The purpose of the study was to determine if specific patterns of neural connectivity were associated with different levels of emotional well-being while processing positively and negatively valenced information. Participants completed the Satisfaction with Life Scale (Diener, Emmons, Larsen & Griffen, 1985) as a measure of life satisfaction before being tested in an fMRI scanner. While they were in the scanner, they viewed 180 pictures (60 positive, 60 negative, and 60 neutral) selected from the IAPS database (Lang, Bradley, & Cuthbert, 1999). Participants were instructed to view the series of pictures and to press a button each time the picture changed. After scanning, a surprise memory task was performed by the participants. Items that were correctly recognized were included in the fMRI analysis.

Older adults with high life satisfaction and who had a stronger connectivity in an amygdala-mediated network showed a stronger response to positive visual images compared to negative images. Older adults who reported lower life satisfaction did not display the valence effect. Stronger activation was noted between the fusiform gyrus, hippocampus, amygdala, thalamus, ventromedial prefrontal cortex and the orbitofrontal cortex in response to positive pictures in those older adults with high life satisfaction than when viewing negative pictures. The study was the first to demonstrate a direct link between amygdala connectivity and subjective well-being in adults. Waldinger et al. (2011) suggested that because higher life satisfaction was associated with lower activation of the orbitofrontal cortex and the ventromedial prefrontal cortex in encoding of positive images, neural efficiency might be enhanced during the encoding.

Individuals high in life-satisfaction might encode positive items more efficiently than those lower in life-satisfaction. Emotional state was measured by the Positive and Negative Affect Scale (PANAS; Watson, Clark & Tellegen, 1988) in the current study and was used to examine the relation between efficient encoding of the musical excerpts and current mood.

The studies reviewed above have used visual stimuli to examine structural and activation differences in younger and older adults in response to positively and negatively valenced items. As a general summary, activity in areas of the prefrontal cortex and the amygdala was noted across all studies, with opposite patterns observed for the different age groups. For emotional arousal, older adults displayed reduced activity in the amygdala for negative stimuli and greater activity for positive stimuli while younger adults displayed reduced activity for positive and greater activity for negative stimuli. For stimulus valence, younger adults displayed greater activity for negative stimuli in the ventromedial prefrontal cortex than for positive stimuli while older adults displayed the opposite effect. For encoding, younger adults displayed stronger activation in the medial prefrontal cortex for negative stimuli while older adults displayed stronger activation for positive stimuli. Overall, these results indicate that younger and older adults process negatively valenced and positively valenced stimuli differently, with younger adults processing negatively valenced stimuli more strongly than positively valenced and older adults processing positively valenced stimuli more strongly than negatively valenced stimuli.

The above cited studies utilize brain imaging as a method to examine differences between younger and older adults in the processing of emotional stimuli, with the final two presenting auditory stimuli. The findings of the studies utilizing auditory stimuli indicate common areas of activation for auditory stimuli and visual stimuli. Findings using behavioral methods have also determined differences in emotional processing between younger and older adults and will be examined next.

Most studies to date have used visual stimuli to elicit emotions but the current study will use auditory, musical stimuli. Music has been used to examine the relations between valence and activation. Blood et al. (1999) were the first to publish a study using positron emission tomography (PET) examining the neural correlates of emotion and music based on the pleasantness and unpleasantness dimension. Participants first heard a novel melody, composed specifically for the experiment, which was repeated five times. Each time the harmonic structure of the accompanying chords was varied in order to increase the dissonance. The dissonance level was increased by increments with each version, with no resolution of the dissonance for any passage. Participants also heard acoustically matched noise bursts as a control, which were constructed to be approximately the same duration and intensity of the melody. Each participant heard the melody twice outside the scanner. After scanning, participants rated the emotional valence and intensity of the stimulus on the basis of pleasant-unpleasant, tense-relaxed, irritated-unirritated, annoying-unannoying, dissonant-consonant, and angry-calm.

Activation in the right parahippocampal gyrus and precuneous regions was noted as the musical stimuli increased in dissonance while activation of the orbitofrontal, subcallosal cingulate and frontal polar cortex was noted with decreasing dissonance of the melodic stimuli. The authors suggested that music might recruit different mechanisms for pleasant/unpleasant states than those recruited for fear. The age range of the participants for this study was not noted, but since older adults recall fewer negative images than positive images (Charles, Mather & Carstensen, 2003), older adults would be expected to display greater activation across the prefrontal cortex for the more consonant than dissonant stimuli.

An fMRI study also used pleasant musical stimuli (instrumental dance tunes recorded from commercially available CDs) and unpleasant musical stimuli (electronically manipulated original dance tunes) to evoke emotion to allow an examination of neural coordinates of emotional processing (Koelsch, 2005). Participants received a copy of the musical stimuli three days before the scanning procedure to ensure they were equally familiar with the music. While in the scanner, pleasant and unpleasant stimuli were presented alternately and participants were instructed to press a response button according to a 5-point scale, rating their current emotional state after hearing the music. The amygdala, hippocampus, parahippocampal gyrus and temporal poles were activated during the presentation of the unpleasant stimuli while during the presentation of the pleasant stimuli strong deactivation of these areas was observed. The authors concluded that activation of a cerebral network involving these areas may be achieved by the processing of emotionally valenced auditory stimuli. This finding provided further support for the use of musical excerpts as stimuli in the current study.

Music elicits emotional responses in the brain, even in those with damage. Peretz and colleagues (1997; 2001) demonstrated that a patient with bilateral brain damage in the auditory cortex was still able to classify music as “happy” or “sad” even when she was unable to classify musical material as familiar (i.e., could not identify “Happy Birthday”, only reporting that it “sounds happy”). In tasks of determining “happy” or “sad” music, this patient was still able to use mode and tempo to determine the emotion conveyed by the music. However, the patient was impaired in her ability to make “same – different” determinations for music that was very easy for controls to classify. Peretz et al. (2001) concluded that emotional judgments of music can be unimpaired, even when the auditory cortex is damaged.

Age-related differences in emotional processing have also been examined using both speech and music. Laukka and Juslin (2007) examined age differences in the ability to recognize emotions and the intensity of emotion using vocal expression and musical performance in a sample of young (20-33 years) and older adults (65-85 years). Participants were assessed with the Mini-Mental State Exam (MMSE; Folstein, Folstein & McHugh, 1975) and completed a demographic questionnaire concerning education level, self-reported hearing problems and personality assessed by the Ten-Item Personality Inventory (Gosling, et al., 2003).

Three sets of stimuli were used in the study. The first set was recorded by three professional actors who portrayed anger, fear, disgust, happiness, and sadness, first weakly and then with a strong emotional intensity. The second set consisted of blended vocal expressions that differed by constant physical amounts and were created using speech synthesis. The stimuli were created by recording a female speaker portraying anger, fear, happiness, and sadness synthesized into continua of anger-fear, fear-happiness, happiness-sadness, and sadness-anger. The third set was composed of short melodies that were performed on an electrical guitar by professional musicians. The musicians were asked to perform the melodies to convey anger, fear, happiness and sadness without varying the pitch of the melody. They were not allowed to use external effect devices to change the sound of the guitar.

Both groups of participants heard the three stimulus sets and could choose from the emotions of anger, fear, happiness, and sadness for the second set and from anger, fear, happiness, neutral, and other for the third set. Older adults were less accurate in identifying negative emotions, especially fear and sadness, but there were no age differences in the ability to identify positive or neutral expressions of emotion as demonstrated by the actor or musician. Specifically of interest to the current study, younger adults were more accurate in recognizing fear and sadness than older adults for the music stimuli set. Additionally, older participants did not have more difficulty recognizing the most difficult stimuli, indicating that age-related differences in cognitive functioning were not entirely responsible for performance. In addition, hearing acuity did not account for the differences, as young and older adults did not differ significantly on self-reported hearing status.

Laukka and Juslin (2007) suggested that the differences observed may have been due to age-related degeneration of specific neural regions (e.g., the amygdala and insula) involved in processing emotions. They further suggested that older adults are motivated to regulate their emotions more completely than younger adults, and do not process negative stimuli as fully as positive stimuli. The authors indicated that previous studies had used stimuli of recorded music, which was not specifically composed to convey discrete emotions. The current study will use music stimuli that was specifically composed for films and written to evoke explicit emotions in relation to film scenes. While the brain imaging studies cited above do not indicate that the neural regions mentioned by Laukka and Juslin (2007) degenerated in older adults, differences in activation of these areas in younger and older participants in relation to the valence of the stimuli do indicate that the age groups processed emotionally valenced stimuli in different ways, a conclusion consistent with Socioemotional Selectivity Theory (SET; Carstensen & Mikels, 2005). The SET has been proposed to account for age differences in processing of emotional information (Carstensen & Mikels, 2005) and is addressed in the following section.

Socioemotional Selectivity Theory (SET).

Traditional theories of aging focused on withdrawal from social roles with age and highlighted the inherent ageism present in society as well as awareness on the part of the older adult of impending death (Carstensen, 1995). As a result, older adults were expected to socially and emotionally withdraw and become more self-reflective. In contrast, more contemporary theories such as the Socioemotional Selectivity Theory (SET: Carstensen, 1995), proposed that older adults actively seek social contact, but as a means of providing emotional reward for themselves, rather than for the purpose of seeking information for the future. An integral part of SET is time perspective and its role in human goal-directed behavior and motivation. Three major principles underlie the theory: 1) In order to survive, social action on the part of humans is necessary; 2) Humans act on their environments to realize goals; and 3) Goals are selected by humans before action is taken (Carstensen et al., 1999).

Behavior throughout the lifespan is directed by the pursuit of goals and selection of these goals is motivated by the perception of time. For example, a major goal of many younger adults is to complete their education to obtain a job and pursue a successful living. Time, for them, is not as limited as time for older adults or for those with terminal diseases. Therefore, in their pursuit of success, the goals of younger adults include acquiring knowledge about positions that will help them be successful and seeking out social relationships that will help them pursue their goals. On the other hand, it is in the best interest of older adults and those will terminal illnesses to regulate their emotions and to try to maintain a positive emotional state. Emotion regulation involves trying to influence which emotions we experience, as well as when and how these emotions are experienced (Gross, 1998). Because older adults and those with terminal illnesses perceive that their time is limited, they are more interested in maintaining close relationships with family and intimate friends than seeking information from casual social contacts. The focus on knowledge seeking goals gradually declines over the course of the lifespan. During infancy and early childhood, emotional rather than information seeking goals are highly pursued. This pursuit declines during middle childhood through early adulthood but then begins to rise again during later adulthood (Carstensen et al., 2003).

An adult's perception of their position in the life cycle helps determine the selection of goals to be pursued. Younger adults, aged 18-29 years, typically do not perceive a limitation of time and are motivated to increase knowledge and develop new skills, with less emphasis on emotional satisfaction. Older adults, over 65 years, who perceive that time is passing rapidly and is limited, pursue emotionally related goals and seek to establish emotionally meaningful ties with others who are important to them. For example, younger adults are expected to be more interested in learning how to use social media technology to communicate with the goal of seeking out information. The primary goal of older adults for using social media is likely to be to communicate with those with whom they might feel emotionally close. Research by the Pew Research Center in their Internet and American Life Project (Madden, 2010), indicates that among internet users aged 50 and older, social networking nearly doubled (from 22% to 42%) from 2009 to 2010 and that half of those aged 50-64 years and one-fourth of those over 65 years use social networking sites. Older adults are more likely to use email than younger adults, with 92% sending or reading email on a typical day.

The assumptions of the SET were supported when longitudinal data from the Child Guidance Study on developmental patterns during childhood was reanalyzed by Carstensen (1992). Infants born between January 1, 1928, and June 30, 1929, in Berkeley, California, were included in the study. The analysis was based on interviews with fifty participants at the ages of 18, 30, 40, and 52 years. The interviews were analyzed for interaction frequency, emotional closeness, and relationship satisfaction. The ratings were based on coding of structured and unstructured clinical interviews conducted by trained raters. Participants had lower rates of interactions with acquaintances as they got older, but more frequent interactions with significant people in their lives. These interactions were characterized as being rated as more emotionally satisfying over the life course. Relationships with siblings were also characterized as being closer and more emotionally satisfying in later life.

SET indicates that older adults are more present oriented and focused on the here and now than future oriented younger adults (Carstensen et al., 1999). Later adulthood becomes a time of development characterized by a desire to derive meaning from life. Pursuit of emotionally related goals and the desire to derive meaning from life lead to a shift in cognitive processing from knowledge seeking to focusing on the present and attention to emotion regulation (Carstensen et al., 2003). Based on this theory, emotionally relevant material is more easily remembered when emotional goals are prioritized (Lockenhoff & Carstensen, 2004) and positive features of remembered information are more likely to be recognized (Charles et al., 2003). Younger adults are more focused on knowledge seeking goals. For example, younger adults would be more interested in learning from and spending time with an expert in their field of interest while older adults would be more interested in spending time with an exceptionally close friend.

Further support that older adults are inclined to pursue emotionally related goals was found in emotional experience sampling with adults ranging in age from 18 to 94 years (Carstensen et al., 2000). Emotion regulation was defined as the maintenance of desirable emotional states and the cessation of undesirable emotional states. Participants were provided with a booklet containing a week's worth of response sheets listing emotions and an electronic pager. They were asked to rate their emotions on a 7-point scale when the pager sounded. The scale on which participants were to indicate the degree they were feeling consisted of 19 different emotions and states ranging from 1 (not at all) to 7 (extremely). The emotions were anger, guilt, pride, sadness, happiness, fear, accomplishment, shame, amusement, anxiety/worry, joy, contentment, irritation, frustration, disgust, interest, embarrassment, boredom, and excitement. They were paged at five random times each day during the following week. Older adults reported that they experienced positive emotions as frequently as younger adults, but younger adults reported that they experienced negative emotions more frequently than older adults. The positive emotional states of older adults were stable and they were less likely to remain in a highly negative state than younger adults. Older adults may therefore be better able to control negative emotions than younger adults (Carstensen et al., 2000).

Additional studies also indicated a difference in recall and recognition memory for emotionally valenced faces in younger and older adults. Young (18-29 years), middle-aged (41-53 years), and older (65-80 years) adults were shown neutral (e.g., highway), positive (e.g., smiling baby), and negative (e.g., accident) images on a computer screen. Participants were asked to recall each image and write a short description about the image after completing questionnaires and cognitive tasks (Charles, Mather, & Carstensen, 2003). They were again shown the images, in addition to 32 foils (i.e., new images), and asked to determine if each image was new or had been seen before. Age group differences in recognition for positive, negative, and neutral images were measured as well as for free recall. Memory for positive images was greater than memory for negative images in middle-aged and older adults. There was no recall memory difference for positive and negative images but better recognition memory was observed for negative images relative to positive or neutral images in the young adults. In a second study in which only younger (18-28 years) and older (65-85 years) groups were compared, participants were shown faces on a computer during a self-paced presentation.

Younger adults recalled and recognized more negative images than positive or neutral images while older adults recalled and recognized negative images as well as they did positive images. Both young and older adults spent more time viewing negative images than positive images, but older adults did not perform better on the memory test despite a longer examination of the negative faces. These results are consistent with the SET and reflect that a shifting in goals with age may occur in which more emphasis is placed on emotion regulation. Poor memory performance across both recall and recognition for negative material was noted for the older participants, across sex, race, and socioeconomic status, indicating that older adults selectively remember less negative information.

Consistent with the idea that older adults remember positive information better than negative information, memory for historical events was positively valenced in older adults. Petrican, Moscovitch, and Schimmack (2008) used a modified version of Green and Brock's (2000) Narrative Transportation Scale to measure memories of public events with a sample of older adults. Participants were asked to respond on a 7-point scale about the vividness of their memories for public events, their cognitive and emotional involvement in each event, as well as a self-assessment of their absorption in the reading of descriptions of those public events while activity was present in their surroundings. Twenty events were included in the study with the most recent having occurred more than 15 years before the session. The events did not span more than 25 years and the set included a roughly equal number of positive, negative, and neutral events. An example of a negative event was a story about the explosion of the space shuttle Challenger shortly after take-off. Absorption in the reading of the events was defined as the vividness of the memories associated with the events, cognitive and emotional involvement in the events, and lack of awareness of surroundings as a result of immersion in the readings about the events.

Higher ratings for positive events relative to negative or neutral events were given by participants with higher spatial working memory capacity. No effect was observed for transportation in memories for negative or neutral events. Public events rated as positive were better remembered and provides further support for the Socioemotional Selectivity Theory (SET). The fact that those with better spatial working memory gave higher ratings for positive events would indicate that the positivity effect postulated by SET is not as a result of cognitive or neural decline, but is an indication of more efficient emotion regulation on the part of these individuals.

Additional support was found for the SET by Mather and Knight (2005) who used visual stimuli in three experiments with younger (18-29 years) and older (65-83 years) adults. They hypothesized that older adults display a positivity effect that originates from goal-directed processes. The model predicts that those who are better able to put their goals into practice should be those who have a better memory for positive pictures rather than negative pictures. The first experiment consisted of two sessions. Young and older participants were randomly assigned to either a morning or afternoon session. During the first session, participants completed the PANAS, (Watson, Clark & Tellegen, 1988) followed by the presentation of 48 pictures from the International Affective Picture System (IAPS; Long, Bradley, & Cuthbert, 2001). The IAPS contains photographs which have been rated on a standard scale based on emotionality evoked by each picture, with 1 being most unpleasant (e.g., a picture of a burn victim), to 9 being most pleasant (e.g., a picture of a smiling baby). Standardized ratings for the arousal level of each picture are also included, with 1 being least arousing and 9 being most arousing. The set of pictures included 16 negative, 16 neutral, and 16 positive pictures. The pictures were shown for two seconds each. Participants then completed a demographics questionnaire and the Horne-Ostberg Morningness-Eveningness Questionnaire (1976). Half of the participants were tested 20 minutes after the picture presentation and recall was assessed by asking them to write as complete a description as possible of the pictures they had seen, in any order. All participants were asked to complete the Horne-Ostberg Morningness-Eveningness Questionnaire (1976) as well as the Nelson-Denny vocabulary test (Brown, Fishco, & Hanna, 1993) and the Center for Epidemiologic Studies Depression Scale (CESD; Radloff, 1977). All participants returned to the lab to complete a recall test after a two day delay, in which they were instructed to write as detailed a description as possible of all the pictures they had remembered seeing. Participants again viewed the pictures in random order, and rated them from highly positive to highly negative.

Older adults reported more positive affect on the PANAS than younger adults. Their ratings of the positive and neutral pictures were more positive than the younger adults while their ratings of the negative pictures did not different significantly from the younger adults. Older adults recalled a larger proportion of the positive pictures than the negative pictures while younger adults recalled more negative pictures. The older adults who were tested after the 20-minute interval recalled a larger proportion of positive images and a smaller proportion of negative images than younger adults. This result was also observed after the two-day delay. Older adults who were required to recall the pictures twice had stronger memories for the positive pictures than for the negative pictures, indicating that the positivity effect may be stronger in older adults with repeated retrieval. More elaborative processing for retrieving positive information relative to negative information may be responsible for the positivity effect observed (Mather & Knight, 2005).

The second experiment investigated individual differences in cognitive control and their effects on emotional memory. Younger and older adults viewed 32 negative, 32 positive and 16 neutral pictures; 78 pictures were from the IAPS (Lang, Bradley & Cuthbert, 1999) and two from outside sources. The pictures varied based on arousal and emotional valence and were arranged in four categories: low arousal positive, high arousal positive, low arousal negative, and high arousal negative. Participants were randomly assigned to a morning or an afternoon testing time. After completing the PANAS, participants viewed the pictures and then completed a demographics questionnaire. They also completed the Attentional Network Test (Fan et al., 2002) in which they were required to indicate the direction of an arrow presented after a spatial cue. A surprise recall test, in which participants had to write detailed descriptions of as many of the pictures as they were able to recall, was administered twenty minutes after the end of the picture show followed by a sentence span task (Baddeley et al., 1985). During the sentence span task, participants were shown a series of sentences and were asked to determine the plausibility of each sentence quickly and accurately, and to recall the last word of each sentence in the order the sentences were presented. Finally, participants rated the pictures on a 1-9 scale for valence and arousal. Older adults who did the best on the cognitive control tests were more likely to recall positive pictures and less likely to recall negative pictures. The authors suggested that those who were better at ignoring goal-irrelevant information and refreshing just-activated information in working memory were better at keeping goal-relevant information in mind. This suggests that those older adults who were better able to inhibit negative information and recall positive information were more proficient at directing their attention to the positive information.

In a third experiment, younger and older adults were randomly assigned to a morning or afternoon testing period as well as to a divided-attention condition or a full-attention condition. Participants again completed the PANAS and a demographic questionnaire. The same series of pictures from the IAPS was used. Those in the divided-attention condition heard a series of rhythmic sound patterns with each picture. The sound pattern randomly changed once or twice during the presentation of each picture. No sounds were presented during the full-attention condition. Those in the sound condition pressed a key to indicate whether the rhythmic pattern had changed once or twice. After the picture show, participants completed the Nelson-Denny vocabulary test, the CES-D (a depression scale), a crossword puzzle, as well as a surprise recall test twenty minutes after completion of the picture show. In the surprise recall test, participants were asked to write a detailed description of as many pictures as they possibly could recall. Participants rated the valence and arousal of the pictures at the end of the testing session. The positivity bias of the older adults was not evident under the divided attention condition (the presence of rhythmic sound patterns). In contrast, the divided attention condition did not affect the influence of emotional valence on memory recall in younger adults. These findings indicate that the younger adults were not using their attentional resources to regulate their emotions as did the older the older adults in the control condition because younger adults demonstrated no significant difference in recall based on valence between positive and negative images in the divided attention condition. If younger adults had used their attentional resources in this way, they would have recalled more negative information than positive information. Mather and Knight (2005) suggested that cognitive control processes mediated the positivity effect experienced by the older adults. While rhythmic sounds were utilized for the third experiment, these stimuli were unrelated to the task. The current study will examine whether the positivity bias will be maintained in older adults if the emotional content of the stimuli facilitates memory recognition.

Younger and older adults' recognition memory for perceptual details, neutral conceptual details and emotional conceptual details was examined in two studies by May, Rahhal, Berry and Leighton (2005). In the first experiment, younger and older adults completed a general health-education questionnaire and the Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976). They then viewed a series of food items that were to be served to guests at a wedding reception either on the left or right side of a computer screen. Half of the participants were assigned to the perceptual plus non-emotional, conceptual conditions (P-NEC) while the other half were assigned to the perceptual plus emotional conceptual condition (P-EC). Those in the P-NEC condition were informed that the location of the items was linked with serving temperature while those in the P-EC condition were informed that the location of the items was linked with safety. They were all asked to remember the location and either the temperature or safety for each item. A distracter task was presented after the learning phase, in which participants created novel designs for different objects. Participants were then shown 36 food items, 24 of which were old and 12 of which were foils (new). In one test, half of the participants from the P-NEC condition and half of the participants from the P-EC condition decided whether each item had originally appeared on the right, the left or was new. The remaining participants in the P-NEC condition determined whether the item was served hot, cold, or was new while the remaining participants in the P-EC condition were asked to determine if each item was safe, spoiled, or new.

Younger adults were better able to recall the location and serving temperature of the food than older adults but there was no difference in younger and older adults' memories of fresh or rotten food items. In the second experiment, younger and older adults were given a general health-education questionnaire and then asked to learn a series of new car names on a computer screen. The model-maker information appeared either in red or green. Half of the participants were informed that the item color was linked to class, with green being linked to luxury and red with economy cars (P-NEC condition). The remaining participants were informed that car color was linked with safety, with green designated as safe cars and red designated as dangerous cars. Participants then made decisions as to whether the item had appeared in red or green or was new, or whether the car was a luxury car, an economy car, or was new. Older adults were better able to report safety information regarding cars than the class or quality of the cars. In both studies, younger participants were better able to remember perceptual details and conceptual details than older adults, but there was no difference in memory for emotional contexts between the two groups. These findings contributed to growing evidence that older adults remember emotional stimuli better than neutral stimuli, specifically: older adults remember positive emotional stimuli better than negative emotional stimuli (May et al., 2005).

Goeleven et al. (2010) found further evidence for age differences in the processing of emotional information using a negative priming task. Pictures were selected from the Karolinska Emotional Directed Faces database (Lundqvist, Flyketk, & Ohman, 1998) based on positive (happy), negative (sad) or neutral facial expressions and were designated as a target by a black background and as a distracter by a grey background. The pictures were divided into a negative and positive prime target list, a negative and positive prime distracter list, a negative and positive probe target list and two neutral probe distracter lists. Trials consisted of a fixation cross in the middle of the screen followed by the prime and probe trials. Participants examined two pictures concurrently on a computer screen and were asked to determine the valence of the target picture by pressing a key on the computer keyboard while ignoring the distracter picture. After completion of the task, participants completed the Beck Depression Inventory, BDI-II, (Beck, Steer, & Brown, 1996). In addition, older participants completed the Mini Mental State Examination (Crum, Anthony, Bassett, & Folstein, 1993; Folstein, Folstein & McHugh, 1975) as well as the Geriatric Depression Scale (Yesavage, 1988).

Older adults responded more slowly than younger adults. Interference for negative stimuli was lower in older adults than in younger adults and interference for negative stimuli as compared with positive stimuli was lower for older adults. Younger and older adults responded more slowly on negative trials than on positive trials. Younger adults showed normal inhibition of all emotional information while older adults displayed reduced inhibition of negative information but not positive information. Older adults may therefore experience less interference from negative information than younger adults (Goeleven et al., 2010). Based on these results, I hypothesized that older adults in the current study would demonstrate memory for fewer negative (dissonant) stimuli than for positive (consonant) stimuli.

Emotion and musically based memory.

It should be noted again that verbal and visual stimuli have been used in the studies presented in this review. Nonverbal stimuli have also been used in memory studies. Examination of different types of stimuli in memory studies is important because stimuli are processed in different areas of the brain, (e.g., language processing in the left hemisphere in Broca's area, images in the visual cortex, and sound in the auditory cortex). Thus, it is necessary to examine auditory as well as visual processing in order to observe distinctions in memory processes in young and older adults. One example of nonverbal stimuli used in auditory processing is music. In a review of studies regarding brain organization for music processing, Peretz and Zatorre

(2005) specified brain areas involved in the processing of specific facets of music, with the right temporal cortex being involved in pitch relations, the right hemisphere discriminating rhythm, while the left is involved in discriminating grouping (i.e., beat), frontal cortical and posterior temporal areas for working memory for tones, and, importantly for this study, the dorsal midbrain, ventral striatum, insula and orbitofrontal cortex for emotional aspects. In the context of the current review, “emotional aspects” referred to the “chills” effect people reported during an especially pleasant musical experience. Because of the number of brain areas involved in processing facets of music, musical stimuli are ideal to help us understand and better delineate the underlying processes related to age-related differences in memory.

In one study utilizing musical stimuli, undergraduates heard musical excerpts from Polish folk songs presented in a female voice with no words (using “la-la”) either once, twice, or four times during study trials (Gardiner et al, 1996). Their task was to designate previously heard melodies as “Remember” or “Know” and to mark those not previously heard as “X”. Participants were to designate melodies as “Remember” if they remembered something they thought about before when hearing the melody or if they experienced something at the time of hearing the memory. They were to designate melodies as “Know” if they had strong feelings of familiarity in the absence of a specific recollective experience of the melody. “Remember” responses are consistent with Tulving’s theory (1985) of the episodic memory system. Episodic memories are those of past events of personal experiences or episodes that occurred in a given place and time. “Remember” responses indicate deeper processing of material while “Know” responses are consistent with the semantic memory system and indicate merely a familiarity with the item that involves less processing. Results indicated that recognition for both states of awareness increased as number of study trials increased.

A second phase of the experiment measured recognition of excerpts from obscure pieces of classical keyboard or solo instrumental music. In this phase, participants again increased the number of “remember” responses with more repetitions of the melodies, but the number of “know” responses decreased. During the third phase, participants were presented with both types of stimuli (the vocal performance of Polish folk songs and keyboard performance of solo instrumental music) in either one or three trials. Participants were also instructed to report “guess” choices as well as “remember” or “know”. Results of phases 1 and 2 were replicated, with guessing being inversely proportional to remember responses. The authors suggested that remembering and knowing are independent states of awareness and indicated that high levels of false alarms across all conditions might be the result of similar musical phrases present in all music, which might lead to feelings of familiarity. The Polish folk songs were performed vocally while other stimuli were presented using a solo keyboard. However, the manner in which these stimuli were presented may have served as a confound. For example, Hailstone et al. (2009) found that even when using timbres created by a synthesizer, select timbres were associated with specific emotions by the participants. This possible confound was addressed in the current study by using the same timbre for all sets of the musical stimuli.

The current study examined age-related differences in recognition memory based on the emotional valence of the music. Under three conditions, younger, middle-aged, and older adults heard musical excerpts from films designed to evoke either pleasant or unpleasant emotions. Historically, music was performed during silent films to mask the noise from the film projector, and, additionally, served as an aid to explain the action of the film (Cohen, 2010). This use of music in film was recently illustrated by the award-winning movie “The Artist” (2012). Anthologies of music were published in order to help represent emotional settings. The use of music and its composition specifically for films continued even after the advent of the “talkies” and remains an important part of the movie experience to this day. Excerpts from music composed specifically to convey and evoke emotions in films were used as the stimuli for the current study. Music stimuli evoke increased activity based on PET in the parahippocampal gyrus (Blood et al., 1999). This area has been associated with learning and memory, as well as age-related decline (Stern, 2009). Based on these findings, it is reasonable to expect that musical stimuli will evoke age-related differences in recognition memory. Older adults display better emotion regulation than younger adults and process emotional information more fully than younger adults. Furthermore, older adults have demonstrated better ability to recognize emotional material than younger adults. Based on these results, I hypothesized that older adults in the current study would have better recognition for pleasant musical stimuli than for unpleasant musical stimuli. A review of the literature indicates emotion regulation has not often been examined in middle-aged adults and an exploratory analysis with this age group was included in the current study. Hypotheses regarding age differences in performance on the musical emotional task are very general. It is not clear when the change from better attention to negative information in younger adults to better attention to positive information in older adults occurs. Examination of middle-aged adults in this study provided an opportunity to better understand this effect. As a result, I hypothesized that middle-aged adults might have a better recognition for pleasant musical stimuli than for unpleasant musical stimuli.

Laterality of processing musical information has been considered in cognitive neuroimaging studies. Gagnon and Peretz (2000) examined brain laterality in university students during affective and non-affective music tasks. In traditional views of laterality, the left hemisphere is assumed to play a role in verbal information processing while the right hemisphere plays a role in nonverbal information processing. The students were asked to listen to consonant melodies or dissonant melodies and to rate them as correct or incorrect during the non-affective task and to rate them as pleasant or unpleasant during the affective condition. No ear difference was noted in the non-affective task but the affective task produced a left hemispheric predominance for pleasant responses (a right ear advantage) and a right hemispheric predominance (a left ear advantage) for unpleasant responses. These results are consistent with the hypothesis that positive emotions are processed more readily in the left hemisphere, while negative emotions are processed more readily in the right hemisphere (Davidson, 1992).

A left hemisphere advantage for processing emotional material was also reported by Flores-Gutierrez et al. (2007) when brain correlates of emotional reactions to musical excerpts using fMRI and EEG were examined. A piano excerpt by J.S. Bach and a passage from Mahler's 5th Symphony were used as pleasant stimuli and a segment by J. Prodromides was used as unpleasant stimuli. The Bach and Mahler pieces are consistent with consonant (generally pleasant) selections and the Prodromides selection is consistent with dissonant (generally unpleasant) selections. These excerpts were chosen based on emotional ratings from 335 previous participants (mean age of 25 years). Participants gave emotional ratings for each musical piece immediately after hearing it. Activity in the left hemisphere was generated by music, which engendered pleasant musical feelings while bilateral activity was generated in both hemispheres during the presentation of the unpleasant musical excerpts. The superior temporal gyrus was activated by all three of the musical stimuli with the left gyrus being activated only by pleasant musical emotions and the right gyrus by unpleasant musical emotions. The left auditory cortex was activated by pleasant music. General listening without cognitive activity produced activation in a wide variety of brain sites. Flores-Gutierrez et al. (2007) emphasized that this was an important finding because earlier studies examining this brain area only reported activation during the discrimination of basic sensory features. However, as noted previously, a possible difference in activation might have occurred because of the differences in timbre between the musical stimuli, with the Bach selection consisting of solo piano, the Mahler instrumentation being an orchestra and the Prodromides section including vocal as well as orchestral instrumentation. Stimuli for this study have been specifically chosen to minimize instrumentation differences.

Evidence of asymmetry in brain activation was also noted in a study of German adolescents (Altenmüller et al., 2002). Adolescents (12 – 15 yrs old) listened to 120 short pieces of music and 40 environmental sounds while EEG measured their brain activity. The adolescents were asked to rate their emotional response to the music after hearing each musical piece based on a 5 point scale, ranging from 1 "liked it very much", 2 "like", 3 "undecided", 4 "do not like" and 5 "do not like at all" . It should be noted that instrumental music was used exclusively to avoid activation of language-related areas in the brain, such as Broca's area and Wernicke's area. Altenmüller et al. (2002) reported that stimuli rated positively produced activation toward the left fronto-temporal cortices (in both males and females) and stimuli rated negatively produced a more bilateral fronto-temporal activation pattern. The EEG patterns in response to positive emotions were lateralized in the left hemisphere, while those for negative emotions produced lateralization in the right hemisphere.

Results of these three studies suggest that pleasant (consonant) music and unpleasant (dissonant) music might be processed in different areas of the brain. The three studies found that activation in the left hemisphere was greater for pleasant music and activation in the right hemisphere was greater for unpleasant music. In addition, Flores-Gutierrez et al. (2007) and

Altenmüller et al. (2002) reported increased bilateral activation for unpleasant music. This finding has interesting implications when the HAROLD model proposed by Cabeza (2002) is considered. The HAROLD model (Hemispheric Asymmetry Reduction in Older Adults) proposes that changes in activity in the prefrontal area occur in older adults as functional compensation. These findings coupled might be indicative of more difficulty processing unpleasant musical stimuli in older adults due to the increased bilateral activity already occurring in frontal areas. They may have already reached the “ceiling” of their capacity to process and/or there may be no more benefit to the increased activity in these areas. Younger adults, who function with the HERA model of encoding of episodic memory in the left prefrontal cortex and retrieval of episodic retrieval in the right prefrontal cortex, would not be expected to exhibit these difficulties.

Valence in terms of pleasantness and unpleasantness in music is also related to consonant aspects of the music. Costa et al. (2004) asked students to rate consonant and dissonant melodies in terms of valence, aesthetic judgment, activity and potency. Students rated melodies high in consonant strength as pleasant and more expressive of positive emotion. Dissonant melodies were rated as unpleasant. Roy et al. (2008) examined the relations between arousal of emotion by music and pain modulation. Pleasant and unpleasant excerpts of music, from a pool of 30 excerpts that had previously been rated by independent participants, induced emotions corresponding to the valence of the music and to affect moods as measured by the Profile of Mood States questionnaire (McNair et al., 1992). Participants between the ages of 19 and 39 years listened to three 5-minute excerpts of pleasant music and three 5-minute excerpts of unpleasant music while having thermal stimulation applied to the skin of their forearms. Listening to pleasant excerpts of music reduced pain relative to the presence of unpleasant excerpts or silence and indicated that music may influence the perception of pain (McNair et al., 1992).

Additional studies indicate that physiological responses can be modulated by music valence. Krumhansl (1997) examined psychophysiological responses to musical excerpts ranging from about three minutes in length from the beginning of six different orchestral compositions. Undergraduate students were asked to adjust a slider on a computer display to indicate the amount of emotion experienced while they listened to the music. The emotions examined were sadness, fear, happiness and tension. After each excerpt, the students completed a short questionnaire about the emotional effects of the music. They were also asked to rate, on a scale from 0-8, the Pleasantness and Intensity of the music and their familiarity with it before the experiment. Cardiovascular, electrodermal and respiratory measurements were taken to examine physiological responses. The students were also asked to complete a questionnaire about the emotional aspects of the excerpts. Self-reported emotions were produced by listening to the music. Physiological measurements were taken at one-second intervals during the playing of the musical excerpts. Reliable differences were shown in physiological measures between each excerpt type. Krumhansl (1997) suggested that these results support the theory that listeners experience emotion when listening to music based on both subjective verbal reports and objectively measured physiological changes in response to the music.

Because of the physiological responses to music that have been demonstrated, music has been successfully used as therapy for insomnia. Older adults (67-93 years) who met the criterion of the DSM-IV for insomnia were examined to compare the efficiency of a muscle relaxation and a music relaxation technique on sleep patterns (Ziv et al., 2008). Baseline sleep patterns were measured by an ActiGraph, which was worn by the participant on the nondominant hand during sleep. The ActiGraph was designed to be worn also while awake and to objectively measure sleep and waking cycles. Participants wearing the ActiGraph pressed a button when going to bed and then again when getting up. Wrist movements were measured every ten seconds. These movements provided objective data regarding time falling asleep, number of wakings at night, and time falling asleep again after waking.

Measurements were analyzed by computer and were validated against polysomnography with agreement rates over 90%. The Mini Sleep Questionnaire (MSQ; Zomer, Peled, Rubin & Lavie, 1985) and the Technion Long Sleep Questionnaire (Haimov, Breznitz, & Shioloh, 2006) were also administered to the participants. Emotional factors were measured by the shortened version of the Zung and Durham depression questionnaire (1965), a short anxiety questionnaire (Sinoff et al., 1999) and the NEO PI-R (Hebrew version, Montag, 1991). Participants were also provided two relaxation CDs: one containing a male voice giving audio instructions for Jacobson's muscular relaxation technique (Jacobson, 1929) and one containing music composed for the study with a duration of 40 minutes. For the first week of the study, participants used the ActiGraphs and completed the questionnaires. During the second week, participants continued to use the ActiGraphs, repeated the questionnaires and listened either to the muscle relaxation CD or the music relaxation CD. In addition, they completed the NEO PI-R. During the third week, questionnaires were repeated and the alternate CD was used. Base level results from the ActiGraphs indicated that all the participants were insomniacs. Sleep efficiency was found to be higher after using the music relaxation CD compared to using the muscle relaxation CD. In addition, when using the muscle relaxation CD, participants reported that they had more difficulty falling asleep and woke more often during the night. Results also indicated that participants reported a lower level of anxiety after using the music CD than the muscle relaxation

CD. The authors suggested, based on their results, that music relaxation may be more beneficial than muscle relaxation in the treatment of insomnia.

In addition to being used as a treatment for insomnia, music has been used in therapeutic settings with older adults. Older adults (70-95 years) with cognitive impairments were trained in an active listening paradigm (Gregory, 2002). Participants diagnosed with probable Alzheimer's disease, dementia, complications from stroke, and depression were regular participants in-group music therapy sessions at a community day care program. Easily recognizable instrumental music was selected. During the first phase of the project, two comparison groups were used in addition to the treatment group. One group was comprised of older adults (55-79 years) from an Alzheimer's Care-givers Support group while the other consisted of college students (22-48 years). Participants were trained to use the Continuous Response Digital Interface (CRDI) which recorded the nonverbal, simultaneous, real-time focus-of-attention responses (Fredrickson, 1994; Gregory, 1995; Madsen & Geringer, 1990) and were instructed to move a dial to specific points on an overlay to register responses while listening to selected music. The names of the songs “Yankee Doodle”, “Battle Hymn of the Republic”, and “American the Beautiful” were printed on the overlay as well as the word “Wait”. When no music was being played, participants were instructed to move the dial to “Wait”. The duration of the listening session was 3.5 minutes. Ten of the participants in the therapy group immediately repeated the listening session with assistance from the therapist.

Approximately one week later, the ten participants again repeated two trials, one with assistance and one without assistance. Older listeners in the therapy group did not move the CRDI dial as often as those in the comparison group and had fewer correct responses overall in the first session. Reaction time comparisons indicated that all participants were slower in responding while processing music information. The therapy group response times were slower than either of the two comparison groups. While the responses were slower, the results indicated that the therapy group participants (those with cognitive impairments) were able to sustain attention for the 3.5 minutes of the task.

During the testing phases, participants in the therapy group moved the dial as often as those in the comparison groups resulting in slower response times for the music excerpts. Participants diagnosed with possible Alzheimer's disease were able to sustain listening during the entire testing phase and were able to recognize all the excerpts and return the dial to the "Wait" position during silences. Gregory (2002) suggested that older adults with cognitive impairments might benefit from music listening interventions designed to promote sustained attention, a common problem for older adults with cognitive impairment. In addition, older adults diagnosed with stroke complications demonstrated better accuracy after training relative to those diagnosed with cognitive impairments, indicating that music listening interventions might function differently for those with different medical diagnoses. While the underlying mechanism is not clearly understood, these results indicate that the use of musical stimuli for examining cognitive processes in older adults can be an effective tool for comparing abilities within groups of adults with common medical diagnoses (e.g., those with the diagnosis of stroke, those with the diagnosis of mild cognitive impairment.). The use of musical stimuli that is varied in emotional valence to examine age differences in memory ability seemed especially appropriate and was employed in the current study.

While there is evidence that physiological responses are modulated by music, spatial memory does not seem to be moderated by experience with musical notation. Meinz and Salthouse (1998) presented musicians and non-musicians, aged 18 to 83 years, with visual stimuli composed of musical notation. Participants had a wide range of musical experience, from no formal musical training to sixty years of experience. Participants were tested on their musical knowledge of written music. Participants completed three practice trials, with the first melody notated on paper so that they did not have to rely on memory while learning to use the computer. Two blocks of six melodies each were then presented on the computer screen and participants were asked to reproduce what they had seen using the keys on the computer keyboard. Next, the participants completed the non-musical task. In this task, the background consisted of five concentric circles divided into two equal halves with symbols constructed in such a way as to be similar to musical notation presented in the concentric circles. Participants viewed the non-musical stimuli and then attempted to reproduce the patterns on the computer screen using the keyboard. The task was used to assess whether musical experience would moderate the relation between age and spatial memory performance. Specifically, Meinz and Salthouse (1998) were interested in examining whether reading musical notation experience in older adult musicians would have a moderating effect on the typical spatial memory decline observed with age and whether there would be a difference between adults with experience and those with little or no experience in reading musical notation. Because the task was domain specific, Meinz and Salthouse (1998) hypothesized they would be able to find an attenuating effect on the age-related declines in memory for the musical notation memory task. Surprisingly, greater amounts of musical experience did not moderate the effects of age on the task. Recency of experience, reductions in sight-reading activity, response biases or instrument effects did not influence performance. It is possible that older adults may have had difficulty in using the computer even though they were given considerable practice. If a paper and pencil test had been used to allow the adults to write the musical notation on a staff, the expected attenuating effect might have been observed.

Musical stimuli have also been used to examine episodic memory and the role of context for performance (Mishra & Backlin, 2007). In a study assessing encoding conditions, younger and older adults were randomly assigned to one of three conditions (Blanchet et al., 2006). In the intentional encoding condition, participants were asked to listen to melodies and remember them for later testing. In the dancing judgment condition, participants were asked to listen to melodies and indicate whether the song was either a “waltz” or a “march”. No mention was made of a later memory test. In the intentional encoding + dancing judgment condition, participants were told to memorize the melodies as well as make a judgment about the song being a “waltz” or a “march”. During the study phase, melodies were presented twice in random order. During the testing phase, 20 melodies, 10 target melodies plus 10 distractor melodies were presented. Participants were asked to indicate whether the melody was new or an older one that had been previously heard. Participants, both younger and older, who were given instructions to remember the melodies, were able to remember the melodies well.

Older participants were able to encode the melodies in an accurate manner (Blanchet et al., 2006). However, memory for melodies in older adults was not as accurate when divided attention was required. Specifically, older adults’ ability to make the march/waltz judgment was impaired. However, when making the judgment alone, this ability was intact. Making a structural judgment, such as deciding if a musical stimulus was a waltz or a march, was not sufficient to aid in the encoding of the material. Because music can elicit powerful emotions, asking participants to make an emotional judgment regarding melodies might allow more efficient, richer encoding of melodic material. In addition, because the emotional aspect of music is contextual, more support is provided during encoding when making an emotional judgment than in making a structural judgment. Older adults would be expected to benefit from using the emotional context to encode the stimuli, which, in turn, would lead to demonstration of better cognitive performance (Blanchet et al., 2006). The current study attempted to make use of the contextual aspect of emotion in music by asking participants to make an emotional judgment regarding melodies and then examined differences in memory for pleasant and unpleasant melodic stimuli.

Eschrich et al. (2008) used symphonic music from film scores in order to examine the effect of emotions on memory for music. Two groups of participants were used in the study: one group was asked to rate arousal, valence and emotional intensity of the music heard while the other group was asked to make a judgment about the length of the music. Participants were non-musicians and ranged in age between 19 and 44 years and attended three sessions. In the first session, they completed questionnaires regarding their present mood and then listened to two blocks of 20 excerpts during the first session and four blocks of 20 excerpts in the second session. Participants in the emotional condition were asked to rate their felt emotion after each excerpt. Those in the estimation condition estimated the total length of each excerpt and compared the length to the previously heard excerpt. Also during the first session, participants completed a demographic questionnaire containing information regarding music preferences and expertise. One day later, participants returned to the lab and heard all the target excerpts again. On the third day, participants heard the 40 old stimuli interspersed with 40 new pieces and were asked to make an old/new decision and to rate the arousal and valence of the excerpts. Excerpts which were rated more positively were remembered better than those rated less positively. This effect was demonstrated across both the group that rated the musical excerpts on valence, as well as the group that estimated the time of the excerpts. Eschrich, et al. (2008) suggested that participants may have automatically processed the emotion in the music, which influenced their recognition of the musical excerpts. The current study will further address this hypothesis by comparing younger, middle-aged, and older adults' memories for musical excerpts through the use of emotional valence ratings. Musical valence will serve as the emotional context and is expected to facilitate encoding and recognition of the musical stimuli. Using emotional context should allow for fewer demands on the limited cognitive resources of older adults and contribute to fewer age differences.

Deffler and Halpern (2011) recently examined memory for repeated melodies in a group of younger and older adults. Melodies were presented in piano timbre with mean length of 6.21 seconds. "Facts" about tunes were created with patriotic, religious, and nature categories and were presented with the tunes (e.g., A soldier played this tune during a military exercises, an awards ceremony or a military funeral). Six sets of tunes were created with patriotic, religious, and nature facts used in each set with half of the emotional "facts" being negative and half being positive. Before presentation of the tunes, participants were given a category for the tune and were told that a fact about the melody might be presented. Participants were instructed to remember the category and the association between the tune and the category for later testing. Participants were not told to remember the tune for later testing. A total of 48 tunes were presented with half of the tunes being presented three times. Following presentation of the tunes, participants completed the WAIS-R vocabulary test and then their memory for the tunes was tested. Following the memory test, participants categorized the tunes and then were tested on the "facts" presented with the tunes.

Participants were able to recognize the facts associated with the tunes well and better overall performance was observed for emotional facts than for neutral facts. Repeated presentation of the facts also increased recognition performance. More false alarms were noted in tune recognition than in fact recognition, with younger adults having a higher hit rate than older adults. Younger adults demonstrated more benefit after repeated presentation of the tunes than did older adults, but older adults demonstrated a recognition benefit when an association of an emotional fact was paired with tunes versus a neutral fact paired with tunes. Because older adults demonstrated a positivity bias, enhanced memory for melodies designated as positive relative to those designated as negative might be expected (Deffler and Halpern, 2011) and is the focus of the current study. Older adults are expected to demonstrate enhanced recognition memory for melodies that are consonant and more positive than for dissonant and negative melodies if a positivity bias exists.

Age-differences in memory for melodic structure have also been assessed. Halpern et al. (1995) examined the effects of age and musical experience on the recognition of melody transpositions. Participants in all four studies were younger adults, ages 18 to 30 years, and older adults, ages 60 to 80 years and included musicians and non-musicians. Musical stimuli were melodies composed specifically for the study and were presented by keyboard. Three types of comparisons were made: those which were exact transpositions (the melodies were transposed up by five semitones) and were labeled "ID" sequences, "SC" sequences, in which the fifth and sixth notes were different from the original melodies but with preserved contours of the melodies, and "DC" sequences, in which the fifth and sixth notes of the melodies differed from the original. Consonantity was preserved in both the ID and SC sequences.

In the second experiment, participants heard half of the items in an initial phase of the study and rated the items based on pleasantness. During the testing phase, participants were asked to make an old-new judgment as well as transposition recognition. Only consonant items were presented in this phase. The performance of younger participants on the old-new portion of the task was better than the older participants, but musicians did not exhibit better memory for the melodies than non-musicians even though musicians were better able to recognize transpositions better than non-musicians. Halpern et al. (1995) suggested that the longer retention interval required in the old-new judgment task in addition to the interference of making the transposition judgment was too cognitively challenging for the older adult musicians. The musicians may have encoded the contour of the line more effectively than the non-musicians and the effortful processing required for this encoding may have affected the processing of the emotional context (Halpern et al., 1995). The current study was designed to examine the effects of making an emotional judgment on the later recognition of musical excerpts and the possible implicit encoding of pleasant music based on the Socioemotional Selectivity Theory, in which older adults display a positivity effect by remembering positively valenced material more efficiently than negatively valenced material (Carstensen, 1995). It should also be noted that the melodies used by Halpern et al. (1995) were specifically composed for the study and were consonant in nature. The stimuli chosen for the current study are consonant and dissonant excerpts of film music, which were composed to evoke specific emotions on the part of the audience and were selected on the basis of high arousal levels with the hypothesis that high arousal levels would contribute to the saliency of the stimuli.

Lima and Castro (2011) recently examined the ability of adults to recognize expressed emotion in music as a function of age. Participants were divided into three age groups: younger (mean = 21.8 years), middle-aged (mean = 44.5 years), and older adults (mean = 67.2 years). Older adults' mental abilities were assessed using the Mini-Mental State Examination (MMSE; Folstein, Folstein & McHugh, 1975; Portuguese version Guerreiro, Silva, Botelho, Leitao &

Garcia, 1994). Fifty-six musical excerpts that have been validated for research on emotions were played for the participants (Vieillard et al., 2008). They heard each excerpt once and rated each on a 10-point scale with 0 being “absent” and 9 being “present”, with scores indicating how much the excerpt portrayed the emotional tone. Emotional tones of happy, sad, scary, and peaceful were also rated and participants were asked to rate each excerpt across the four dimensions. The emotion expressed by the music was more accurately recognized.

Interestingly, age-related differences in the magnitude of the ratings were also noted. Older adults demonstrated decreased ratings of sadness and fear/threat, with happiness and peacefulness magnitude ratings remaining stable. Older adults demonstrated a decline in accuracy for sadness and fear/threat relative to younger and middle-aged adults. In addition, middle-aged adults misclassified expressed sadness more often than younger adults. Responsiveness to sad and scary music demonstrated a progressive decline with age while responsiveness to happy and peaceful music remained stable across the age groups. It should be noted that Lima & Castro (2011) examined the concept of emotion recognition in music. Participants were asked to determine the emotion being expressed in the musical stimuli.

The current study examined evoked emotion in musical stimuli. Participants were asked to determine whether the music was pleasant or unpleasant based on their reaction to the stimuli. The musical excerpts have been chosen based on ratings provided by Eerola and Vuoskoski (2010) as “high arousal” indicating that hearing the stimuli kindle strong emotional cues. A group of middle-aged (45 to 60 years) participants were included in the current study to further examine emotion regulation across the lifespan.

Memory abilities in older adults have been tested using a variety of stimuli. Many of the studies cited in this literature review have utilized visual and verbal materials. With the exception of the Gardiner (1996) study, musical stimuli have not been used in memory studies examining age. The Gardiner study had a possible confound – some stimuli were presented vocally while other stimuli were presented using a keyboard. The differences in timbre may have been confusing to the participants when trying to remember the melodies. All stimuli in the current study were presented using an orchestral timbre to avoid this possible confound.

The second part of the Halperin et al. (1995) study only presented consonant stimuli, rated positively. The current study presented both consonant and dissonant excerpts, with the expectation that consonant excerpts would be rated positively while the dissonant excerpts would be rated negatively. Memory recognition for these emotionally rated stimuli was then assessed. Older adults prioritize emotion regulation (Carstensen & Mikels, 2005) and emotional valence of stimuli has also been noted to influence age-related memory, with positively valenced stimuli being more effectively remembered than negatively valenced stimuli.

The Eschrich et al. (2008) study examined the facilitative role of emotional valence using musical stimuli on memory recognition but only in younger adults (mean age 25.5 years). The current study comparatively examined these effects in younger, middle-aged, and older adults in a task designed to present positively and negatively valenced information. Eschrich et al. (2008) included musical excerpts ranging from neutral to strongly positive but negatively valenced excerpts were not included. Participants heard the musical stimuli on three different occasions, once during an encoding phase, once a day later when all excerpts were again heard, and lastly, on the third day, when participants were asked to make a decision regarding whether the excerpts were old or new. The current study included younger, middle-aged and older adults, utilizing consonant (positive) and dissonant (negative) excerpts and the stimuli were presented to each participant twice during the session to address the limitations of previous studies examining the relations between music, emotion, and memory.

A summary of important studies and findings is presented in Table 1.

Summary

Memory for emotionally valenced stimuli has been frequently assessed using visual and verbal stimuli. The use of auditory stimuli to assess memory for emotionally valenced material, especially in older adults, has been limited. The current study utilized both positive and negative stimuli in the form of musical excerpts to examine their effects on memory in younger, middle-aged and older participants.

Music has profound effects on emotions. These emotional effects extend to cognition, in younger, middle-aged, and older adults, with better memory for emotional material found in younger as well as older adults. Studies cited previously document that older adults remember and focus on positive information in order to better regulate their emotions, supporting the Socioemotional Selectivity Theory (Carstensen, 1995). While the effects of the emotional aspects of music have been widely studied with younger adults, little empirical study has been conducted with middle-aged and older adults and the effect of the emotional valence of music on their memory abilities. The current study attempted to focus on one aspect of these effects, that of positive valence of music and its role in episodic memory recognition. Music excerpts that are considered consonant in nature have been consistently rated as pleasant while those that are dissonant in nature have consistently been rated as unpleasant (Costa, 2004).

Based on the Socioemotional Selectivity Theory, older adults were expected to be more focused on emotional regulation in their cognitive processes and encode positive information more efficiently to regulate those processes. Older adults were expected to recognize musical excerpts rated as “pleasant” better than those rated “unpleasant”. The emotional valence of music should make memory for the music more salient and facilitate more elaborate encoding of the stimuli when asked to make an emotional judgment. In contrast, memories for musical excerpts in young adults should be biased toward those rated as “unpleasant” compared to those rated “pleasant” since they have been noted to focus on and remember material with a negative bias (Kern, 2005). Under this condition, the negative valence of the music was expected to be more salient for the younger adults and should have facilitated encoding of the musical stimuli.

Hypothesis 1: I expected that there would be a relation between consonant musical excerpts and pleasantness ratings and between dissonant musical excerpts and unpleasantness ratings. Since consonant excerpts are rated as more pleasant to the ear and dissonant excerpts have been found to be unpleasant to the ear (Costa et al., 2004), participants across all age groups were expected to rate consonant excerpts as “pleasant” and the dissonant excerpts as “unpleasant”.

Hypothesis 2: I expected there would be a relation between age and valence ratings across conditions. Based on the Socioemotional Selectivity Theory (Carstensen, 1992) and studies in which older adults have been found to remember more pleasantly valenced (consonant) information than unpleasantly valenced (dissonant) musical excerpts, I hypothesized that, while younger adults would remember quantifiably more excerpts overall, older adults would remember more pleasantly valenced (consonant) musical excerpts than unpleasantly valenced (dissonant) musical excerpts. Based on the same studies, I expected younger adults would remember more unpleasantly valenced (dissonant) musical excerpts than middle-aged and older adults.

Hypothesis 3: I expected that younger adults would have better recognition memory across all conditions than middle-aged and older adults and middle-aged adults would demonstrate less recognition memory than younger adults but more recognition memory than older adults. Previous research by Salthouse (2009) determined that a linear decline in scores across cognitive abilities begins near age 30 and continues across the lifespan. Therefore, I hypothesized that younger adults would remember more musical excerpts than middle-aged or older adults and that middle-aged adults would remember fewer musical excerpts than younger adults but more excerpts than older adults.

Hypothesis 4: I expected there would be a relation between the age of the participants and the condition in which they participated. In the Study Only condition, I expected younger adults would remember more of the musical excerpts than the middle-aged and older adults and the middle-aged adults would remember more of the musical excerpts than the older adults and fewer than the younger adults. However, in this condition, I expected, based on studies in which older adults were instructed to intentionally remember material (Blanchet et al., 2006), older adults would demonstrate recognition memory for more of the excerpts than in the other conditions. Based on studies in which older adults have been found to recognize emotionally valenced material, I expected older adults would demonstrate memory for more of the pleasantly rated musical excerpts in the Rate and Study condition than in the Rate Only condition. I expected middle-aged adults would begin to demonstrate a trend toward recognizing more positively valenced musical excerpts in the Rate and Study condition.

CHAPTER 2

METHOD

Participants

Power analysis based on G Power 3.1 indicated that to achieve an effect size of .4 (a large effect) a sample size of 35 participants in each age and condition group would be necessary. The 135 participants in this study ranged in age from 17 to 92 years. The young group (ages 17-35 yrs) consisted of 19 males and 35 females for a total of 54, mean age was 22.13, $SD = 3.686$. The middle-aged group (ages 36-64 yrs) consisted of 10 males and 30 females, mean age was 49.52 yrs, $SD = 7$. The old group (ages 65-92 yrs) consisted of 9 males and 32 females with the mean age being 74.49 yrs, $SD = 7.086$.

Participants in the young group were drawn from a large introductory psychology course, an upper level psychology course, and from a nursing course from a local community college. Participants in the middle-aged group were drawn from the surrounding community and from the nursing course, and were recruited by word of mouth, postings on social media and by direct approach on the part of the researcher. Participants in the old group were drawn from the surrounding community and were recruited by word of mouth and by direct approach on the part of the researcher. Participants from the psychology courses and the nursing course received course credit for participation. Community participants received a $10 gift card as thanks for their participation.

Measures

St. Louis University Mental Status Exam (SLUMS). The SLUMS (Tariq, et al., 2006) was used to screen for Mild Cognitive Impairment (MCI) and dementia (Appendix C). The SLUMS has been developed as a more sensitive alternative to the Mini-Mental Status

Examination (MMSE; Folstein, Folstein & McHugh, 1975). Responses are scored based on educational level, with a lower total score indicative of mild cognitive impairment in those not having completed high school. After testing and analysis, Tariq et al. (2006) determined that a score of 23.5 in participants with less than a high school education is indicative of mild cognitive disorder, with a sensitivity/specificity value of 0.92/0.81 and 19.5 for dementia with a sensitivity/specificity value of 1.0/0.98. For participants with a high school education or above, Tariq et al. (2006) recommended that a score of 25.5 is indicative of mild neurocognitive disorder with a sensitivity/specificity value of 0.95/0.76 and 21.5 for dementia with a sensitivity/specificity value of 0.98/2.0.

Hearing Acuity. The American Speech-Language-Hearing Association, January, 2012, reports that loss of hearing for frequencies of 2000 Hz and above frequently occurs in older adults (www.asha.org). Hearing acuity was assessed with both a self-report measure (Appendix) and a digital medical hearing screener: a Redding Medical Universal Hearing Screener, #9360, for 40dB at 500, 1000, 2000, and 4000 Hz. Participants first placed the hearing screener by their right ear. A tone was played for each frequency and the participant indicated detection of the tone by raising the left hand. The researcher administering the test was able to determine when the tone was played by illumination of a small light next to each frequency level. After testing in the right ear, the same procedure was repeated for the left ear. Participants wore noise-cancelling over-the-ear headphones for the testing procedure and were instructed in the use of the volume control located on the headphones to adjust sound levels.

Positive and Negative Affect Schedule (PANAS). The PANAS is an assessment of mood states based on self-report (Watson, Clark & Tellegen, 1988). Participants completed the 10-item PANAS scale with the current mood of the participant as the time measurement.

Positive Affect refers to a participant's feelings of enthusiasm and alertness, with high positive affect being a state of high energy, alertness and enthusiasm, and low positive affect indicative of lethargy and low enthusiasm. Negative Affect refers to a participant's feelings of distress and includes anger, guilt, fear, and nervousness, with high negative affect indicating the presence of these feelings and low negative affect indicating the absence of these feelings.

Older adults were expected to remember musical excerpts rated as "pleasant" more readily than musical excerpts rated as "unpleasant". The PANAS scale assessed the current mood state of the participant and enabled us to examine whether a relation existed between the current mood state and the type of musical excerpt remembered by the participant. The use of the PANAS has been validated for older adults as well as for college students (Kercher, 1992) and is highly correlated with the scales of the Profile of Mood States (POMS; McNair, Lorr & Droppleman, 1971). The scales show good internal consistency with coefficient alphas ranging from .84 - .87 and .86 - .90 for the Positive Affect and Negative Affect scale, respectively (Watson, Clark & Tellegen, 1988). Watson and Clark (1994) reported coefficient alphas ranging from .83 to .91 for the scales based on large samples.

Verbal Paired Associates (VPA). The updated version of the Wechsler paired associative recognition task (Wechsler, 1945), the Verbal Paired Associates test (VPA; Uttl, Graf, & Richter, 2002) was administered to assess episodic memory. The test consists of 15-paired words, 5 pairs that consist of easy associations (e.g., baby – cries) and 10 pairs that are less common associations (e.g., frog – neck). At times 1 and 2, the researcher read the list of word pairs to the participants. Following this, the researcher read the first word of each pair and asked the participant to recall the matching word. At time 3, the researcher did not read the list of word pairs but gave the participant the first word of the pair and asked the participant to recall the matching word. At each time the word pairs were read and tested in a fixed, random order. Reliability was reported to be .85 (Uttl, Graf, & Richter, 2002).

Digit Span Forward and Backward Tasks. The Digit Span Forward and Backward subtests of the Wechsler Adult Intelligence Scale-Revised (WAIS-R, Wechsler, 1981) were administered to assess short-term memory and working memory, respectively. Reliability has been determined to be .96 - .97 for Full Scale IQ (Axelrod & Schretlen, 1996).

Participants were presented a series of digits and asked to immediately recall them in the order that they were presented. The longest list that could be recalled was recorded as the Digit Span Forward score. For the Digit Span Backward, participants were asked to reverse the order that the digits were presented (i.e., this condition requires not only holding the digits in short term memory, but also manipulating the order of the digits). The longest list recalled was recorded as the score.

Future Time Perspective Scale. The Future Time Perspective Scale (Carstensen & Lang, 1996) was used to examine age-related differences in viewpoint regarding expectations for the future and perceived limitations on time. Participants were asked to indicate their agreement with 10 statements using a scale of 1 (very untrue) to 7 (very true). Examples statements include "My future seems infinite to me." "I have the sense that time is running out." Internal consistency ranged from α = .76 to .92 (Fung, Lai & Ng, 2001; Lang & Carstensen, 2002; Young, Fung, & Lang, 2007).

Musical Stimuli. Twenty eight musical excerpts were used as stimuli and were chosen based on the following criteria: 1) Bachorick et al. (2009) found that an excerpt of 8.31 seconds in length was necessary for participants to make an emotional judgment. The excerpts chosen for this study were at least 15 seconds in length. Each excerpt was programmed to be heard for 10 seconds to maintain equal lengths. 2) The number of consonant melodies chosen was 13 and the number of dissonant melodies chosen was 15. Fourteen of the stimuli were target stimuli and 14 of the excerpts were foils (i.e., new, never before presented). They were presented in random order. The target stimuli were presented twice, in random order. Foils were interspersed among the target stimuli and presented for testing in random order.

3) Excerpts were chosen from the Eerola and Vuoskoski (2010) stimulus set. Film music was chosen as a basis for their set of stimuli because it is relatively neutral yet provides powerful emotional cues during movie scenes. Episodic memory for the music was avoided by choosing excerpts that were unfamiliar. The selection was limited to music composed within the last three decades (1967 - 2006). The melodies in the set have been tested and validated by an expert panel of trained musicians. The panel choosing the excerpts for the Eerola and Vuoskoski stimulus set was composed of 12 expert musicologists who were given five different soundtracks and asked to find five examples of target emotions. Comparisons across the group resulted in a finalized stimulus set to provide an effective means of measuring discrete emotions. Cronbach's alpha was used to measure the consistency between raters, with results including happy ($\alpha = .93$, $\eta^2 = .63$), sad ($\alpha = .89$, $\eta^2 = 71$), tender ($\alpha = .92$, $\eta^2 = .72$), fearful ($\alpha = .92$, $\eta^2 = .63$), angry ($\alpha = .92$, $\eta^2 = .63$) and surprising ($\alpha = .66$, $\eta^2 = .23$).

The musical excerpts used in the testing phase of the current study were listened to and rated by three independent musicians (the researcher and two musicians with extensive training including a BA in performance for one musician and some college credit in music performance for the other). The stimuli were a subset rated as "high arousal" from the Eerola and Vuoskoski (2010) set. The musicians were asked to rate the excerpts on the basis of consonantity (dissonant or consonant). Fifteen excerpts were in the original set. The raters were unable to agree on consonantity for only one excerpt, therefore that item was discarded. Complete agreement about consonantity was reached for the other fourteen items, thus they were retained.

The fourteen items were pilot tested with 93 individuals ranging in age from 18 to 81 years. Consonant items were rated as "pleasant" 60-100% of the time while dissonant items were rated as "unpleasant" 44-100% of the time by individuals in this sample. The foil items were pilot tested with 61 individuals ranging in age from 18 to 75 years. For this sample, consonant items were rated as "pleasant" by 67-100% of the sample while dissonant items were rated as "unpleasant" by 67-100% of the sample.

Stimuli were programmed using E-Prime 2.0 (Schneider, Eschman, & Succolotto, 2002) and were presented on a Dell Inspiron 1018,using Intel ® Atom ™ CPU N455 @ 1.66 GHz, 1.67 GHz, 32-bit Operating System.

Conditions. Three conditions were presented in the current study with random assignment to condition within each age group to examine age-related differences in recognition memory for musical stimuli:

Study Only – Participants listened to the musical excerpts and were instructed to learn them for later recall. While participants listened to the excerpts, a colorful musical note was displayed on the screen. A laminated copy of the note was placed beside the computer keyboard for participants to view. Between each excerpt, the symbol for *pianissimo* (*pp* – very soft) was displayed on the screen for the duration of 5 seconds (Figure 1). Participants were tested on their recognition memory for the excerpts as described below.

Rate Only –Participants listened to the musical excerpts and rated them as "pleasant" or "unpleasant". While participants listened to the excerpts, a colorful musical note was displayed on the screen. A laminated copy of the note was placed beside the computer keyboard for participants to view (Figure 1). Between each excerpt, the instructions to "Press u if you find the music unpleasant." and "Press p if you find the music pleasant." were displayed (Figure 2). Participants were given 5 seconds to make a decision about the pleasantness or unpleasantness of the excerpt before the next excerpt began. A surprise recognition test was administered at the end of the session as described below.

Rate and Study – Participants listened to the musical excerpts and rated them as "pleasant" or "unpleasant". In addition, they were instructed to learn the excerpts for later recall. While participants listened to the excerpts, a colorful musical note was displayed on the screen. A laminated copy of the note was placed beside the computer keyboard for participants to view (Figure 1). Between each excerpt, the instructions to "Press u if you find the music unpleasant." and "Press p if you find the music pleasant." were displayed (Figure 2). Participants were given 5 seconds to make a decision about the pleasantness or unpleasantness of the excerpt before the next excerpt began. Participants were tested on their recognition memory for the excerpts as described below.

Procedure

A visual representation of the procedure is presented in Figure 3.

Phase 1. A demographic questionnaire was first administered to all participants and included questions about previous musical experience, training and preferences, as well as a self-report on physical health and hearing ability (Appendix). Participants also were given a list of movies from which the stimuli were taken and asked to circle those they had seen. The St. Louis University Mental Status exam (SLUMs) was administered to adults over 65 years of age.

Hearing acuity was assessed with a Redding Medical Universal Hearing Screener. Adults having difficulties with hearing frequencies above 1000 Hz were instructed on the use of the volume controls of the over-the-ear noise cancelling headphones.

Following the hearing screen, participants were administered the first testing of the Verbal Paired Associates test (VPA). The VPA was administered a total of three times during the session. The first two times the researcher read the pairs for the participant. After reading of the pairs was completed, the researcher gave the first word of the pair and the participant was instructed to respond with the second word. During the last phase of testing, the researcher did not read the word pairs but gave the first word of the pair and asked the participant to respond with the second word of the pair. The researcher circled correct responses on a record sheet.

Phase 2. The first presentation of the musical stimuli was played through the over-the-ear noise cancelling headphones, Philips, model SHP2500, 15-22000 Hz frequency range, 100 dB sensitivity, 32 Ohm impedance, 500 mW maximum power input. The researcher listened to the musical excerpts with headphones via a "Y" connector as well, to monitor stimulus presentation. In the Study Only condition, participants were instructed to listen to the excerpts and remember them for recall later in the session. In the Rate and Study condition, participants were instructed to listen to the stimuli, rate each one as "pleasant" or "unpleasant" and remember the stimuli for recall later in the session. In the Rate Only condition, participants were instructed to listen to the stimuli and rate each one as "pleasant" or "unpleasant". It should be noted that in this condition, participants were not informed of the later recall phase of the session.

Phase 3. Participants completed the PANAS and a second presentation of the Verbal Paired Associates test, followed by the Digit Span Forward and Digit Span Backwards tests.

Phase 4. The musical experience questionnaire (e.g., experience with music lessons and amount of time listening to music, music performance groups and concert attendance) was administered followed by the second presentation of the musical excerpts. Participants in the Rate Only and Rate and Study conditions again rated the musical excerpts on a "pleasant" or "unpleasant" basis.

Phase 5. Participants completed the Future Time Perspective Scale (Carstensen & Lang, 1996). The third and final administration of the Verbal Paired Associates test followed the second presentation of the musical excerpts. In this presentation, the researcher said the first word of the pair and asked the participant to respond with the appropriate word match to the pair.

Phase 6. Finally, the third presentation of the musical excerpts occurred. Participants heard the original 14 stimuli with 14 other "foils" interspersed in random order. Participants were asked to indicate whether each item was old (recognized) or new. Participants were asked to press the 'r' key if they recognized (remembered) the excerpt and recalled something they had thought or felt when hearing the excerpt earlier. They were asked to press the 'k' key if they recognized (knew) the excerpt, but did not recall anything they thought or felt when hearing the excerpt earlier. They were asked to press the 'g' key if they might have heard the excerpt earlier. They were asked to press the 'n' key if the excerpt was new (they had not heard it earlier). These instructions were displayed on the computer screen between each excerpt and also on a laminated sheet placed beside the computer keyboard (Figure 4). Participants had an unlimited amount of time to make the decision about whether or not they recognized the excerpt.

Hypotheses and Data Analysis

Preliminary analyses were done to determine whether there are any significant differences between age groups based on gender, education, health status, hearing acuity, movies seen, music experience, types of music enjoyed, and the Positive and Negative Affect and Future Time Perspective scores.

Hypothesis 1: I expected that there would be a relation between consonant musical excerpts and pleasantness ratings and between dissonant musical excerpts and unpleasantness ratings. Since consonant excerpts are rated as more pleasant to the ear and dissonant excerpts have been found to be unpleasant to the ear (Costa et al., 2004), participants across all age groups were expected to rate consonant excerpts as “pleasant” and the dissonant excerpts as “unpleasant”.

Analysis*:* Reliability analyses based on Cronbach’s α were conducted between consonant musical excerpts and pleasantness ratings and dissonant musical excerpts and unpleasantness ratings to test the hypothesis of consonant musical excerpts corresponding to pleasant ratings and dissonant musical excerpts corresponding to unpleasant ratings.

Hypothesis 2: I expected to find a relation between age and valence ratings across conditions. Based on the Socioemotional Selectivity Theory (Carstensen, 1992) and studies in which older adults have been found to remember more pleasantly valenced information than unpleasantly valenced information, I hypothesized that, while younger adults would remember quantifiably more excerpts overall, older adults would remember more pleasantly valenced (consonant) musical excerpts than unpleasantly valenced (dissonant) musical excerpts. Based on the same studies, I expected that younger adults would remember more unpleasantly valenced (dissonant) musical excerpts than middle-aged and older adults.

Analysis: An analysis of variance was conducted to determine whether the interaction between age and valence was significant. Planned comparisons with Bonferroni correction were completed to determine where the differences lay.

Hypothesis 3: I expected that younger adults would have better recognition memory across all conditions than middle-aged and older adults and middle-aged adults would demonstrate less recognition memory than younger adults but better recognition memory than older adults. Previous research by Salthouse (2009) determined that a linear decline in scores across cognitive abilities begins near age 30 and continues across the lifespan. Therefore, I hypothesized that younger adults would remember more musical excerpts than middle-aged or older adults and that middle-aged adults would remember fewer musical excerpts than young adults but more excerpts than older adults.

Based on Tulving's Remember/Know procedure (1985), participants were asked to indicate whether they remembered, knew, or guessed they had heard an excerpt earlier or if it was new. A "Remember" response corresponded to episodic memory, recalling something thought or felt when hearing the excerpt previously. A "Know" response corresponded to recalling having heard the excerpt earlier, but not recalling anything thought or felt. A "Guess" response corresponded to possibly recalling the excerpt earlier, but not being sure. Remembering has been equated with recollection and knowing with familiarity. Age-related declines have been demonstrated in remember hits (McCabe et al., 2009). I expected that older adults in this sample would show this decline in remember hits.

Analysis: Repeated measures analysis was carried out to determine age-related differences in recognition memory for consonant and dissonant excerpts across conditions.

Hypothesis 4: I expected that there would be a relation between the age of the participants and the condition in which they participated. In the Study Only condition, I expected that younger adults would remember more of the musical excerpts than the middle-aged and older adults and the middle-aged adults would remember more of the musical excerpts than the older adults and fewer than the younger adults. However, in this condition, I expected that, based on studies in which older adults were instructed to intentionally remember material (Blanchet et al., 2006), older adults would demonstrate recognition memory for more of the excerpts than in the other conditions. Based on studies in which older adults have been found to recognize emotionally valenced material, I expected that older adults would demonstrate recognition memory for more of the pleasantly rated musical excerpts in the Rate and Study condition than in the Rate Only condition. I expected that middle-aged adults would begin to demonstrate a trend toward recognizing more positively valenced musical excerpts in the Rate and Study condition.

Analysis: Repeated measures analysis was conducted to determine age-related differences between recognition memory for consonant and dissonant musical excerpts across all three conditions.

CHAPTER 3

RESULTS

This study was designed to examine group differences between younger, middle-aged, and older adults on recognition memory for emotionally valenced musical excerpts. The relations between the pleasantness/unpleasantness of the musical excerpts based on harmonic consonance and dissonance and memory for the excerpts as well as current and recent emotional states and perception of future time were also examined.

Preliminary analyses, main analyses and supplementary analyses were performed using SPSS 17.0 and SPSS 20.0 statistical software packages and are presented respectively in the following sections. Tukey post-hoc comparisons are reported for each analysis where appropriate.

Preliminary Analyses

Preliminary analyses included an examination of frequency distributions for the demographic variables, measures of cognitive abilities and affect, as well as the future time perspective scale. Characteristics of the sample can be found Table 2. Frequency distributions and scatterplots of dependent variables were examined for possible outliers. Means and frequencies for data normalization were examined. Data for the negative scale of the Positive and Negative Affect Scale was positively skewed (2.86) and kurtotic (9.59). The negative scale scores were transformed using the transformation recommended by Tabachnick & Fidell, 2007, page 89, of 1/variable.

General Demographic Information

Differences across the age groups based on marital status, education level, and living arrangement were consistent with what would be expected in the general population (Table 2).

There were no significant differences across age groups based on gender, χ^2 (2) = 2.3, p = .317. Significant age group differences for marital status were noted, χ^2 (6) = 109.38, p < .001. As expected, participants in the young group were more likely to be single (90.7%) than either the middle-aged group (16.3%) or the older group (0%). More participants in the middle-aged group were divorced (10%) than those in the younger (1.9%) and older groups (0%). Finally, a higher percentage of older adults were widowed (19.5%) than participants in either the young group (0%) or middle-aged group (2.5%).

Significant differences for race between age groups were noted, χ^2 (8) = 16.15, p < .001. A larger number of minorities was found in the young group (24%) than in the middle-aged group (.03%) and the older group (.05%). This difference was not unexpected and is representative of the university population from which the younger sample was drawn.

Types of living arrangement were significantly different across age groups, χ^2 (14) = 108.07, p < .001. Participants in the young group were more likely to live alone (16.7%) than participants in the middle-aged group (15%) and the older group (7.3%). Participants in the middle-aged (80%) and the older groups (78%) were more likely to live with their spouse or partner than those in the young group (9.3%). Participants in the old group (4.9%) were more likely to reside in an assisted living facility than participants in the young or middle-aged groups. Participants in the young group (59.3%) were more likely to live with roommates than middle-aged and older participants and were more likely to live with their parents (13%).

As might be expected, significant differences were noted for educational level across age groups, χ^2 (8) = 57.79, p < .001. Older adults (34.1%) were more likely to have graduate or professional degrees than middle-aged (20%) or young adults (0%).

Self-Rated Physical Health, Self-Rated Hearing, and Hearing Screener

Self-rated physical health and self-rated hearing assessments by age are presented in Table 3. The questionnaire administered to all participants to examine self-rated health and hearing can be found in Appendix A. Participants rated their physical health on a 5 point Likert scale ranging from 1 being poor health to 5 being excellent health. There were no significant differences between age groups in terms of self-rated physical health, χ^2 (8) = 9.99, p = .266. Participants rated their own hearing ability on a 5 point Likert scale ranging from 1 being poor hearing to 5 being excellent hearing. While there was no significant difference between age groups in self-rated hearing ability, χ^2 (8) = 12.46, p = .132, a significant difference was noted between age groups on responses to items on the hearing questionnaire based on the American Speech-Language-Hearing Association, χ^2 (12) = 36.81, p <.001. The score for the hearing questionnaire was based on the total number of "yes" responses. As expected, older adults answered more questions in the affirmative than did younger and middle-aged adults, with 46% of older adults answering 4 or more questions in the affirmative while 13.5% of middle-aged adults and 9% of younger adults answered 4 or more questions in the affirmative. Hearing difficulties were equated with affirmative answers and Appendix B contains the specific questions.

Each participant's hearing was assessed at the frequencies of 500, 1000, 2000, and 4000 Hz. 100% of the participants in the young group detected all frequencies presented to both the left and right ears. In the middle-aged group, 99% of the participants were able to detect the tones at 500, 1000 and 4000 Hz and 100% of the participants were able to detect the tone at 2000 Hz. Of the participants in the older group, for the left ear, 92% were able to detect the 500 Hz tone, 95% were able to detect the 1000 Hz tone, 99% were able to detect the 2000 Hz tone, and

85% were able to detect the tones at 4000 Hz. For the right ear, 95% of the participants were able to detect the 500 Hz tone, 99% were able to detect the 1000 Hz tone, 100% were able to detect the 2000 Hz tone and 85% were able to detect the 4000 Hz tone.

Medical History

Participants were asked about significant medical events in the past and chronic conditions (Table 4). There were no differences between the young, middle-aged, and older groups with respect to head injuries, being unconscious after a head injury, stroke, Parkinson's disease, or sleep apnea. Older adults reported having had more heart surgery than either of the other age groups, χ^2 (2) = 14.4, $p = .001$. Differences in reported chronic conditions were as would be expected based on age. Older adults reported a higher incidence of diabetes than younger and middle-aged adults, χ^2 (2) = 14.0, $p = .001$. Having a heart condition was reported more often by older adults than younger and middle-aged adults, χ^2 (2) = 9.91, $p = .007$. Older adults reported having high blood pressure more often than younger and middle-aged adults, χ^2 (2) = 37.5, $p < .001$ and a majority of participants in the older age group reporting having arthritis, χ^2 (2) = 66.0, $p < .001$. A greater number of older adults also reported having COPD than participants in the younger and middle-aged groups, χ^2 (2) = 11.9, $p = .003$.

Movies Seen

To control for the possible confound of recognizing the musical scores derived from the listed movies, participants were asked to indicate the number of movies they had seen from which the excerpts of music were taken. As expected, there were age differences in the total number of movies seen, but there were no differences observed across conditions. A significant difference in the total number of listed movies seen was noted across age groups, F (2, 132) = 7.46, $p = .001$, $\eta^2 = .102$, occurring between the young ($M = 3.02$, 95% CD [2.04, 3.63]) and the middle-aged groups (M = 4.83, 95% CI [3.76, 5.89]), p = .002 and between the middle-aged and older groups (M = 2.98, 95% CI [2.41, 3.54]), p = .003. Participants in the middle-aged group reported seeing a greater number of the movies than participants in the young or older groups. The difference between the young and middle-aged groups may have occurred because these movies were from the period of 1976-2006, a period in which those in the middle-aged group might be expected to have attended more movies. Participants in the young group could be expected to have less experience with the movies, as they would have been too young to have seen many of these movies when they were in theaters.

Music: Lessons, Experience and Time Spent Listening

No significant differences were noted across age groups regarding whether or not the participants had taken music lessons, χ^2 (2) = 3.65, p = .161. There was no significant difference noted across age groups for how long participants took music lessons, χ^2 (8) = 8.61, p = .376, or when the lessons were taken, χ^2 (8) = 8.61, p = .376. Participants reported the amount of time they listened to music in a Likert type scale with scores ranging from 1 indicating "never listen to music" to 5 "listen to music on a daily basis". Significant differences were noted across age groups in the amount of time listening to music, F (2, 132) = 7.184, p = .001, η^2 = .098. Those in the young group (M = 4.85, 95% CI [4.69, 5.02]) indicated that they listened to music significantly more often than those in the older group (M = 4.22, 95% CI [3.94, 4.5]). There were no significant differences across conditions for the amount of time spent listening to music.

Main Analyses

Three types of analyses were performed: validity check, analysis of variance (ANOVA), repeated measures analysis of variance (ANOVA), and supplemental analyses of Remember and Know responses.

Valence of Musical Excerpts: Validity Check

The purpose of the first analysis was to examine the reliability of participants' subjective ratings for consonant and dissonant excerpts to ensure that participants were experiencing the emotional valence of the excerpts in the manner intended. Participants in the Rate condition and Rate Only condition listened to the musical excerpts on two occasions during the testing period. On both occasions, participants were asked to press "p" on the computer keyboard if they subjectively found the excerpt to be pleasant or to press "u" on the computer keyboard if they found the excerpt to be unpleasant. Ratings of musical stimuli in the Rate condition and the Rate and Study condition were highly reliable with Cronbach's α ranging from = .74 to .92 across conditions and age (Cronbach's α from .52 to .95) with the exception of the middle-aged group in the Rate Only Condition for the consonant pleasantness ratings (α = .32).

Proportion of Total Hits – False Alarms Analyses

A mixed ANOVA was conducted with the dependent variable being Proportion of Total Hits – False Alarms. The Between Subjects variables were Age Group (Young, Middle-Aged, Old) and Condition (Study Only, Rate Only, Rate and Study). A main effect of age, F (1, 126) = 43.4, $p < .001$, $\eta^2 = .281$, was noted and a main effect of Sound Type was also noted, F (1, 126) = 49.34, $p < .001$, $\eta^2 = .28$. An interaction between Age and Sound Type was present as well, F (2, 126) = 3.57, $p = .031$, $\eta^2 = .05$. Neither the main effect nor interactions involving condition was significant and were excluded from further analyses, F (4, 126) = 1.88, $p = .12$, $\eta^2 = .06$.

Because of the Age Group by Sound Type interaction, simple Repeated ANOVAs were performed for each age group (Young, Middle-aged, Old). The dependent variable for this computation was Proportion of Total Hits – False Alarms. The within subjects variable was Sound Type (Consonant, Dissonant). A main effect of Sound Type was noted within each age group: Young, $F = (1, 53) = 6.53$, $p = .013$, $\eta^2 = .11$; Middle-Aged, $F\ (1, 39) = 29.16$, $p < .001$, $\eta^2 = .43$; and Old, $F\ (1, 40) = 15.51$, $p < .001$, $\eta^2 = .28$ in which all participants in each age group recognized more consonant than dissonant excerpts (Table 5, Figure 5).

To further examine the Age Group by Sound Type interaction, simple one-way ANOVAS were performed separately for the Consonant and Dissonant trial types. The dependent variable was Proportion of Total Hits – False Alarms. The between subjects variable was Age Group (Young, Middle-aged, Old). Post hoc analyses revealed that younger adults performed significantly better on the Proportion of Consonant Hits – False Alarms than did older adults, as did middle-aged adults. Younger adults also performed significantly better on Proportion of Dissonant Hits – False Alarms than either the middle-aged or older adults, and middle-aged adults performed significantly better than older adults. Means and standard deviations are presented in Table 5.

Analyses of Know and Remember Responses

Participants were asked to indicate that they remembered an excerpt if they recalled something they thought or felt when they had heard the excerpt previously and to indicate they knew an excerpt if they recalled having heard the excerpt previously but nothing they thought or felt at the time. This procedure allowed for the examination of source memory, which has been shown to decline with age. Age-related differences in the number of Know and Remember responses were examined by using mixed ANOVAs. For Know responses, the dependent variable was Proportion of Total Know Hits – False Alarms. The between subjects variables were Age Group (Young, Middle-aged, and Old) and Condition (Study, Rate, and Rate and Study). The within subjects variable was Sound Type (Consonant, Dissonant). Results indicated a main effect of Sound Type, $F\ (1, 126) = 6.39$, $p = .013$, $\eta^2 = .05$. Across all age groups, the mean of Proportion of Consonant Know Hits – False Alarms, $M = .08$ ($SD = .02$) was greater than the mean of Proportion of Dissonant Know Hits – False Alarms, $M = .04$ ($SD = .01$), suggesting that participants expressed more familiarity with the Consonant excerpts than the Dissonant excerpts. The interaction between Age Group and Proportion of Total Know Hits – False Alarms was not significant, however, suggesting that age was not related to familiarity for this sample of participants, $F\ (2, 132) = 1.03$, $p = .36$, $\eta^2 = .02$.

For Remember responses, the dependent variable was Proportion of Total Remember Hits – False Alarms. The between subjects variables were Age Group (Young, Middle-aged, and Old) and Condition (Study, Rate, and Rate and Study). The within subjects variable was Sound Type (Consonant, Dissonant). A main effect of Sound Type was noted, $F\ (1, 126) = 16.78$, $p < .001$, $\eta^2 = .12$. Across all Age Groups, the mean Proportion of Consonant Remember Hits – False Alarms, $M = .6$ ($SD = .03$) was greater than the mean Proportion of Dissonant Remember Hits – False Alarms, $M = .5$ ($SD = .02$), indicating the participants recognized more of the Consonant excerpts than the Dissonant excerpts. The interaction between Age Group and Remember responses was not significant, suggesting that age was not related to recognition in this sample, $F\ (2, 132) = 2.41$, $p = .09$, $\eta^2 = .04$.

Supplemental Analyses

Supplementary analyses included chi square analyses and ANOVAs to examine the relations between demographic variables, cognitive abilities and measures of affect, as well as future time perspective and music recognition task performance.

Cognitive tasks.

Verbal Paired Associates Test. There was a significant difference between age groups for Time 1, $F\ (2, 132) = 7.22$, $p = .001$, $\eta^2 = .099$; Time 2, $F(2,132) = 21.01$, $p < .001$, $\eta^2 = .241$, and Time 3, $F(2, 132) = 17.39$, $p < .001$, $\eta^2 = .209$. At Time 1 the young group ($M = 7.22$, 95% CI [6.28, 8.17]) scored significantly higher than the older group ($M = 4.85$, 95% CI [4.22, 5.48], $p = .001$. Comparisons between the young and middle-aged groups and the middle-aged and older groups were not statistically significant ($p = .504$ and .082 respectively). At Time 2 the young group ($M = 11.22$, 95% CI [10.41, 12.04] scored significantly higher than the older group ($M = 7.02$, 95% CI [6.00, 8.05]), $p < .001$, and the middle-aged group ($M = 10.08$, 95% CI [9, 11.15]), $p < .001$, scored significantly higher than the older group. Finally, at Time 3, the young group ($M = 10.94$, 95% CI [10.05, 11.84] scored significantly higher than the older group ($M = 6.9$, 95% CI [5.83, 7.97], $p < .001$, and the middle-aged group ($M = 9.68$, 95% CI [8.6, 10.75], $p = .001$, also scored significantly higher than the older group.

Digit Span. As Table 2 indicates, no significant differences were observed between age groups on the Digit Span Forward, Backward or Total score.

Measures of Affect

Measures of affect included the Center for Epidemiological Studies Depression Scale (CES-D), the Positive and Negative Affect Schedule (PANAS), and the Future Time Perspective. A summary of the results by age and condition can be found in Table 5.

CES – D. No significant age group differences in depression scores were noted nor were significant differences observed by condition.

PANAS. The PANAS was used as an assessment of each participant's current mood state based on self-report. The PANAS consists of a positive scale and a negative scale. Participants used a Likert-type scale of 1-5 (1 being lowest to 5 being highest) to indicate their current state. An ANOVA was used to examine differences between age groups based on these scores. A significant difference based on age was noted for positive affect scale scores, $F(2, 131) = 3.27$, p

= .041, $\eta^2 = .04$. The young group (*M* = 32.43, 95% CI [30.58, 34.27]) scored significantly lower than the older group (*M* = 35.95, 95% CI [34, 37.9], but scores for the middle-aged group were not significantly different from either the young or the older group. When the transformed variable scores for the negative affect scale were analyzed, a significant difference was noted between age groups, F (2, 131) = 4.16, $p = .018$, $\eta^2 = .06$. The young group (*M* = 12.74, 95% CI [11.86, 13.62] exhibited more negative affect than the older group (*M* = 11.41, 95% CI [10.45, 12.38]), $p = .03$. The middle-aged group (*M* = 13.31, 95% CI [11.64, 14.97]) also scored significantly higher than the older group for the negative affect scale, indicating that in this sample older adults were experiencing less negative affect than the young and middle-aged groups at the time of testing. Significant differences between conditions were not observed. The PANAS scale was used to assess the current mood state of the participant, facilitating examination of the relation between current mood state and the type of musical excerpt the participant was able to remember.

Future Time Perspective. The Future Time Perspective scale consists of 10 statements. Participants indicate the trueness of the statement as applied to themselves based on a 1-7 Likert-type scale with 1 indicating that the statement is very untrue and 7 indicating that the statement is very true. Higher scores are indicative of more optimism regarding the participant's personal future. An ANOVA was performed to examine the differences between groups on these scores. A significant difference in the Future Time Perspective scores between groups was noted, F (2, 132) = 46.18, $p < .001$, $\eta^2 = .412$, with younger adults reporting a great sense of opportunities for the future and the belief that their futures were less limited than older adults. Young adults (*M* = 57.65, 95% CI [55.66, 59.64]) were significantly more optimistic about their futures than participants in the older group (*M* = 39.78, 95% CI [36, 43.56]0, $p < .001$. The middle-aged group (M = 54.9, 95% CI [52.06, 57.74]) also indicated more optimism about the future than did the older group, $p < .001$. There were no significant differences noted by Condition.

CHAPTER 4

DISCUSSION

Emotion and cognition are closely intertwined. Few would dispute the idea of the difficulties in performing a demanding cognitive task when depressed or ill, or conversely, to concentrate fully on a challenging task during an extremely joyful time. Changes in the ability and desire to regulate these types of emotions occur across the lifespan (Blanchard-Fields, Stein & Watson, 2004) but the factors that influence these changes are still not well understood. This study examined the effects of evoked pleasant and unpleasant emotions of younger, middle-aged and older adults on recognition memory for musical excerpts. Despite failing physical health, older adults demonstrate consistent or even increasing subjective emotional health and well-being. This observation is known as the “paradox of aging” (Jeste et al., 2012). Carstensen (1992) proposed the Socioemotional Selectivity Theory, in which it was hypothesized that increased emotional health and well-being occurred because older adults increasingly focus on positive information and emotional ties with close friends and family because of their awareness of the rapid passage of time. Younger adults, in contrast, focus on gathering information and seeking knowledge because their awareness is not time limited. Studies using visual stimuli have provided support for this theory (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2003; Mather et al., 2004). To our knowledge, the current study is the first using aural stimuli to examine the relations between evoked emotion and recognition memory. The goal of the study was to examine if the positivity effect is domain specific to visual information and if it could be generalized to the auditory domain. Participants in the study included undergraduate college students from a Midwestern university, middle-aged adults, and older adults living in the surrounding communities.

Pleasantness-Unpleasantness Ratings for Consonant-Dissonant Excerpts

I first examined whether there would be age-related differences in valence ratings for consonant and dissonant excerpts of music. In order to examine age-related differences in memory for emotionally valenced material, it was necessary to have stimuli that consistently evoked the same emotions across age groups. The results supported the hypothesis that participants in all age groups would rate consonant music as pleasant and dissonant music as unpleasant. This finding is consistent with findings of Costa, Fine, and Bitti (2004), in which participants rated consonant excerpts as “pleasant” and dissonant excerpts as “unpleasant”. While Costa, Fine, and Bitti examined undergraduate students’ ratings of perceived emotional expression, I asked participants across a wide age range (17-91 years) to rate their own responses to the stimuli. The current findings support the behavioral results of numerous studies in which participants were requested to make emotional judgments of consonant and dissonant music (e.g. Altenmuller et al., 2002; Bidelman & Krishnan, 2009; Blood et al., 1999; & Peretz et al., 2001). While it is interesting to note that in this sample younger adults did not rate the dissonant excerpts to be as unpleasant as the older adults, across age groups, participants reliably rated consonant musical excerpts as pleasant and dissonant musical excerpts as unpleasant indicating that the musical excerpts were evoking the same emotions across age groups.

Analyses of physical health, movies seen, and music questions

Differences across the age groups in my study were as would be expected in the general population, indicating that this sample was representative. In terms of physical health, older participants in this sample reported significantly more physical difficulties than those in the younger and middle-aged groups. I did note that participants in the Study group reported significantly more head injuries than those in the Rate group. However, regression analysis using head injuries reported as a variable revealed that having a head injury did not successfully predict the number of correctly recalled musical excerpts in either condition.

Participants in the middle-aged group reported seeing significantly more of the movies represented by the excerpts than did those in the younger and older age groups. The excerpts were chosen from movies from the period of 1976-2006, during which time middle-aged participants in this age group might be expected to have attended more movies currently in theaters. No significant differences were noted across the age groups or conditions regarding a history of music lessons or for the number of years lessons were taken. The majority of the participants reported having taken music lessons at some point during their lifetimes. Younger adults reported listening to music significantly more often than did those in the older group but there was no difference between the middle-aged and older groups in the amount of time spent listening to music. Only one younger adult reported never listening to music while most reported listening to music on a daily basis. Anecdotally, most of the participants across all age groups reported using music as a means of regulating their emotions. For example, many participants told me that when they were unhappy, they would listen to their favorite music in order to help "cheer themselves up". The pervasiveness of music in our culture and the self-recognized use of music as an emotion regulating tool indicated using music as a measure to examine memory for emotionally valenced information was appropriate for this study.

Memory for Musical Excerpts

I hypothesized there would be a significant difference in recognition memory for the musical excerpts across age groups based on condition. I expected to find, across conditions, that younger adults would remember significantly more excerpts overall and this hypothesis was supported. Further, I expected in the Study Only condition, that older adults would remember significantly more of the musical excerpts than they did in either the Rate Only or the Rate and Study conditions. The basis of this hypothesis was a study by Blanchet, Belleville, and Peretz (2006) in which younger and older participants were either told to study musical excerpts, make a judgment as to whether the excerpt was a waltz or a march and study the excerpt, or make the waltz judgment. In the Study Only condition, older adults were able to remember the excerpts as well as the younger adults. Based on this result, my hypothesis was that older adults would remember more excerpts in the Study Only condition. This hypothesis was not supported. Older adults did not recognize more musical excerpts in the Study Only condition than they did in the Rate Only or the Rate and Study conditions. Post hoc power analysis indicated sufficient power to detect differences between conditions was present (Observed Power = .56), suggesting that the sample size was sufficient to detect differences if they were significant. This result suggests that the basis for the positivity effect is during retrieval rather than at the time of encoding of emotionally valenced material.

The basis for examining age-related differences in emotionally valenced musical excerpts in the current study was the suggestion from Blanchet, Belleville, and Peretz (2006). They proposed that directing attention to the emotional aspects of the musical excerpts might be a more efficient manner for older adults to encode musical material. When I examined recognition memory across conditions, I in fact did find differences in recognition of the musical excerpts based on the consonance and dissonance of the excerpts. Overall, participants in the three age groups had better recognition memory for the consonant than the dissonant excerpts. The finding that all adults remembered the consonant better than the dissonant excerpts has important implications. Adults are presented with important choices on an almost daily basis. For example, simple choices between healthy foods and those of little nutritional value at the grocery store are important in terms of long-term health and well-being. If the manner in which the choices are presented has an effect on the quality of the decisions, it is important to know how to best present the choices. The finding that older adults recognized the consonant excerpts better than the dissonant is an important contribution to the understanding of the Socioemotional Selectivity Theory because it implies that the focus on positive information observed in older adults encompasses not just the visual domain, but also includes the auditory domain.

Participants were asked to indicate that they remembered an excerpt if they recalled something they thought or felt when they had heard the excerpt previously and to indicate they knew an excerpt if they recalled having heard the excerpt previously but nothing they thought or felt at the time. This procedure allowed for the examination of source memory, which has been shown to decline with age. Age-related differences in source memory were examined by using the Remember/Know procedure developed by Tulving (1985). These differences have not been examined before for emotional stimuli. That no differences were found may imply that older adults' source memory for emotional stimuli are not as affected as source memory for non-emotional stimuli. Post hoc power analysis for Know responses suggest perhaps significant results might be obtained with a larger sample (Observed Power = .23). However, mean values for this variable were extremely low. It is possible that participants either did not understand the instructions or really did recall something they felt or thought when they first heard the excerpts, actually recognizing the excerpts rather than expressing familiarity with the excerpts. Observed power for Remember responses was higher (.48), suggesting participants did understand the instructions. Perhaps a larger sample size would have the power to detect the difference. Across age groups, means were much higher for Remember responses than for Know responses. In addition, means were higher for consonant than for dissonant excerpts across all age groups for both Know and Remember responses.

Cognitive Tasks

During the testing phase, participants were presented with 28 musical excerpts and asked to indicate which of the excerpts were “new” and which were “old”. As hypothesized, younger adults remembered significantly more musical excerpts overall than either the middle-aged or older participants. The middle-aged participants remembered significantly more excerpts overall than did the older adults. These results are consistent with a linear decline in memory function observed beginning at age 30 and continuing across the lifespan (Salthouse, 2008). The Wechsler Paired Associative Recognition Task (VPA; Uttl, Graf, & Richter, 2002) was used in this study as a measure of episodic memory during the experimental session. Younger participants demonstrated memory for more of the word pairs than participants in the older but not in the middle-aged group during the first administration of the VPA. Participants in the middle-aged group did not display memory for more of the word pairs than participants in the older group. Participants in the young group and in the middle-aged group remembered more of the word pairs than participants in the older group during the second and third administration of the VPA. This finding is consistent with results of a study comparing younger and older adults on an episodic memory task similar to the VPA used in the current study (Naveh-Benjamin, 2000). Younger participants remembered more of the paired word lists than did the older participants. Participants in the current study were also given the Digit Span Forward and Backward subtests of the Wechsler Adult Intelligence Scale-Revised (WAIS, Wechsler, 1981) to assess short-term memory (Digit Span Forward) and working memory (Digit Span Backward). No significant differences between age groups were observed for these scales. This finding is consistent with findings by Myerson et al., (2003) which noted a lack of significant age-related differences in scores for the Digit Span Forward or Backward. It should be noted that the middle-aged and older adults in our sample were high functioning, community dwelling, and greatly motivated. Individual observation of the participants by the researcher indicated that these adults were extremely interested in doing well and used compensatory strategies in order to optimize their performance, particularly on this task. For example, one older participant placed his left hand palm down on the table top. When I spoke the numbers, he touched each finger with his right hand and repeated the number, assigning a number to each finger. When he recalled the numbers, he touched each finger again and repeated the number that he had assigned to that finger. Other participants closed their eyes and told me they visualized a telephone pad. When they heard the numbers, they visualized each number being touched on the pad and then recalled the order when asked to do so. Another older participant, who had been trained as a code breaker in the Navy, told me he broke everything down into groups of 4 or 5 and remembered them in that manner because most words contain 4 or 5 letters. Interestingly, he stated that he tried to influence me to give the numbers in groups of 4 or 5 by repeating them in a cadence back to me in the hope that I would use the same cadence. Participants who used compensatory strategies were quite successful in completing the digit span tasks, as evidenced by the fact that there was no significant difference between age groups for scores on the Digit Span. Mahncke et al. (2006) utilized a computer training program specifically designed to improve cognitive function in older adults. Participants were found to demonstrate significant improvements in scores on measures such as the Digit Span task after completing the training. This finding indicates that older adults can be trained to use compensatory skills to slow their cognitive decline.

Affect

Analysis of measures of affect indicated no significant differences between age groups on the Center for Epidemiological Studies Depression Scale. However, younger adults reported significantly lower levels of positive affect than the older group and significantly higher levels of negative affect than the older group on the Positive and Negative Affect Schedule (PANAS). Participants in the middle-aged group also reported significantly higher levels of negative affect than participants in the older group. This finding suggests that older adults in this sample were experiencing more positive emotions at the time of testing, which supports the assumptions of the Socioemotional Selectivity Theory (Carstensen, 1992) and would be consistent with the observation of the current study indicating that older adults recognized more of the consonant, pleasant excerpts than the dissonant, unpleasant excerpts.

Younger adults in this sample reported a greater sense of opportunities for the future and an awareness of time as being less limited than did older adults. Middle-aged adults in this sample also indicated more optimism about the future than the older group as measured by the Future Time Perspective scale (Carstensen & Lang, 1996). These findings further suggest that the participants in this sample were representative of the general population. Our finding that older adults remembered more consonant (pleasant) musical excerpts provides additional support for the Socioemotional Selectivity Theory. Studies have primarily examined only memory for visual information, e.g., positive and negative images. The current study examined memory for emotionally valenced auditory information. These results indicate that the positivity effect is not restricted to the visual domain, but is also evident in the auditory domain. Older adults receive an immense amount of important auditory information almost on a continual basis. Much of this information is emotionally valenced. For example, their health care provider may remind them of the importance of eating right and exercising, their financial advisor may provide options to consider regarding retirement planning, or they may interact with family members, or discuss caregiving issues with providers. The manner in which this information is conveyed may impact their reception of the information and influence the manner in which they process the information and interact with others. Based on the findings of this study, along with findings from a meta-analysis of studies examining the influence of emotion of judgment and decision making (Angie et al, 2011), age-related differences in memory for aurally presented emotionally valenced information should be considered when presenting important information to older adults.

Strengths and Limitations

Support for the hypotheses of the Socioemotional Selectivity Theory was found in the current study using stimuli from an auditory domain. Based on the theory, younger adults should not be as focused on regulating their emotions, but should be intent on gathering information to use in the future. Older adults, who realize that their time is limited, are expected to be more focused on regulating their emotions (Carstensen, Isaacowitz, & Charles, 1999). One form of emotion regulation is attentional deployment (Gross, 2008). Older adults should redirect their attention from information they find unpleasant to information they find to be pleasant. In the current study, remembering more of the consonant excerpts than the dissonant was consistent with such a deployment of attention. This finding should be further examined by studying the specific role of attention deployment by examining age-related differences in reaction times to consonant (pleasant) and dissonant (unpleasant) musical excerpts. The music could be cued to continue to play until the rating was registered. Allowing the music to continue would indicate that participants were paying closer attention. I would expect older adults to exhibit faster rating times for the dissonant (unpleasant) music as opposed to the consonant (pleasant) music in order to end the playing of the excerpt. The demonstration of better recognition memory for consonant stimuli than for dissonant stimuli in the current study implies that the older participants were directing their attention and their cognitive resources to the stimuli they found to be most pleasant. The finding that older adults' perspective of time is more limited than time perspectives of younger and middle-aged adults in this sample supports the hypothesis from the Socioemotional Selectivity Theory that older adults focus on and remember information they find more pleasant as a way to regulate their emotions.

The use of consonant and dissonant musical excerpts as auditory stimuli appears to have been effective. Participants from all age groups remarked that they enjoyed hearing the music and felt they remembered the excerpts well. The successful use of auditory information as stimuli adds another sensory domain in support of the Socioemotional Selectivity Theory. Until this study only visual information had been used to examine these age-related differences. The results of this study indicate that the emotional valence of auditory information also plays an important role in memory recognition.

There were a few limitations to the study that should be noted. The sample may have been select overall, as the study was promoted as one entailing the use of music. Possible participants who did not enjoy music may have "self-selected" out of the study, leaving only those with a positive response to music and perhaps biasing the results by not including those with a dislike of music. In addition, the older sample was select, in that most participants were high functioning older adults. The older adults were extremely motivated to do well, especially on the cognitive tests, in order to satisfy themselves that they were still able to perform competently. A lack of age differences is Digit Span scores is often observed with healthy older samples and is consistent with our findings. For example, Myerson et al., (2002) found no evidence of age-related differences Forward versus Backward Digit Span scores based on data from 1,050 adults aged 20-89 years,

Because the sample was one of convenience, we were unable to completely control for morningness-eveningness age-related differences. Yoon, May, and Hasher (2000) indicated that younger adults demonstrate better performance on cognitive tasks in the evening, while older adults perform better in the morning, with the shift beginning to occur about age 50. While attempts were made to control for this factor, some younger adults were tested in the morning and some older adults were tested in the evening, based on scheduling convenience for the participants, and this may have contributed in part to the age-related differences in cognitive performance observed. However, a supplemental regression analysis indicated that "time of day" did not significantly predict the number of correct answers across age or condition.

Significant results are often paired with significant challenges. One such challenge with this study is that of determining the underlying basis for the findings. Grady, Grigg, and Ng (2012) examined age-related changes in activation in the Default Network (defined by the authors as the ventromedial prefrontal cortex, posterior cingulate cortex, medial temporal lobes, superior frontal gyri, and some inferior parietal and lateral temporal areas) and the Reward Network (defined by the authors as the ventral and dorsal striatum, anterior cingulate, medial temporal lobes, medial prefrontal cortex, and dopaminergic cells in the ventral tegmental area) in addition to self-ratings and ratings for significant others for positive and negative traits. Older adults endorsed more positive ratings for themselves and others than younger adults while younger adults tended to rate themselves and others more negatively. During fMRI scanning, younger and older adults displayed activation differences in the networks for the self-reference task and a baseline task; however, older adults displayed less activation than younger adults. The authors indicated that the differences in self-ratings coupled with the differences in activation suggested a neural basis for the positivity effect demonstrated by older adults. Younger adults demonstrated more activity in the networks than older adults while completing the self-reference task while rating themselves and others in a more negative fashion than older adults. The decreased activation demonstrated by the older adults might indicate an underlying neural basis for the positivity effect. Currently, more emphasis is being placed on the study of age-related differences in emotion regulation and the neurological basis for those differences.

Implications

Older adults in the current study demonstrated higher levels of positive affect than the younger and middle-aged adults with a greater awareness of the rapid passage of time. In addition, they remembered significantly more pleasant excerpts of music than the unpleasant excerpts, indicating they were more focused on the pleasant than the unpleasant. This finding may suggest that, when making decisions, framing the choices in a negative manner rather than in a positive manner might disadvantage older adults. For example, when making important decisions regarding medical care, older adults who are given information about negative aspects of treatment may ignore those aspects and hear only the possibility of positive outcomes. Their ability to make informed choices may suffer from this focus. Older adults might not pay close attention if choices are framed negatively or may limit the amount of negative information they obtain regarding choices, resulting in poor decisions (Lockenhoff & Carstensen, 2004). Age-related differences in recalled information were noted when younger and older adults were presented with positive, negative, and neutral information regarding different physicians and health care plans (Lockenhoff & Carstensen, 2004). Younger adults were more accurate in recalling the alternative they had chosen. Older adults reviewed more positive material related to the choices than younger adults and recalled the choices they had more positively. However, when participants were to pay more attention to gathering information, the age differences disappeared. Mikels et al., (2010) examined age-related differences in decision quality under different instructions. Younger and older adults were assigned to a control, emotion focused or instruction focused condition. Participants were asked to make health care decisions based on information presented on a computer screen. Those in the control group were given no instructions. Those in the emotion-focused condition were asked to pay attention to their emotional reactions when the facts were presented while those in the information focused condition were asked to pay attention to specific details. There were differences in the quality of choices. Younger adults made better quality decisions in the information focused condition while older adults made better quality decisions in the emotion focused and control conditions. The results of both studies indicate that older adults appear to pay more attention to emotionally valenced material, which influences the quality of the decisions they make. A review of literature does not indicate any studies that manipulate the framing of the choices (e.g., whether in a positive or negative manner). Perhaps examining the quality of choices made after health-related information is presented while focusing on the positive aspects (e.g., "You likely will have much more energy if you follow this advice.") versus focusing on the negative aspects ("Your health will suffer if you don't follow this advice.") might be an effective way to study this manipulation. The results of our study indicate that perhaps age-related changes in decision making might be expected with such a manipulation. These differences would have practical implications for the presentation of choices, particularly for older adults. While many everyday decisions are not life altering, poor choices in terms of health care, insurance, and end of life matters could have negative consequences for older adults. Further study in this area is warranted to determine the best manner of presentation of choices and better understanding of the interaction between affect and cognition with age and how that interaction influences everyday choices as well as important life choices.

The finding that older adults remembered more pleasant excerpts than unpleasant might also suggest that older adults may be more proficient in regulation of their emotions. Emotion regulation consists of various strategies that individuals employ to manage emotional responses (Gross, 2008). These strategies can be either employed before emotional responses are fully developed (antecedent-focused) or after an emotional response has developed (response-focused). The findings of this study imply that older adults employed the emotion regulation strategy of Attentional Deployment, an antecedent-focused strategy, by directing their attention to the stimuli they found to be most pleasant, the consonant excerpts, and paying less attention to the unpleasant, dissonant, stimuli (Gross, 2008). The use of this strategy, coupled with the shift in goal-directed motivation posited by the Socioemotional Selectivity Theory, is consistent with the current findings.

CHAPTER 5

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

The basic tenet of the Socioemotional Selectivity Theory is the perception of time (Carstensen, Isaacowitz, & Charles, 1999). This perception underlies individual's goals and their pursuit of social partners to fulfill those goals. People require and actively seek social interaction in order to survive. In addition, people have multiple concurrent goals and must choose between the goals before taking action. There are two broad categories of goals: knowledge-related and emotion-related. Perspective of time influences each of these categories. Infants do not cognitively comprehend time and actively pursue both knowledge-related and emotion-related goals. This pursuit of both categories continues through early childhood. During middle childhood, a shift occurs toward knowledge-related goals in anticipation of the future. Many social partners are required in order to fulfill these goals. This shift continues through adolescence and middle adulthood, when a great deal of information is needed to prepare for the future. During this time, the regulation of emotion is a lower priority. However, in late adulthood a shift again occurs in which individuals become focused on the present due to their awareness of the passage of time. This shift in focus comes with a desire to spend the limited time remaining with close social partners and family members in an attempt to optimize remaining time by regulating emotions in a positive way. To this end, older adults are expected to use the antecedent focused strategy of attentional deployment (Gross, 2008), redirecting their attention to things that they find pleasant and ignoring things they find unpleasant. In our study, this took the form of focusing on and remembering musical excerpts rated as pleasant (consonant) and ignoring unpleasant, dissonant excerpts.

One implication of the findings of this study is that older adults may make decisions based on the way choices are framed and, consequently, the framing of those choices is important. Because older adults are faced with making important life decisions, further study of this area is important. The older adult population is increasing rapidly. Older adults have many important decisions to make and require that these choices be presented in the best possible manner so they can make decisions that are most beneficial to them.

For older adults who enjoy music, music might also be a useful tool in rehabilitation settings, for physical therapy or to improve well-being. For example, Ziv, et al., (2008) compared the effectiveness of music relaxation and progressive muscle relaxation in 15 older adults suffering from insomnia and found that music relaxation was a more effective form of improving sleep than progressive muscle relaxation and that older adults demonstrated a lower level of anxiety after using music relaxation than progressive muscle relaxation. Roy, Peretz, and Rainsville (2008) demonstrated that participants who listened to pleasant music while experiencing temporary painful conditions due to thermal application experienced less pain than participants listening to unpleasant music. Thus, music might be used as a pain reduction tool in pain management situations. Gregory (2002) demonstrated the effects of using music with older adults with cognitive impairments by training them to move a dial to a presented song title or to a "wait" response on a dial. Based on these results, Gregory (2002) indicated that cognitively impaired adults might benefit from music listening interventions designed to promote sustained attention. For non-clinical populations, the use of music might be an effective emotion-regulating tool especially for older adults. Sole' et al., 2010, examined community-dwelling older adults' perception of their quality of life before they enrolled in a music program and after the program ended. Results indicated that participants felt participation in the program contributed to their quality of life. These very different types of interventions using music suggest that the use of music therapy with older populations has great potential and is an area that should be developed and studied further.

This current study revealed age-related differences in recognition memory for pleasant and unpleasant musical excerpts. The results contribute to the growing number of findings supporting the Socioemotional Selectivity Theory and add another dimension to the current knowledge about emotion and memory in older adults. The findings are important because they indicate that age-related differences occur in processing of emotional material in the domain of auditory perception as well as in the domain of visual perception. These differences should be examined in greater detail and may provide the basis for interventions not just for clinical populations, but for the general population of older adults as well.

Table 1

Review of Literature Related to Music, Emotion, SET: Key Studies

Authors & Reference	Participants	Design	Measures	Major Results
Bachorick et al., 2009	81 adults 19-82 years	Repeated-measures linear regression	138 musical excerpts Emotion-rating task using IAPS Measurement of emotional valence using joystick on computer Musical preference questionnaires	Mean time for initial response: 8.31 s
Blanchet et al., 2006	90 adults 45 young 45 older	ANOVA Hits, false alarms, decision criterion	Music experience questionnaires (none) Mill Hill Stimuli from Montreal Battery of Evaluation of Amusia	Older adults – fewer hits than younger in dancing, judgment + intentional coding, not in intentional coding Main effect of age, older with more FA than younger overall Older – fewer correct judgments in judgment + intentional coding (had difficulty making waltz/ march judgment condition)
Blood et al., 1999	5 M & 5 F	Regional covariation analyses ANOVA	rCBF	Increased dissonance - activation in R parahippocampal gyrus, precuneous regions Decreased dissonance – activation in orbitofrontal, subcallosal cingulate and frontal polar cortex
Carstensen	28 F & 22 M	MANOVA Longitudinal Reanalysis of interviews from Child Guidance Study	Interaction frequency Emotional closeness Relationship satisfaction	Reduction in social contacts across life span – increasing selectivity for social partners Emotional closeness stays stable in spite of number of contacts with social partners over life span
Carstensen et al 2000	184 adults 18-94 years	Cross sectional Data reduction Regression analyses Correlation	Emotion sampling booklet Cornell Medical Index Health Questionnaire (CMI) Category instance fluency Adjective checklist	Older adults experienced positive emotions as often as younger Younger adults experienced more negative affect Decrease in frequency of negative emotion between 18 and 60 years
Charles, Mather & Carstensen, 2003	18-29 year olds 41-53 year olds 65-80 year olds	Repeated measures general linear model Between and within subjects factors Repeated measures ANOVA	Vocabulary & Digit Symbols subtests of WAIS-R Wahler Health Symptoms Inventory Pictures from IAPS Center for Epidemiological Studies – Depression Scale (CES-D) Positive and Negative Affect Schedule (PANAS)	Older adults demonstrated better memory for positive vs. negative images Age x Valence interaction – age-related decrease in memory for negative stimuli
Costa, Fine & Bitti, 2004	17 F Mean age 21.7 12 M Mean age 22.5	Principal Component Analysis Correlations Regression analyses	Battery of 10 bipolar scales	Consonant music rated as pleasant more frequently Dissonant music rated as unpleasant more frequently

Table 1 (continued)

Deffler and Halpern, 2011	28 younger, mean age 18.93 27 older, mean age 69.68	ANOVA Paired *t* tests	WAIS-R vocabulary test Fact recognition test	All able to recognize facts Better overall performance for emotional facts More false alarms for tune recognition than fact recognition, especially in older adults Older – benefit for association of emotional fact with tune vs. neutral fact with tune Positivity bias
Eerola & Vuoskoski, 2011	18-42 years old	Linear trend analysis Inter-rater reliability ANOVA – repeated measures Correlations Regression analysis	POMS-A	Music excerpts highly represented examples of emotions
Eschrich, Munte, & Altenmuller, 2008	19-44 years old	Values of d' ANOVA Cronbach's Alpha – consistency	80 excerpts of 20-30 s length	Musical pieces rated very positive recognized better one week later
Goeleven, De Raedt, & Dierck, 2008	27 between 67-82	Data reduction ANOVA	Mini Mental State Examination Beck Depression Inventory Geriatric Depression Scale NAP paradigm	Reduced interference of negative stimuli, reduced inhibitory processing in older adults
Good et al., 2000	465 between 17-79	General Linear Model ANCOVA		Decline of global grey matter with age; superior parietal gyri, pre- & postcentral gyri, insula/frontal operculum, R cerebellum Preservation in lateral thalami, amygdala, hippocampi, entorhinal cortex Global increase of CSF with age
Halpern, Bartlett & Dowling, 1995	18-30 or 60-80	ANOVA Hits and false alarms	Newly composed melodies Hearing screening WAIS – vocabulary	Younger – better memory No better performance for older musicians than younger
Lima & Castro, 2011	114 adults; 17-84 years	ANCOVA Correlation Analysis	Mini-Mental State Examination Preliminary questionnaire Hearing screening	Perceived magnitude of sadness and fear/threat decreased with age, stable for happiness and peacefulness Changes in emotion recognition significant at middle-age
Petrican, Moscovitch & Schimmack, 2008	Adults between 69-79	Hierarchical linear modeling analyses	Symmetry Span Task Narrative transportation task	Executive attention resources enhanced positive event memory No effect on memories of neutral or negative events
Salthouse, 2009	Adults between 18-60	Trend analysis Correlations Cross-sectional Longitudinal	WAIS Vocabulary & Digit Symbol Matrix reasoning Form boards Pattern comparison	Age-related declines prior to age 60

Table 2

Sample Characteristics
Total n = 135
Age Range: 17-92 years

Variable	Young (n=54, 40%)		Middle (n=40, 29.6%)		Old (n=41, 30.4%)		Total
Age							
Mean (SD)	22.1 (3.7)		49.5 (7.6)		74.5 (7.1)		
Range	17-34		35-64		65-92		
	N	(%)	N	(%)	N	(%)	N (%)
Gender							
Male	19	(50)	10	(26)	9	(24)	38 (28)
Female	35	(36)	30	(31)	32	(33)	97 (72)
Education							
High School	4	(7)	2	(5)	10	(24)	16 (12)
Some College	46	(85)	19	(48)	6	(15)	71 (53)
College Degree	4	(7)	11	(20)	9	(22)	24 (18)
Some Graduate School	0		0		2	(5)	2 (1)
Graduate/Professional School	0		8	(20)	14	(34)	22 (16)
Marital Status							
Single	49	(91)	6	(15)	0		55 (41)
Married	4	(7)	29	(73)	33	(81)	66 (49)
Divorced/Separated	1	(1.9)	4	(10)	0		5 (3.7)
Widowed	0		1	(2.5)	8	(6.7)	9 (6.7)
Race							
African American	8	(14.8)	0		1	(2.4)	9 (6.7)
Asian	4	(7.4)	1	(2.5)	1	(2.4)	6 (4.4)
Hispanic Latino	1	(1.9)	0		0		1 (0.7)
White Caucasian	41	(75.9)	38	(95)	39	(95.1)	118 (87.4)
Other	0		1	(2.5)	1	(2.5)	2 (0.7)

Table 3

Physical Health and Hearing Self-Ratings

	Young		Middle-Aged		Old	
Physical Health Self Rating Percent Reporting Very Good to Excellent Health	66.7%		50%		73.2%	
Hearing Percent Reporting Very Good to Excellent Hearing	79.6%		68.5%		63.4%	
Hearing Questionnaire Percentage of "Yes" responses to 2 or fewer questions	81.4%		72.5%		36.6%	
Redding Medical Universal Hearing Screener						
	R	L	R	L	R	L
500 Hz	100%	100%	99%	99%	95%	92%
1000 Hz	100%	100%	99%	99%	99%	95%
2000 Hz	100%	100%	100%	100%	99%	95%
4000 Hz	100%	100%	99%	99%	85%	85%

Table 4

Medical History

Condition	Young n (%)	Middle-Aged n (%)	Old n (%)
Head Injury	10 (40%)	11 (27.5%)	4 (9.8%)
Unconscious at time of injury	-	2 (5%)	2 (4.9%)
Heart Surgery	-	-	6 (14.6%)
Stroke	-	-	2 (4.9%)
Diabetes	-	3 (7.5%)	9 (22%)
Heart Condition	-	3 (7.5%)	7 (17.1%)
High Blood Pressure	1 (1.9%)	5 (12.5%)	21 (51.2%)
Arthritis	-	4 (10%)	28 (68.3%)
Parkinson's Disease	-	-	-
COPD	-	-	5 (12.2%)
Sleep Apnea	1 (1.9%)	4 (10%)	2 (4.9%)

Table 5

Overall Hits Minus False Alarms/Know and Remember Responses by Soundtype and Age Group

	Consonant			Dissonant		
	Young (*SD*)	Middle-Aged (*SD*)	Old (*SD*)	Young (*SD*)	Middle-Aged (*SD*)	Old (*SD*)
Overall	.83 (.21)	.74 (.24)	.48 (.29)	.76 (2)	.74 (.24)	.3 (.26)
Know	.09 (.02)	.08 (.03)	.08 (.03)	.06 (.02)	0 (.02)	.06 (.02)
Remember	.74 (.04)	.66 (.05)	.41 (.05)	.71 (.03)	.56 (.04)	.25 (.04)

Table 6

Measures of Affect

Measure	M	SD	F	p	η_p^2
CES – D					
Young	11.69	6.06			
Middle-Aged	10.87	8.05			
Old	9.03	7.21	1.644	.197	.025
PANAS					
Positive					
Young	32.43	6.77			
Middle-Aged	34.00	6.95			
Old	35.95	6.18	3.272	.041*	.048
Negative					
Young	12.74	3.23			
Middle-Aged	13.3	5.14			
Old	11.41	3.07	4.155	.018*	.06

Figure 1. Colorful musical symbol and symbol for pianissimo displayed during presentation of musical excerpts

"u"

I thought this music
was unpleasant.

"p"

I thought this music
was pleasant.

Figure 2. Rating Scale Displayed During Rate Only and Rate and Study Conditions

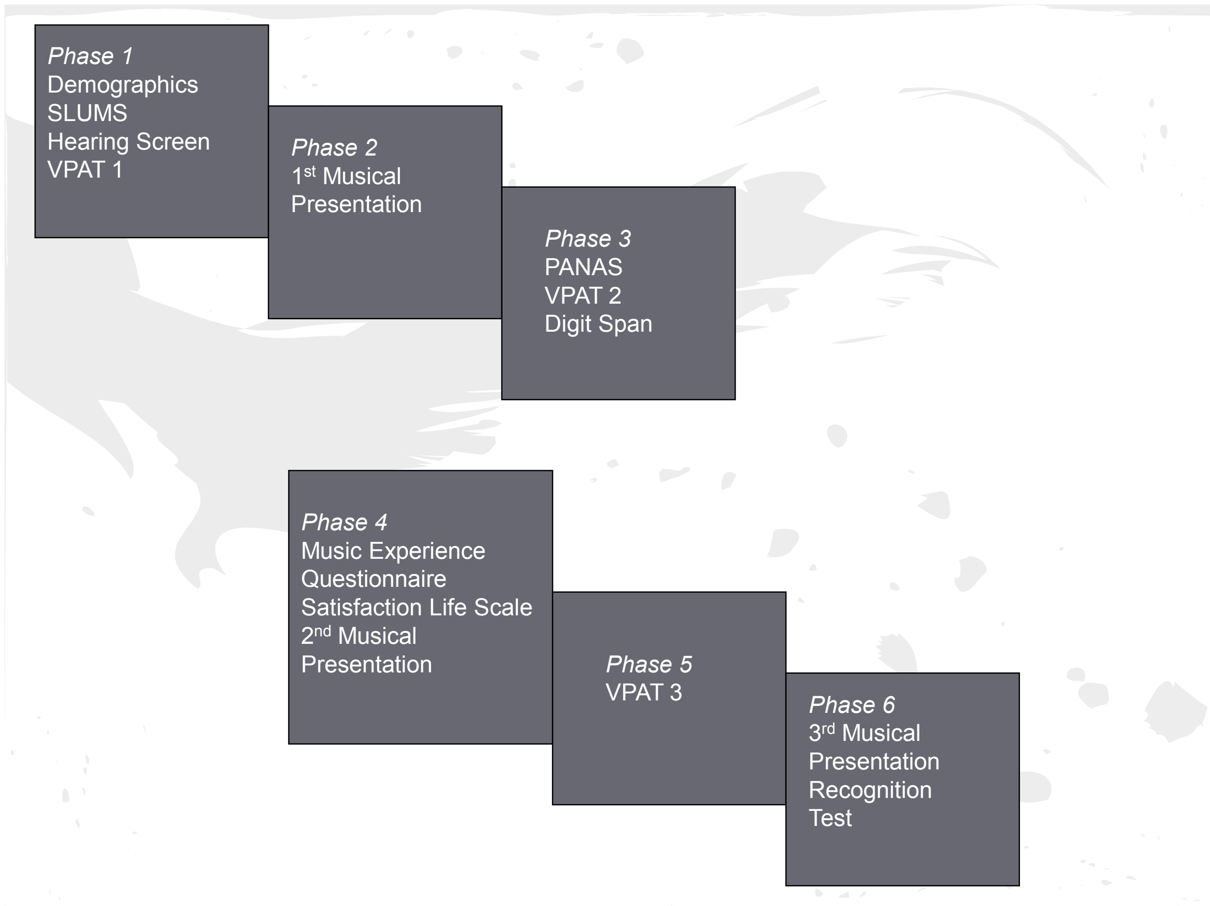

Figure 3. Presentation Order

"r"	"k"	"g"	"n"
I remember it and how I felt or thought.	I remember it but do not recall how I felt or thought.	I might have heard it earlier.	This excerpt is new to me.

Figure 4. Guide for Responses for Testing Phase

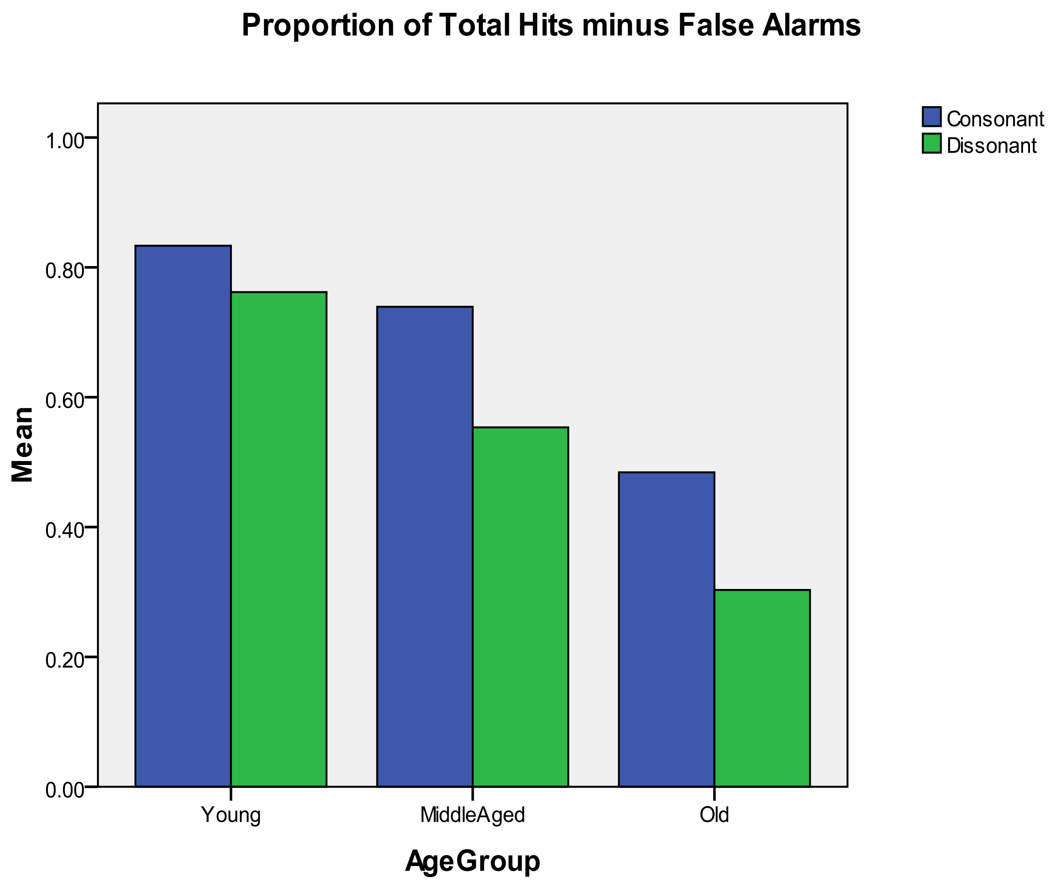

Figure 5. Proportion of Total Hits Minus False Alarms

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APPENDIX

APPENDIX:

Demographic Questionnaire

Name _________________________

Address _________________________

____

Email address _____________________

Phone ___________________________

Age ______________________________

Gender ___________________________

Marital Status ________ Single
________ Married
________ Divorced/Separated
________ Widowed

Race/Ethnicity__________ African American
__________ Asian
__________ Asian American
__________ Hispanic or Latino
__________ Native American
__________ White/Caucasian
__________ Other

Current living arrangement

__________ Alone
__________ With spouse/partner
__________ With Adult Children
__________ Assisted living
__________ Nursing home
__________ With parents
__________ With Young Child

Education

___________ Some High School
___________ High School Degree
___________ Some College
___________ College Degree
___________ Some Graduate/
Professional School
___________ Graduate/Professional
School Degree

In general, would you say your PHYSICAL health is:
(please circle one)

Poor Fair Good Very Good Excellent

In general, would you say your HEARING ability is:
(please circle one)

Poor Fair Good Very Good Excellent

Have you ever had any of the following?

Head Injury _____ Yes _____ No
If yes, were you unconscious for longer than 2 minutes?
_____ Yes _____ No

Heart Surgery _____ Yes _____ No

Stroke _____ Yes _____ No

Do you have any of the following medical conditions?
(please check)

_____ Diabetes
_____ Heart Conditions
_____ High Blood Pressure
_____ Arthritis
_____ Parkinson's
_____ COPD

Hearing Screen

Since we are going to play music for you, we would like to ask you a few questions about your hearing.

Do you hear better through one ear than the other when you are on the telephone?

Yes No

Do people complain that you turn the TV volume up too high?

Yes No

Do you have trouble hearing in a noisy background?

Yes No

Do you have trouble hearing in restaurants?

Yes No

Do you find yourself asking people to repeat themselves?

Yes No

Do many people you talk to seem to mumble (or not speak clearly)?

Yes No

Do you have trouble understanding the speech of women and children?

Yes No

Frequency	Right Ear	Left Ear
500		
1000		
2000		
4000		

Have You Seen Any of These Movies?

Please circle the movies you have seen from the list below.

Dead Alive

Shakespeare in Love

Man of Galilee

Cape Fear

Falling Down

Shine

Naked Lunch

The Rainmaker

Batman Returns

The Craft

The Missing

Dances with Wolves

Just Cause

JFK

Band of Brothers

Music Experience

1. Have you ever taken music lessons? ___ Yes ___ No

If yes, When? _______

How many years? _______

What instrument(s)? ____________

How long has it been since you took lessons? _______

Do you play now? _______

How often do you play? _______

2. How often do you listen to music?
   (please circle one)

Often – Music is a part of my life on a daily basis

Frequently – I listen to music two or three times a week

Occasionally – I listen to music on a weekly basis

Rarely – I rarely listen to music

Never – I never listen to music

3. Where (and when) are you most likely to listen to music?

4. Have you ever participated in a singing group, such as a choir or band?

If yes, When? ________
What instrument did (do) you play?

5. Do you currently perform any type of music, either privately (for yourself) or publicly? If so, how often?

6. When is the last time you attended a concert? _____
   What was it? _____________

7. When is the last time you attended a movie?
   What was it? _____________

What Kinds of Music Do You Like?

Please circle the type(s) of music that you enjoy:

(You may circle more than one!)

Classical

Jazz/Blues

Pop

Easy Listening

Country

Christian

Rock

Hip Hop

Alternative

R & B

Dance

Heavy Metal

Rap

Folk

Oldies

VITA

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