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Music-evoked autobiographical memories (MEAMs) in Alzheimer disease: Evidence for a positivity effect

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Abstract: We present a study designed to assess the presence of the positivity effect in music-evoked autobiographical memories or MEAMs. In particular, we sought to determine whether the positivity effect was evident in cases of Alzheimer's disease (AD), where a preserved memory for music in AD might also be reflected in an ability to retrieve memories associated with music. The positivity effect refers to instances where, compared to younger adults, older adults reveal a relative preference in attention and memory for positive over negative information. It is considered to be a hallmark of healthy aging. Three groups of participants—20 younger adults, 20 older adults, and 20 adults with mild-to-moderate AD—were asked to listen to familiar musical excerpts and describe any memories evoked by the excerpts. Word usage and topics in the memory transcripts were analyzed, as well as ratings of the memories provided by the participants in order to detect any positive bias or absence-of-negativity bias in older as compared to younger adults. Self-ratings yielded the strongest evidence. Compared with young adults, MEAMs for both groups of older adults were self-rated as less specific, but more vivid, more positive and less negative. In general, the characteristics of MEAMs reflected the effects of age rather than disease. For AD, MEAMs may reveal a sense of self-identity that has been preserved despite the ravages of neural degeneration.

Lola Cuddy

ABOUT THE AUTHOR

Lola Cuddy is the director of the Music Cognition Laboratory at Queen's University in Kingston, Ontario, Canada. Lola also serves on the Scientific Advisory Board for the *International Conference for the Perception and Cognition of Music* and is the editor of the journal *Music Perception*, an interdisciplinary journal of music perception, cognition, and performance. Lola is interested in the perceptual, cognitive, and emotional processes involved in music appreciation and understanding. She has studied topics such as the effects of music lessons on nonmusical cognitive skills, aging and music, amusia following stroke, and sparing of musical and related autobiographical memories in Alzheimer's disease. After testing over 200 people—young adults, older adults, and adults with dementia—on a variety of music and cognitive tests, she has shown that musical memories are present for many people throughout the various stages of dementia.

PUBLIC INTEREST STATEMENT

Alzheimer's is an incurable brain disease that can rob a person of memory and personality. The diagnosis of Alzheimer's has devastating consequences not only for the person with the disease, but also for family, friends, and caregivers. However, not all mental faculties are equally destroyed in the progress of the disease. Here, we show that music can be used to evoke personal memories of a past life. Music-evoked memories of our Alzheimer's participants were similar to those of healthy older adults. Both Alzheimer's and healthy older participants rated their memories as both more positive and less negative than did young adults, revealing sparing in Alzheimer's of an effect known as the *positivity effect*, whereby adults become overall more positive in life with age. Understanding the sparing of music-related memories in Alzheimer's is useful when creating rehabilitation programs to encourage communication with individuals with Alzheimer's.

Subjects: Memory; Psychology of Music; Gerontology/Ageing; Dementia; Cognitive Neuroscience of Memory; Quality of Life; Dementia & Alzheimer's Disease

Keywords: Alzheimer's disease; positivity effect; music; memories; autobiographical memories; music-evoked autobiographical memories; MEAMs

1. Introduction

The neurodegenerative disease Alzheimer's disease (AD) affects some 46.8 million people worldwide and is predicted to reach 131.5 million by the year 2050 according to the 2015 World Alzheimer Report (Prince et al., 2015). Behavioral hallmarks of the disease include memory and language impairment, with serious consequences for interpersonal communication and the sense of self and well-being in AD. Given the unrelenting progress of the disease and the fact that there is no cure, a diagnosis of AD is a devastating situation for both patients and caregivers alike. Methods for improving communication have the potential to improve quality of life in AD and thereby alleviate caregiver burden.

Music has long been thought to be a therapeutic means of reaching out to persons with AD and encouraging responses from such persons. Music is seen as an important component of dementia care and treatment. However, empirical studies where the efficacy of a treatment group (music therapy) has been compared with a nontreatment group have yielded mixed or inconclusive results (Vink, Bruinsma, & Scholten, 2003). Music intervention studies therefore yield a limited view of music efficacy, one that needs to be enhanced with a larger picture of music cognition and the brain.

We offer an alternative and complementary approach to the power of music, which is to focus on the implications of a particular research finding: Musical memories—familiarity for music heard in one's past—are preserved in healthy aging and also in the early stages of AD (Cuddy et al., 2012; Fornazzari et al., 2006; Hsieh, Hornberger, Piguet, & Hodges, 2011; Omar, Hailstone, & Warren, 2012). Musical memories are sometimes spared, despite severe cognitive impairment, even in the later stages of AD (Cuddy & Duffin, 2005; Vanstone & Cuddy, 2010). Research on spared systems can help us better understand and identify the mechanisms and neural substrates of the neurodegenerative process (Jacobsen et al., 2015). It may also provide directives for care management.

Musical memories may be associated with other, nonmusical, memories that are previous personal experiences, or autobiographical memories. Music-evoked autobiographical memories are known as MEAMS (Janata, Tomic, & Rakowski, 2007). To elicit MEAMs, musical excerpts are played to participants who are asked to describe any memory from their recent or remote past that was brought to mind by the music. The paradigm differs from the usual autobiographical memory test in that the latter requires a voluntary and directed memory search for a particular experience at a particular time following an explicit test instruction (e.g. the autobiographical memory interview or AMI: Kopelman, Wilson, & Baddeley, 1989). By contrast, MEAMs are simply memories of past personal events that come to mind spontaneously and effortlessly, triggered by a perceptual cue or a current thought and, as such, may be considered involuntary memories (Berntsen, 1996, 1998; Rasmussen & Berntsen, 2009). An oft-cited literary example of an involuntary memory is Proust's narrator in *Remembrance of Times Past,* where the taste of a madeleine arouses earlier episodes in his life.

MEAMs have been collected and the contents described for young adults by Janata and colleagues (Janata et al., 2007), for healthy older adults and persons with AD by El Haj and colleagues (El Haj, Fasotti, & Allain, 2012; El Haj, Postal, & Allain, 2012) and for patients with acquired brain injury (Baird & Samson, 2014). Compared to memories retrieved in silence, MEAMs are typically specific, positive, and automatic (El Haj et al., 2012).

The study by El Haj et al. (2012) obtained MEAMs from 12 patients diagnosed with probable (mild) AD and 12 matched healthy older controls. The music presented to all participants was either

Vivaldi's *Four Season*s or self-selected "Chosen" music, tested in separate conditions and compared against memories elicited in a separate "Silence" condition. El Haj et al. reported an enhancement of positive emotional words in the MEAMs, particularly evident for the AD patients. Such a finding is intriguing for two reasons. First, it is remarkable that AD patients responded with MEAMs, given the known deterioration of autobiographical memory accompanying the disease (El Haj, Kapogiannis, & Antoine, 2016; Greene, Hodges, & Baddeley, 1995). Second, although it might well be expected that the music would influence emotion in a positive way (for a review, see Croom, 2015), the memories evoked by music may have revealed an additional and potentially informative influence known as the *positivity effect* (Kennedy, Mather, & Carstensen, 2004).

1.1. The positivity effect

In general, the positivity effect refers to instances where, compared to younger adults, older adults reveal a relative preference in attention and memory for positive over negative information (Mather & Carstensen, 2005; Reed & Carstensen, 2012). The effect may be uncovered in a variety of experimental paradigms, tasks, and stimuli (Reed, Chan, & Mikels, 2014). The positivity effect can be evidenced either through older adults recalling memories with more positive or less negative content than younger adults (e.g. Schlagman, Schulz, & Kvavilashvili, 2006); for recognition of musical excerpts, see Parks & Dollinger, 2014). Alternatively, it can be evidenced through older adults rating all memories either more positively or less negatively than younger adults, regardless of memory content (e.g. Schlagman et al., 2006).

It is considered by many to be a hallmark of successful aging. Opinions vary as to whether the positivity effect in old age is an adaptive or nonadaptive process (Reed & Carstensen, 2012). On the one hand, it may be a nonadaptive process, a natural and fixed consequence of cognitive decline because in aging brains, cognitive flexibility decreases and the networks for processing emotion are compromised (e.g. Wurm, 2011). On the other, it may reflect a controlled process where cognitive resources are recruited to adapt to changing lifestyle and time-limited goals. It has also been proposed as a disease-avoidance mechanism, following from the observation of a stronger positivity bias for attractive faces among older adults with health problems, relative to those without health problems (Zebrowitz, Franklin, & Palumbo, 2015). These authors argue that older adults in generally poor health feel vulnerable to disease and thus show voting preferences for attractive faces and avoidance of unattractive faces that may be associated with poor health.

According to socioemotional selectivity theory (SST: Carstensen, 1992, 1995), the goals and expectations in old age, as opposed to the young, direct cognitive processing to emotion regulation, emotional meaning, and well-being. Young adults perceive time as open-ended and focus on preparatory goals, such as seeking new experiences, friends, and knowledge. In contrast, the goals of older adults involve emotional satisfaction obtained through the emotional regulation of negative affect and the enhancement of positive affect. Older adults focus on emotional information in order to optimize well-being relatively quickly. Behavioral evidence for this effect converges with neurobiological findings of age-related changes to the noradrenergic system which may alter the mechanisms of emotional memory (for a review, see Mammarella, Di Domenico, Palumbo, & Fairfield, 2016). Greater activity of the system during aging means that "healthy older adults are able to circumvent or minimize the experience of negative emotions and stabilize or even enhance positive emotional experiences" (p. 61).

Further support for the thought that the positivity effect is a controlled process comes from evidence that older adults who performed poorly on tests of executive control or who were distracted with a divided attention task during memory encoding were less likely to exhibit the positivity effect (Mather & Knight, 2005). Recent research by Belleville, Chertkow, and Gauthier (2007) suggests that executive control is one of the first areas of cognitive decline in AD. Thus, it would be particularly interesting if older adults with AD still exhibit the positivity effect—a (likely) controlled emotion regulation process.

1.2. The positivity effect, music, and AD

In a recent review, Baird and Samson (2015) point out that music is perhaps unique in its power to elicit memories and emotions. Given this "island of preservation" (Baird & Samson, 2015, p. 209) in otherwise cognitively impaired persons, it would seem likely that the positivity effect may also be present in AD. However, no clear evidence has indicated whether the positivity effect is preserved in the MEAMs of patients diagnosed with AD. As MEAMs capture a personal past and self-identity they may, for persons with AD, offer a special means of communication with music therapists and care givers. Implications for preserving the well-being of AD patients may follow.

As noted above, either emotional processing or, alternatively, the cognitive control required for emotion regulation is involved with the positivity effect. Either may be damaged in AD, leading to the prediction that the positivity effect would be reduced or eliminated in AD. For example, a positivity effect was not observed in mild AD patients viewing familiar neutral faces and novel fearful human facial expressions (Wright, Dickerson, Feczko, Negeira, & Williams, 2007). The researchers used functional magnetic resonance imaging to examine and compare amygdala responses in young and elderly controls; the groups did not significantly differ from each other. The patients, however, showed greater amygdala activation in response to both the neutral familiar faces and the fearful novel faces. Wright et al. (2007) interpret their findings according to pathological changes in either the amygdala or prefrontal regions that modulate amygdala activity, such that amygdala activation becomes less specific or hyper-responsive in mild AD patients. This activation is clinically meaningful as patients are more irritable and agitated or aggressive when they are overly reactive to irrelevant neutral or negative stimuli. According to Scheibe and Carstensen (2010, p. 5), "It is intriguing to assume that in [AD patients] cognitive control processes are no longer effective in inhibiting amygdala activation in response to negative stimuli." Lack of control processes would eliminate the selective bias toward positive information, or the positivity effect. Moreover, in the review by Mammarella et al. (2016), it is noted that weaker noradrenergic activity in AD may lead to reduced or null effects of emotion and reduced positivity effects in memory.

For music, the results obtained by El Haj and colleagues have provided suggestive evidence for a possible link between AD and the positivity effect. El Haj et al. (2012) reported that a group of AD persons produced more positive words in their MEAMs than did elderly age-matched controls. The study did not include a younger adult group so an assessment of the positivity effect is not possible. As well, the AD group produced more negative words than the elderly controls, a finding indicating that emotional words overall, not just positive words, were more prevalent in the AD MEAMs—again a finding that does not allow a conclusion that a positivity effect was present. El Haj et al. (2012) did include a younger group of participants and in that study, rather than calibrating the word count of positive and negative words, the researchers collected emotional ratings of MEAMs on a five-point scale ranging from "1-very negative," to "5-very positive." The mean rating for elderly controls was higher than for younger controls, indicating a positivity effect in healthy aging, but the mean rating for the AD group in this case, was lower than the mean rating for the age-matched controls and was similar to the younger controls. Thus, the two studies do not reveal clear evidence of a positivity effect in AD.

1.3. The present study

El Haj and colleagues have provided strong evidence that music evokes memories more effectively than do specific instructions to recall in silence. Thus, our focus in the present study is not the comparison of music and silence. Rather, we follow the direction of the study by Janata et al. (2007), undertaken with young adults, to explore further the properties of memories aroused by music; we include the effects of aging and neurodegenerative disease. We present a study designed to assess the presence of the positivity effect in MEAMs with 20 healthy older adults and 20 persons with AD. The data from these two groups were compared with those from a group of 20 young adults.

The expectation that a positivity effect would be found with healthy adults was derived from three proposals arising from the studies cited above: (1) that music-perceptual cues arouse involuntary memories; (2) that involuntary memories involve less cognitive control (fewer demands on executive and attentive resources) than voluntary memories, and (3) fewer demands on memory-retrieval resources release cognitive resources for emotional control in aging, leading to the positivity effect.

The expectation regarding AD participants is less clear. As noted above, the cognitive damage associated with AD may result in a lack of emotional control. However, if cognitive demands for memory retrieval are lightened in the production of involuntary memories, emotional control of memories may be possible and the positivity effect may emerge.

Additional features of the study include:

(1) Choice of musical excerpts: The musical excerpts presented to participants were familiar instrumental tunes—unlike most previous work which used songs as stimuli. Instrumental tunes allow us to gauge whether music alone is successful in evoking MEAMs, whereas songs with lyrics confound the role of music and words. Familiarity was determined by pilot work.

(2) Number of excerpts: Twelve instrumental tunes (rather than one or two as in previous work with AD and MEAMs) were employed so that we could examine the relation between number of MEAMs evoked and cognitive status in AD, and could extend our results beyond the single pieces used in earlier studies.

(3) Response measures: Three different response measures were used to assess the content of MEAMs. We could therefore examine whether evidence for a positivity effect was measure-dependent or whether measures converged. The first measure was the word count obtained by the Linguistic Inquiry Word Count software, (LIWC: Tausczik & Pennebaker, 2009), which provides a tally of both positive (e.g. "love, nice, sweet") and negative (e.g. "hurt, ugly, nasty") words. The second was the distribution of content topics according to the categorical scheme for the distribution of topics in involuntary diary entries by Schlagman et al. (2006). Schlagman et al. identified both positive (e.g. "Holidays," "Going out") and negative ("Accidents/illness") topics. The third was a self-rating of the valence of each MEAM on each of two scales, one reflecting the positivity of the memory, the other the negativity. The use of two scales allowed participants to respond, if they chose, that the memory contained both positive and negative aspects (i.e. mixed emotions; see Hunter, Schellenberg, & Schimmack, 2010).

(4) Mood-congruence hypothesis: The mood-congruency hypothesis predicts that emotional valence of the memories will be strongly related to current mood, especially in older people who tend to report more positive affect (Schlagman et al., 2006). Mood was assessed by administering the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) before and after collecting MEAM data.

2. Method

2.1. Participants

MEAM data from three groups of volunteer participants are presented: 20 younger adults (YA), 20 older adults (OA), and 20 adults with a diagnosis of probable AD. All participants were native English speakers.[1] Length of formal music training ranged from less than 1 to over 10 years; the modal years of training for OA and AD was less than one year and slightly more for YA at 4–7 years. (The availability of music in the high schools in this area makes it virtually impossible to find a YA with less than 1 year of training). The minimum level of education for all groups was high school attendance; the modal level of education was high school completion. Exclusion criteria were severe hearing loss, a known history of substance abuse, and a history of severe psychiatric disorders, stroke, head injury, or major neurological disorder other than a diagnosis of dementia in the AD group. Hearing was not formally assessed, but all participants were able to hear well enough to have a regular conversation. All participants in the OA and AD groups (except four AD who resided in long-term care facilities) were community-dwelling adults and not living in an institution. Participants were compensated $10/hour for their participation (approximately $10 for YA and $15 for OA and AD). This study was approved by the Queen's University General Research Ethics Board.

2.1.1. Younger adults
YA (*n* = 20; 10 females) were undergraduate university students recruited through advertisements on campus. Their age range was 19–24 years (*M* = 21.2, SD = 1.2).

2.1.2. Older adults
OA (*n* = 20; 11 females) were recruited through advertisements in community newspapers and appropriate seniors' organizations. They ranged in age from 66 to 83 years (*M* = 73.1, SD = 5.2). A minimum score of 28 out of 30 on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) was required for participation. Two of the OA participants from an initial set of 22 were excluded due to MMSE scores below 28.

2.1.3. Alzheimer's disease
A total of 24 AD participants was recruited though a geriatric medicine outpatient clinic and an inpatient geriatric ward for physical rehabilitation. Recruitment personnel were asked to locate interested participants with mild-to-moderate AD.

Participants met the criteria for probable AD as defined by the Diagnostic and Statistical Manual for Mental Disorders (4th ed., text rev., DSM-IV-TR; American Psychiatric Association, 2000) and the National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) criteria (McKhann et al., 1984). Cases of "mixed" dementia (*n* = 4, AD plus cerebrovascular involvement such as minor infarcts) were included given that they met the criteria of dementia of the AD type, and that, in the judgment of the referring geriatrician, AD, not cerebrovascular involvement, was responsible for their cognitive impairment.

Of the 24 participants, 20 (termed "responders"; 10 females) provided at least 1 MEAM and 4 (termed "nonresponders"; 2 females) were unable to provide any MEAMs. There were no easily identified demographic or diagnostic factors (on referral) on which to discriminate nonresponders from responders—that is, factors that would place the nonresponders in a clearly distinct group. For example, the age range and MMSE status of the nonresponders fell within the range of the responders. The age range of the responders was 63–89 years (*Mdn* = 77.5), and MMSE scores out of 30 ranged from 8 to 29 (*Mdn* = 21.0). Nonresponders ranged in age from 71 to 84 years (*Mdn* = 74.0), and had MMSE scores ranging from 9 to 20 (*Mdn* = 16.5). Both groups lacked music training (responders and nonresponders mode = "less than 1 year," range = "less than 1 year" to "4–7 years"). Data from only responders were entered into further analysis of MEAMs.

2.2. Stimuli
Twelve excerpts from instrumental tunes were selected based on pilot testing in our laboratory where the melodies for the tunes were assessed for familiarity in both younger and older adults. All tunes had a familiarity rating below 2.1 on a scale from "1" to "3," where "1" was "very familiar" and "3" was "very unfamiliar" These tunes were also considered pleasant as shown by a mean rating below 2.5 on a scale from "1" to "5," where "1" was "very pleasing" and "5" was "very displeasing." The tunes were required to have a mean rating, for both YA and OA, above "2" on a familiarity scale from "0" to "3," where "3" was "very familiar." Each tune excerpt was 30 s in length, with a 2-s fade-in and fade-out. Tune duration was adopted from Janata et al. (2007) and extensive pilot work that ensured that 30 s was adequate to recover a MEAM in younger and older participants. The excerpts were in their original instrumentation downloaded as mp3 files from commercially available internet sources. Examples of tunes were "The Sorcerer's Apprentice" by Paul Dukas and "In the Mood" by Glen Miller. The full set is given in the Appendix A.

2.3. Procedure
YA and OA, as well as 5 out of the 20 AD responders, were tested in a quiet laboratory (sound-isolated rooms), whereas the remaining 15 AD were tested in their place of residence, either their own homes or a quiet ward room. The session began with administration of a standard lab questionnaire to capture demographic data and participant's musical background, followed by the MMSE for OA

and AD. The participant's mood at the moment was then assessed using the Positive and Negative Affective Schedule (PANAS; Watson et al., 1988). The PANAS is a standardized questionnaire consisting of two 10-item scales describing different feelings and emotions. Examples of items on the positive scale are "excited," "enthusiastic," and "alert"; examples from the negative scale are "distressed," "upset," and "nervous." The participant was asked to read each item and then rate a number from "1" or "very slightly or not at all" to "5" or "extremely," to "the extent you feel right now." YA and OA answered with pencil and paper. The items were read aloud to AD adults by the test administrator who then recorded their responses.

The PANAS was followed by the music and memories session. The excerpts were played in random order without replacement though the speakers of a laptop for YA and OA participants and on an iPod with computer speakers for AD. The entire session was recorded using a Sony HDR-CX200 video camera.

At the start of the music and memories session participants were informed that music may evoke memories from their past that "come to mind spontaneously" without any explicit effort to recall them. They were told that these memories could be from the distant or recent past, could be specific or general, and could have a vague or vivid image. The participants were instructed to listen to each excerpt and, for each excerpt in turn, to elaborate immediately on the first memory from their past that spontaneously arose while the excerpt played or after it stopped. If no memories had arisen by the time the excerpt finished playing, or shortly thereafter, they were asked to indicate this by simply saying "No memory." After the tune stopped, if participants had not already begun describing a memory, then the test administrator asked if they had had any memories. After a participant's initial description, the test administrator provided one prompt: "Is there anything more you could add to that?"

After the participant finished a memory description, a series of questions followed concerning the valence, specificity, vividness, and age of the memory. Visual rating scales were presented to YA and OA or read to AD by the test administrator. Four valence scales were presented first. Participants were instructed to rate on a scale from "0" to "3," how positively, and on a second scale from "0" to "3," how negatively, they felt about the memory now. On a third and fourth scale, they recorded how positively, and how negatively, they felt about the memory at the time of the event. It was explained to the participants that both positive and negative feelings, or neither, might occur toward the event. The participant was then asked if the memory was specific (a single event) or general (a repeated event or multiple events). The vividness of the memory was specified on a visual scale from 1 to 7, with "1" representing low vividness. Finally, the participant was asked to provide an estimate of his/her age at the time of the memory. These questions were repeated for each memory.

After all excerpts were played and any corresponding memories recorded, the PANAS was administered for a second time. The memories were later transcribed to a text file for content analysis.

The testing session was followed by a collection of supplementary measures intended for AD participants:

(1) The informant version of the Music Engagement Questionnaire (Vanstone, Wolf, Poon, & Cuddy, 2015), completed by the caregiver.
(2) The Familiarity Decision Test (FDT; Liegeois-Chauvel, Peretz, Babai, Laguitton, & Chauvel, 1998) to assess long-term familiarity with well-known tunes, and Distorted Tunes Test (DTT; Drayna, Manichaikul, de Lange, Snieder, & Spector, 2001) to assess the ability to detect pitch distortions in familiar tunes.
(3) The Animal Naming task (Rosen, 1980), a test of semantic fluency where the participant is asked to name as many animals as possible within a one-minute period. The semantic fluency

test has been shown to predict the retrieval of autobiographical memories (Benjamin, Cifelli, Garrard, Caine, & Jones, 2015).

(4) Dementia Severity Rating Scale (DSRS; Clark & Ewbank, 1996), an informant-based questionnaire for assessing disease severity with a possible score range of 0–54 (0 = no impairment, 54 = maximum impairment).

(5) The Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) as a verification of the MMSE results. The correlation between MMSE and MoCA results was high, $\rho(n = 23) = 0.87$, $p < 0.0005$.

(6) The Geriatric Depression Scale (GDS; Sheikh & Yesavage, 1986), a screen that has been validated for detecting depression in the elderly, including those with mild to moderate dementia (0–5 is considered a normal score, and the maximum possible score is 15).

Each participant was then debriefed to conclude the testing.

3. Results

As our focus is the examination of music-evoked autobiographical memory, we conducted a preliminary review of the data to ensure that our data base consisted of autobiographical memories. All responses to the excerpts were categorized as either an autobiographical memory (MEAM) or as nonautobiographical (nonMEAM) by two independent judges. The criterion for a MEAM was that the response should include reference to the self in some manner—that is, following instructions, the memory contained a description involving the participant's "real life."

MEAMs occurred in all participant groups; groups did not differ in the frequency of MEAM responses relative to all responses. The median percent of responses categorized as MEAMs was 100% for both OA and AD with YA slightly but not significantly lower at 90%, $U = 340$, $N = 60$, $p = 0.293$). Overall, nonMEAMs were relatively rare (36/472 of total responses or 7%). MEAMs were entered into further data analysis.

Each MEAM was categorized by the same two independent judges as either episodic or semantic and for those deemed episodic, further as specific or general. A memory was considered episodic if it included information on the time or place of the event. An episodic memory, in turn, was marked as specific if it referred to a single event and as general for a repeated or extended event. A semantic MEAM was a response that reflected knowledge of one's past self but with no reference to the time or place of a personal event or episode.

Agreement between the two judges was good ($\kappa = 0.79$, 95% 95% CI [0.74, 0.84]). Disagreements were resolved by discussion.

3.1. Occurrence and characteristics of MEAMs

The measures reported in Tables 1a and 1b (upper and lower sections of Table 1) are the relative occurrence of MEAMS and certain characteristics of these obtained MEAMs. All measures in Table 1a were either extracted from the memory descriptions (first two rows) or provided directly by participants (remaining entries). Measures in Table 1b are the results of categorization of memories by independent judges.

For relative occurrence (Table 1a), the dependent variable was the percent (out of a total of 12) of excerpts yielding MEAMS, calculated for each participant. Characteristics of these MEAMS, again calculated as an average for each participant were: word count per MEAM; age of the participant when the memory occurred (given as an age range in "years from" and "years to"); percent of MEAMs rated by the participant as specific; and vividness of the MEAMs on a seven-point scale.

Table 1a presents the median and the range of values across participants for each of the above measures. Between-group differences (overall differences among YA, OA, and AD) were assessed

Table 1a. Descriptive measures for music-evoked memories

OA vs. AD	OA (*n* = 20) Median (range)	AD (*n* = 20) Median (range)	Mann–Whitney test	
			U-statistic	*p*-value
Percent of tunes with MEAMs	67 (17–100)	42 (8–100)	117	0.024
Word count per MEAM	95 (15–298)	82(11–208)	188	0.758
Age of memory—Years from	25 (16–50)	20 (4–54)	139	0.096
Age of memory—Years to	34 (18–65)	26 (5–58)	139	0.102
Percent specific	50 (22–100)	10 (0–100)	80	0.001**
Vividness rating	5.5 (3.1–7.0)	6.0 (1.5–7.0)	1687	0.383
YA vs. OA + AD	YA (*n* = 20) Median (range)	OA + AD (*n* = 40) Median (range)	*U*-statistic	*p*-value
Percent of tunes with MEAMs[a]	67 (42–83)	58 (8–100)	264	0.031
Word count per MEAM	73 (26–226)	89 (11–298)	352	0.452
Age of memory- From	14 (8–17)	23 (4–54)	77	<0.001**
Age of memory-To	14 (8–18)	31 (5–65)	31	<0.001**
Percent specific	67 (38–100)	33 (0–100)	211	0.003*
Vividness rating	4.6 (2.7–5.8)	5.6 (1.5–7.0)	173	<0.001**

[a]When the median of both groups is 0, the *U*-statistic and *p*-value are not calculated (i.e. the two groups are not compared).

*$p < 0.05$ according to Bonferroni correction.

**$p < 0.01$ according to Bonferroni correction.

Table 1b. Episodic and episodic-specific memory categorization

OA vs. AD	OA (*n* = 20) Median (range)	AD (*n* = 20) Median (range)	Mann–Whitney test	
			U-statistic	*p*-value
Percent episodic	88 (36–100)	83 (0–100)	185	0.698
Percent episodic specific	27 (0–100)	20 (0–100)	127	0.046
YA vs. OA + AD	YA (*n* = 20) Median (range)	OA + AD (*n* = 40) Median (range)	Mann–Whitney test	
			U-Statistic	*p*-value
Percent episodic	89 (40–100)	83 (0–100)	317	0.184
Percent episodic specific	50 (20–100)	17 (0–100)	167	<0.001**

**$p < 0.01$ according to Bonferroni correction.

through an omnibus analysis followed by two orthogonal contrasts. The first contrast was OA versus AD, which tested the effect of the disease as the difference between two groups of comparable age but differing in cognitive status. The second was YA versus (OA + AD) which tested the effect of age as the difference between a young versus older group irrespective of cognitive status of the latter. The normality of the distributions was checked by the Shapiro–Wilk test. The assumption of normality was violated in multiple distributions; thus, nonparametric tests were applied to determine the statistical significance of differences.

For five of the measures in Table 1a, that is, for all measures except the word count per MEAM, the Kruskal–Wallis H test revealed significant differences among the groups (for five measures, $9.88 < \chi^2(2\ df) < 35.40$, all $p < 0.007$). The right-hand columns of Table 1a show the results of the

Mann–Whitney test for the significance of the orthogonal contrasts. The table also notes the outcomes that were significant given the Bonferroni correction for multiple tests.

For the OA versus AD contrast (presented at the top of Table 1a), the only measure that was significantly different after the Bonferroni correction was applied, was the percent of MEAMs identified by participants as specific, with OA being higher than AD (50 versus 10%). For the YA versus (OA + AD) contrast (bottom of Table 1a) the age range of the memory, percent of MEAMs identified as specific, and vividness rating were all significantly different. Memories for YA tended to have occurred in early adolescence; memories for OA and AD tended to occur in early adulthood (the "reminiscence bump" first demonstrated by Rubin, Wetzler, and Nebes (1986)). The younger group reported their memories to be more specific, but less vivid, than the combined older groups. In sum, for the measures in Table 1a, the effects of age were more prevalent than the effects of the disease.

For AD, but not OA, the age range at which the memory was said to occur was negatively correlated with percent of excerpts yielding MEAMs ("age from" $\rho(n = 20) = -0.62$, $p = 0.004$; "age to" $\rho(n = 20) = 0.44$, $p = 0.051$). In other words, for AD, a larger number of MEAMs was associated with earlier memories.

Table 1b reports the percent of MEAMs judged episodic and the percent of all episodic memories judged specific as opposed to general; statistical analysis followed the procedures adopted for Table 1a. The Kruskal–Wallis H test revealed statistical differences among groups for the latter measure only (for percent episodic $\chi^2(2\ df) = 1.91$, $p = 0.386$; for percent episodic-specific $\chi^2(2\ df) = 16.35$, $p < 0.01$). Here again, the orthogonal contrasts in the right-hand column of Table 1b show that the effect of age is more evident than the effect of the disease, with, as might be expected, specific episodic memories less available in older age.

3.2. AD nonresponders and supplementary tests

It was noted in the recruitment of AD participants (see above) that neither age, MMSE status, nor years of music training, accounted for nonresponding. The nonresponders did not form a distinct group on the PANAS scales (positive affect scores for responders ranged from 16 to 45 and for nonresponders 22 to 38; negative affect scores for responders were from 10 to 15 and for nonresponders from 11 to 19). They did not show a greater tendency toward depression on the GDS than nonresponders (GDS range for responders was 0–7 and for nonresponders 1–2).

The supplementary tests were administered at the end of the testing protocol to AD participants. Not all participants were available or willing to complete the supplementary session, and in the case of the informant questionnaires, not all informants submitted their forms. However, despite the reduced *N* we examined the responses as an exploratory means of providing guidelines for future research. In particular, we looked for clues why some AD persons were unable to produce memories to the excerpts.

Inspection of the results of the supplementary tests indicated that musical memory and attraction to music did not predict inability to respond. However, the DSRS questionnaire revealed greater functional impairment in nonresponders (responders $Mdn = 16.0$, range = 0–31; nonresponders $Mdn = 31.0$, range = 25–39; $U = 7.0$, $n_1 = 14$, $n_2 = 4$, $p = 0.025$). The total absence of MEAMs in the nonresponders may have been due to a higher severity of impairment than that revealed by their MMSE or diagnostic status.

For the AD responders, none of the supplementary tests was indicative of the percent of excerpts yielding MEAMs, even though there was considerable variability in this responsiveness. Individual participant scores varied from 8 to 100% for evocation of MEAMs—see Table 1a. Although the DSRS discriminated responders from nonresponders, it did not predict responsivity within the responder group ($\rho(n = 14) = -0.13$, $p = 0.653$).

Table 2. Assessing the positivity effect using positive and negative words from LIWC analysis

OA vs. AD	OA (*n* = 20) Median (range)	AD (*n* = 20) Median (range)	*U*-statistic	*p*-value
Percent positive words	3.14 (0.00–6.25)	3.96 (0.00–16.67)	197	0.989
Percent negative words	0.45 (0.00–1.22)	0.37 (0.00–9.09)	170	0.429
YA vs. OA + AD	YA (*n* = 20) Median (range)	OA + AD (*n* = 40) Median (range)	*U*-statistic	*p*-value
Percent positive words	2.48 (0.45–4.54)	3.35 (0.00–9.16.67)	246	0.016
Percent negative words	0.67 (0.00–2.72)	0.43 (0.00–9.09)	279	0.057

3.3. Positivity effect

This section continues the content analysis of MEAMs with a specific focus on the evidence for greater positive affect and lower negative affect among older participants. Three different analyses were conducted, comparing across groups: (1) a computational word count of the proportion of both positive and negative emotion words relative to all words contained in the MEAMs; (2) the proportion of both positive and negative content categories reported in the MEAMs according to the content categorization system of Schlagman et al. (2006); (3) the subjective rating of positivity and negativity of a memory provided by the participants themselves. The analyses are presented in order of ascending confidence that can be placed on a positivity effect.

3.3.1. Word count analysis

Table 2 shows for each group of participants the results of the word count analysis conducted by text analysis software, the Linguistic Inquiry Word Count. The LIWC vocabulary contains 406 positive emotion words and 499 negative emotion words. The data shown in Table 2 are the median percent (and range) across participants of words classified as positive or negative according to the count.

According to the LIWC count, emotion words were rare. Positive words accounted for less than 4% of all words expressed; negative words for less than 1% of all words. Numerically, YA expressed fewer positive words and more negative words than the older groups and OA expressed more negative words than AD. However, the Kruskal–Wallis test was not significant for either positive or negative words. For positive words, the contrast YA versus (OA + AD) was significant, but has to be interpreted with caution. All in all, given the low count of emotion words, we conclude that the word count analysis was not a productive means of examining a positivity effect.

3.3.2. Content categories

Table 3 shows the assignment of content of MEAMs according to the Schlagman et al. (2006) categorical analysis for involuntary diary memories. The first column is the category label ascribed by Schlagman et al. There are three main columns, one each for YA, OA, and AD The first two columns in each main column represent the frequency and percentage of MEAMs in each category. Assignment was done by two independent raters who read each MEAM and allotted it to a category. Agreement among raters was moderate, Cohen's $\kappa = 0.59$ ($p < 0.001$), 95% CI (0.54, 0.65). Disagreements arose when the memory involved more than one category; they were resolved by discussion as to which category was best represented.

Inspection of Table 3 reveals that the categories most popular across groups were similar to those for Schlagman et al. (2006) and for MEAMs collected by Janata et al. (2007), e.g. Persons, Leisure/Sports, Object/Places. A log-linear procedure was applied to compare group differences in distribution across all categories with an expected MEAM count greater than 1. An initial model of complete independence was used to test the hypothesis that the MEAM counts were distributed similarly in the two groups under consideration. The categories did not differ between OA and AD, as the independence model fit the data well, $LR(7) = 4.89$, $p = 0.673$, and all adjusted residuals between ±1.51. For comparison of YA and (OA + AD), the independence model was rejected, $LR(11) = 60.09$, $p < 0.001$. Group–category interactions corresponding to cells with adjusted residuals above 2 were then added to the independence model in order to create the most parsimonious partial independence

Table 3. Descriptive statistics for MEAMs based on the Schlagman et al. (2006) categories. The four columns in each group represent (1) frequency, (2) percentage, (3) mean positivity ratings, and (4) mean negativity ratings for memories in each content category

Content category	Frequencies (percentages) positivity and negativity ratings											
	YA (*n* = 20), MEAMs (*n* = 162)				OA (*n* = 20), MEAMs (*n* = 154)				AD (*n* = 20), MEAMs (*n* = 104)			
	Freq	(%)	Pos	Neg	Freq	(%)	Pos	Neg	Freq	(%)	Pos	Neg
1. Person	22	(12.9)	1.66	0.41	18	(11.5)	2.47	0.11	18	(16.5)	2.75	0.19
2. Accidents/Illness	0	(0)	N/A	N/A	1	(0.6)	2.00	1.00	0	(0)	N/A	N/A
3. Stressful Events	10	(5.9)	0.75	1.80	2	(1.3)	1.50	1.50	0	(0)	N/A	N/A
4. Holidays	3	(1.8)	2.67	0.17	1	(0.6)	3.00	0.50	0	(0)	N/A	N/A
5. Conversations	1	(0.6)	3.00	0.50	1	(0.6)	1.50	1.00	0	(0)	N/A	N/A
6. Leisure/Sports	44	(25.9)	1.87	0.32	39	(24.8)	2.47	0.32	35	(32.1)	2.52	0.20
7. Objects/Places	16	(9.4)	1.66	0.38	18	(11.5)	2.25	0.19	7	(6.4)	2.79	0.43
8. Going Out	15	(8.8)	1.87	0.20	41	(26.1)	2.34	0.27	27	(24.8)	2.40	0.08
9. Work/University	11	(6.5)	1.68	0.59	1	(0.6)	2.50	0.50	0	(0)	N/A	N/A
10. Romance	0	(0)	N/A	N/A	2	(1.3)	2.50	0	1	(0.9)	1.50	1.00
11. School	26	(15.3)	1.35	0.62	6	(3.8)	2.25	0	6	(5.5)	2.50	0.25
12. Deaths/Funerals	1	(0.6)	0	2.50	1	(0.6)	0.00	3.00	1	(0.9)	1.50	1.50
13. Miscellaneous	0	(0)	N/A	N/A	0	(0)	N/A	N/A	0	(0)	N/A	N/A
14. Special occasions	18	(10.6)	2.18	0.32	20	(12.7)	2.58	0.38	12	(11.0)	2.80	0.10
15. Births	0	(0)	N/A	N/A	0	(0)	N/A	N/A	0	(0)	N/A	N/A
16. Traveling/Journeys	2	(1.2)	2.25	0.50	2	(1.3)	2.50	0.50	0	(0)	N/A	N/A
17. War/Army	1	(0.6)	2.00	1.00	4	(2.5)	2.00	0.63	2	(1.8)	1.75	0.50
Totals	170	(100)	1.76	0.72	157	(100)	2.12	0.66	109	(100)	2.28	0.47

model that fit the data well, $LR(7) = 4.56$, $p = 0.713$, with all remaining adjusted residuals between ±1.56. The following categories had significantly different percentages in YA and the combined older groups: "Stressful events" (YA 5.9%, Older 0.8%), "Going out" (YA 8.8%, Older 25.6%), "Work/University" (YA 6.5%, Older 0.4%), and "School" (YA 15.3%, Older 4.5%). Of these categories that were different between the groups, "Going out" is the only category classified by Schlagman et al. (2006) as positive, and "Stressful events" the only negative. Differences found here in both categories are in the direction of a positivity effect.

Categories considered positive by Schlagman et al. (2006) were "Holidays," "Going out," "Romance," and "Special occasions." The MEAM data were pooled across these categories to form a Percent Positive Categories score for each participant. Median scores for each group are shown in Table 4. Medians for positive categories were significantly different according to the Kruskal–Wallis

Table 4. Assessing the positivity effect using percent of positive and negative memories according to the categorical system of Schlagman et al. (2006)

OA vs. AD	OA (*n* = 20) Median (range)	AD (*n* = 20) Median (range)	*U*-statistic	*p*-value
Percent positive categories	41 (13–100)	42 (0–100)	184	0.678
Percent negative categories	0 (0–20)	0 (0–100)	N/A[a]	N/A[a]
YA vs. OA + AD	YA (*n* = 20) Median (range)	OA + AD (*n* = 40) Median (range)	*U*-statistic	*p*-value
Percent positive categories	16 (0–50)	41 (0–100)	212	0.003**
Percent negative categories	0 (0–30)	0 (0–100)	N/A[a]	N/A[a]

[a]When the median of both groups is 0, the *U*-statistic and *p*-value are not calculated (i.e. the two groups are not compared).

**$p < 0.01$ according to Bonferroni correction.

Table 5. Assessing the positivity effect using participant self-ratings

OA vs. AD	OA (*n* = 20) Median (range)	AD (*n* = 20) Median (range)	*U*-statistic	*p*-value
Present positivity ratings	2.22 (1.33–3.00)	2.54 (1.00–3.00)	154	0.221
Present negativity ratings	0.14 (0.00–1.25)	0.00 (0.00–1.50)	162	0.301
Past positivity ratings	2.50 (1.40–3.00)	2.62 (0.00–3.00)	160	0.277
Past negativity ratings	0.26 (0.00–1.63)	0.00 (0.00–3.00)	159	0.277
YA vs. OA + AD	YA (*n* = 20) Median (range)	OA + AD (*n* = 40) Median (range)	*U*-statistic	*p*-value
Present positivity ratings	1.70 (1.00–2.44)	2.40 (1.00–3.00)	147	<0.001**
Present negativity ratings	0.32 (0.00–1.20)	0.09 (0.00–1.50)	288	0.068
Past positivity ratings	1.73 (0.14–2.44)	2.50 (0.00–3.00)	107	<0.001**
Past negativity ratings	0.55 (0.00–1.38)	0.10 (0.00–3.00)	193	0.001**

**$p < 0.01$ according to Bonferroni correction.

H test ($\chi^2(2\ df) = 9.4$, $p < 0.01$) In Table 4, it may be seen that memories in positive categories were significantly more represented for OA and AD than for YA.

Categories considered negative by Schlagman et al. (2006) were “Accident/illness,” “Stressful events,” and “Deaths/funerals.” Instances of negative categories in all groups were too rare to allow reliable statistical analysis. The median percent of pooled negative categories was zero for all groups.

In summary, the results in Tables 3 and 4 support a positivity effect where memories of positive topics are more frequent for older than for younger adults.

3.3.3. Subjective ratings

Table 5 shows for each group the median (and range) of ratings given to MEAMs by participants on the scales of positivity and negativity. The higher the value (with an upper limit of “3”), the more intense the reported feeling of a positive or a negative emotion attached to the memory Participants rated their feelings at the time of the memory and also how they felt about it at the present. Past and present positivity ratings were stable and not significantly different for all groups (Wilcoxon $Z = 1.49$, $N = 60$, $p = 0.135$). Past and present negativity ratings were, however, significantly different (Wilcoxon $Z = 3.25$, $n = 60$, $p = 0.001$); for all groups, the negativity attributed to a past event memory appears somewhat diminished in the present.

Overall group differences emerged in the ratings for the Kruskal–Wallis test. For positive ratings for the past, $\chi^2(2\ df) = 21.63$, $p < 0.001$; for the present, $\chi^2(2\ df) = 16.96$, $p < 0.001$. For negative ratings from the past, the $\chi^2(2\ df) = 11.69$, $p < 0.01$; for the present, the significance level failed to reach a conventional value, $\chi^2(2\ df) = 4.18$, $p = 0.124$.

In Table 5, it can be seen that YA memories were rated, on average, as significantly less positive than the OA and AD groups combined. The YA also rated their memories as more negative in the past than these older groups. The direction of these differences also held across all Schlagman et al. categories (Table 4, bottom line).

The subjective ratings support an effect of age rather than that of disease, and of the three above measures most clearly reflect a positivity effect.

3.4. Mood assessment (PANAS)

Table 6 shows the results of the PANAS scale. Two participants (one OA, one AD) declined to respond so *N* is reduced to 19 for OA and AD. Scores are out of a possible total of 50 (10 items × a top rating

Table 6. PANAS measures of positive and negative mood across two administrations of the test

OA vs. AD	OA (n = 19) Median (range)	AD (n = 19) Median (range)	U-statistic	p-value
Average positive mood ratings (before and after)	32.5 (13.0–47.5)	34.0 (15.5–45.0)	170	0.773
Average negative mood ratings (before and after)	10.5 (10.0–12.5)	11.0 (10.0–14.5)	141	0.258
YA vs. OA + AD	YA (n = 20) Median (range)	OA + AD (n = 39) Median (range)	U-statistic	p-value
Average positive mood ratings (before and after)	28.3 (14.0–38.0)	33.3 (13.0–47.5)	197	0.003*
Average negative mood ratings (before and after)	12.3 (10.0–20.0)	10.5 (10.0–14.5)	182	0.001**

*$p < 0.05$ according to Bonferroni correction.

**$p < 0.01$ according to Bonferroni correction.

of "5" per item) and a minimum of 10. Median scores are combined across the two administrations of the positive and the negative scale because no differences were found between the two administrations of the scale for any group (a result reflecting the test–retest stability of the PANAS instrument as a measure of trait mood).

Median scores for positive affect ranged from 28.3 to 34.0. Median scores for negative affect scores were relatively low (10.5–12.3). The mean score for the development sample of the PANAS was 29.7 (SD = 7.9) for positive affect and 14.8 (SD = 6.2) for negative affect (Watson et al., 1988). Our sample was similar to the development sample in positive affect but possibly was less negative.

The Kruskal–Wallis H test showed group differences for both the positive PANAS ($\chi^2(2\ df) = 9.1$, $p = 0.011$) and the negative PANAS ($\chi^2(2\ df) = 12.1$, $p < 0.01$. Median scores for positive affect differed significantly between YA and combined OA and AD; the latter group had higher scores. Negative affect scores were, however, significantly higher (reflecting greater negativity of mood) for the YA compared to the older groups.

Within groups, PANAS positive and negative affect scores for YA and OA were not significantly correlated with present or past, positive or negative subjective ratings, indicating that the positivity or negativity of the memories recalled was likely not due to the mood congruence effect. AD, however, did show a correlation of the positive PANAS affect score to the present positivity rating ($\rho(n = 19) = 0.55$, $p = 0.015$), as well as the negative PANAS affect score to both the present positivity ($\rho(n = 19) = -0.66$, $p = 0.002$) and past positivity ($\rho(n = 19) = -0.71$, $p = 0.001$) ratings, such that the AD participants, to some degree, either recalled mood-congruent memories or at least matched the memory valence ratings to their mood.

3.5. Age within OA and AD

As noted above, age effects were demonstrated by the difference in responding between YA in their early 20s and the older adults in their 70s (OA and AD). We also looked at possible age effects within our older groups as the AD group was slightly but significantly older ($N = 40$; Mann–Whitney $U = 102$, $p < 0.01$) than the OA group, though the range of ages was comparable. The difference in median age arises from the fact that within the range, the age distributions were positively skewed in the OA group, negatively skewed in the AD group. Nonparametric (Spearman) correlations were conducted within groups between age and the dependent variables on which the positivity effect was assessed: Table 2 (positive and negative words); Table 4 (positive and negative categories); and Table 5 (positive and negative ratings for the present and the past). No correlation was significant ($N = 20$; $-0.13 < \rho < 0.31$, all $p > 0.18$), a result indicating that age between approximately 60 and 90 did not predict greater positivity or less negativity. Age differences were therefore not implicated in the positivity effect comparisons for OA and AD.

4. Discussion

We have successfully replicated and extended earlier findings that music is an effective perceptual cue for evocation of autobiographical memories (MEAMs). Our paradigm (following Janata et al., 2007) investigated memories spontaneously arising from musical cues, as opposed to memories obtained by direct questioning during music exposure (e.g. the Autobiographical Interview; Irish et al., 2006). We extended the procedure of El Haj et al. (2012) in that we collected memories elicited by a variety of familiar instrumental excerpts. We have thus also shown that MEAMs do not require the presence of song lyrics or even preferred music; rather, "pure" instrumental music generally familiar in the culture is sufficient to evoke memories.

The majority of AD participants tested here not only recovered memories, but also as a group responded similar to healthy controls on a number of measures—percent excerpts evoking memories, length (word count) of the memories, selection of memory topics, recency (age from and to) of the memories, rated vividness, and rated positivity of the memories. As well, independent estimates of the percent of memories judged as specific episodes were also similar for AD and OA. As far as our analyses reached into the evidence for memory evocation and memory content, AD participants displayed the effects of age, but not of disease.

Other features of the data also reflect the effect of age more than the disease. These are rated vividness (Table 1a) and percent of memories categorized as episodic-specific by independent raters (Table 1b). The implication is that, with perhaps the exception of percent rated specific, the phenomenological reliving of episodic events may be preserved in AD. AD were similar to OA on these features; vividness, in fact, was rated as even higher by OA and AD than YA. Such an implication runs counter to conclusions that retrieval of phenomenological features is compromised in AD (El Haj, Antoine, Nandrino, & Kapogiannis, 2015; El Haj et al., 2016) with accompanying decline in autobiographical memory, and loss of sense of self and identity. The findings cited by El Haj and colleagues do not refer to MEAMs, however. They refer to the standard assessments of autobiographical memory in silence. We propose, therefore, an alternative explanation that stronger reliving is evoked by spontaneous memories such as those associated with musical cues. See Larsson and Willander (2009) for a similar conclusion regarding the use of odor cues to trigger memories.

Importantly, we have now shown for the first time that the music-evoked memories in aging and AD reveal a positivity effect—that is, in old age and AD, compared to young adults, the topics of memories are more positive and the rated valence of memories is both more positive and less negative. The presence of the positivity effect strengthens the claim that musical cues arouse involuntary memories (El Haj et al., 2012).

To address the finding of the positivity effect in AD, three points are relevant. The first is that the functions of autobiographical memory are varied, but most accounts refer to the preservation of self-identity and self-knowledge. For example, Harris, Rasmussen, and Berntsen (2014) propose four classes of memory function—which they label reflective, generative, ruminative, and social—and link them to the ways people "make meaning of their selves, their environment and this social world more generally" (p. 559). The result of impairment of this ability in AD is a compromised sense of self and identity (El Haj, Antoine, Nandrino, & Raffard, 2015). See also Eustache et al. (2013) who found impairments in self-knowledge with AD patients, which the authors attribute to the patients' episodic memory deficits. Second, the evoking of involuntary autobiographical memories from perceptual cues may be an automatic process. Whereas, a dedicated memory search places high demands on executive control, attention, and other cognitive processes involved in the search, involuntary memories may be aroused despite the degenerative loss of executive control and attention in AD. Third, the positivity effect uncovered here may be the result of the lower cognitive demands associated with involuntary memories and, in accordance with SST, may free additional cognitive resources to control emotional responses to memories. Thus, despite the difficulties associated with emotional control processes in AD (Henry, Rendell, Scicluna, Jackson, & Phillips, 2009) there may be instances where an apparent preservation of emotion regulation is evident. In sum, the positivity effect in AD may signal a positive and controlled sense of self that has been spared the ravages of the disease.

Several issues arise from the above conclusions concerning (1) the similarities and differences between OA and AD, including mood-congruence; (2) the nonresponders among the AD participants; (3) the selection of musical excerpts; and (4) the status of music as a memory retrieval cue. These issues will be addressed in turn. First, although the similarities overall found here between OA and AD, and the differences with YA, were striking, it is acknowledged that there were certain differences between AD and OA in the memory protocols. Memories were rated as more specific by OA than AD participants and current further analyses of the video transcripts (Belyea, Sikka, Chan, & Cuddy, 2016) suggest that although OA and AD reacted similarly in many ways to the excerpts (e.g. smiling, laughing, nodding) other visible musical reactions (e.g. humming, singing, tapping) were more frequent in AD than OA. Other differences, such as those that might be uncovered through linguistic analysis of the transcripts, warrant further investigation.

Moreover, the similarity of AD and OA with regard to the positivity effect does not mean that similar mechanisms are involved. Mood (as assessed by the PANAS scales) was not a predictor of rated MEAM valence in OA, yet it was for AD Thus, for AD, mood may have either (1) enhanced decisions about the valence of memories, decisions based on possibly compromised cognitive processes, or (2) enhanced sensitivity to memories with positive content or information. Therefore, the found positivity effect does not necessarily indicate that music increases deliberate selection of positive memories. Behaviorally, though, if music allows or encourages patients' sensitivity to mood-congruent positive memories, playing music for patients could possibly reduce the irritability and agitation/aggression stemming from their usual sensitivity and responsivity toward negative and neutral information (e.g. Wright et al., 2007). In terms of broader implications, even if the positivity effect is not necessarily a process involving cognitive effort in AD, these results show that MEAMs are likely to be a source of positive reminiscence and life satisfaction for AD.

Second, we noted that not all AD persons responded with MEAMs. Several AD participants, whom we termed "nonresponders," were unable to produce a single memory to the instrumental excerpts. This finding was unexpected, given the willingness of most of our AD participants to respond, but it is not unknown: El Haj et al. (2012) reported that two AD participants and one OA participant had no memories triggered by music. Nonresponders in the present study appeared to have crossed a diagnostic line not easily identified by neuropsychological testing and clinical assessment. The one test that separated nonresponders from responders was the DSRS, which is completed by an informant familiar with the day to day behavior of the AD participant. Scores suggested greater functional impairment among nonresponders. Yet DSRS scores were not predictive of number of memories evoked among the responders, and so cannot account for individual differences in responsivity to the musical excerpts. Future research with a larger sample could explore beyond our present tests to detect the correlates of nonresponding and thereby to discover processes or links that are broken if memories cannot be evoked by music in AD.

Third, the musical excerpts cues used here were not self-selected but experimenter-selected after extensive pilot work to ensure above-average familiarity (and its co-variate pleasantness) of excerpts with both YA and OA. Whereas, preferred music, or self-selected music, may be an optimal choice for music-therapeutic interventions, the use of individualized musical stimuli in MEAM studies is arguably not optimal. The self-selection procedure loses experimental control of known acoustical parameters that influence, in part, emotional responding to music (for example, see Dean & Bailes, 2016). In the current study, all groups received the same acoustical stimuli so that the differences in groups, on which evidence for the positivity effect rests, could not be attributed to differences induced by acoustical parameters.

Finally, we did not set out to find, neither do we claim, that music is unique in its power to evoke positive memories. Nevertheless, the ubiquitous nature of music, its strong ties with emotion, and its preserved familiarity in OA and AD, all point to its potential value as a practical and effective adjunct to care and rehabilitation. Positive memories that support a positive sense of self can be explored for purposes of communication with music therapists, caregivers, and family. As well, the present findings support theoretical proposals of functional neuroanatomical connections between brain networks for music and large-scale networks supporting autobiographical memory (Janata, 2009; Peck, Girard, Russo, & Fiocco, 2016). Understanding behavioral patterns of loss and sparing—such as music and memory—can help narrow the search for the neural substrates of this connectivity and so facilitate understanding of the AD disease process.

In conclusion, the findings have both theoretical and practical relevance. In support of earlier research, we have further documented the finding that music is an effective cue for retrieval of autobiographical memories in AD. Moreover, we support the theoretical proposal that such memories are representative of involuntary memories, being memories spontaneously aroused by a sensory cue (music) rather than responses to specific instructions requiring voluntary recall. As such, they are more vivid, specific, and positive. A practical implication for care and rehabilitation is that music may be beneficially employed to assist the person with AD to recall details of a personal past and perhaps restore communication with family members. That MEAMs are generally positive suggests that reminiscence experiences through MEAMs will also be generally positive and that music can still be enjoyed despite the cognitive impairments accompanying AD.

The current project was not designed to assess different explanations of the positivity effect—top-down or bottom-up accounts of its emergence through aging. It is particularly intriguing, nevertheless, to speculate that music provides an avenue for assessing a spared mechanism of emotional arousal and processing in AD. If that is the case, further research in the sparing of emotional processes in AD (e.g. Gagnon, Gosselin, Provencher, & Bier, 2012) is warranted with a view to assessing the origin of the positivity effect in AD, possibly engaging automatic emotional responding associated with posterior brain regions (Grady, 2012; Kramer, Humphrey, Larish, Logan, & Strayer, 1994).

The results could be further strengthened by a replication in a larger scale study where extensive behavioral and neurobiological assessments are conducted to examine positivity effects within the aging process. It would be informative to collect data across the lifespan so that the development of the positivity effect could be traced in a quantitative manner. Aging effects in our data were evident over decades of life but not over a short range within old age. It would also be informative to gather information about the participants' socio-musical experiences, as more and greater such experiences likely lead to the availability of more memories. Finally, as noted above, a subsequent study could be conducted to analyze the transcripts for evidence whether the positivity effect in AD is related to linguistic or behavioral characteristics of the respondents.

Support for the positivity effect in older age and AD will be welcome news for caregivers and therapists. Reminiscence through music can be used to enhance wellbeing through a focus on positive memories of the past. See El Haj et al., (2015, p. 188), for a critical commentary on reminiscence therapy. Evidence of the validity of the therapy in AD is mixed, but music as a cue for recall has not yet been rigorously studied in this context.

Positivity in older age comes with a caution. Although it may enhance well-being in both healthy older and neurally compromised adults, it could also lead to impoverished decision-making in financial and social situations. Too high a level of positivity could leave a person vulnerable to fraud and deceit (Scheibe & Carstensen, 2010). Future research could address the issue of adaptive vs. nonadaptive levels of positivity.

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Competing Interests
The author declares no competing interest.

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Note
1. One AD participant had German as her native language, but she spoke English fluently and expressed familiarity with the tunes in the study, and so her data were retained in the sample.

References
American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: American Psychiatric Association.
Baird, A., & Samson, S. (2014). Music evoked autobiographical memory after severe acquired brain injury: Preliminary findings from a case series. *Neuropsychological Rehabilitation, 24*, 125–143. doi:10.1080/09602011.2013.858642
Baird, A., & Samson, S. (2015). Music and dementia. In E. Altenmüller, S. Finger, & F. Boller (Eds.), *Progress in brain research* (Vol. *217*, pp. 207–235). Amsterdam: Elsevier. doi:10.1016/bs.pbr.2014.11.028
Belleville, S., Chertkow, H., & Gauthier, S. (2007). Working memory and control of attention in persons with Alzheimer's disease and mild cognitive impairment. *Neuropsychology, 21*, 458–469. doi:10.1037/0894-4105.21.4.458
Belyea, A. D., Sikka, R., Chan, J., & Cuddy, L. L. (2016, November). *Visible responses to music-evoked autobiographical memories in Alzheimer's disease*. Poster session presented at the 12th annual Canadian Undergraduate Conference on Healthcare, Kingston, ON.
Benjamin, M. J., Cifelli, A., Garrard, P., Caine, D., & Jones, F. W. (2015). The role of working memory and verbal fluency in autobiographical memory in early Alzheimer's disease and matched controls. *Neuropsychologia, 78*, 115–121. doi:10.1016/j.neuropsychologia.2015.10.006
Berntsen, D. (1996). Involuntary autobiographical memories. *Applied Cognitive Psychology, 10*, 435–454. http://dx.doi.org/10.1002/(ISSN)1099-0720
Berntsen, D. (1998). Voluntary and involuntary access to autobiographical memory. *Memory, 6*, 113–141. doi:10.1080/741942071
Carstensen, L. L. (1992). Social and emotional patterns in adulthood: Support for socioemotional selectivity theory. *Psychology and Aging, 7*, 331–338. http://dx.doi.org/10.1037/0882-7974.7.3.331
Carstensen, L. L. (1995). Evidence for a life-span theory of socioemotional selectivity. *Current Directions in Psychological Science, 4*, 151–156. http://dx.doi.org/10.1111/cdir.1995.4.issue-5
Clark, C. M., & Ewbank, D. C. (1996). Performance of the dementia severity rating scale: A caregiver questionnaire for rating severity in Alzheimer disease. *Alzheimer Disease & Associated Disorders, 10*, 31–39.
Croom, A. M. (2015). Music practice and participation for psychological well-being: A review of how music influences positive emotion, engagement, relationships, meaning, and accomplishment. *Musicae Scientiae, 19*, 44–64. doi:10.1177/1029864914561709
Cuddy, L. L., & Duffin, J. M. (2005). Music, memory, and Alzheimer's disease: Is music recognition spared in dementia, and how can it be assessed? *Medical Hypotheses, 64*, 229–235. doi:10.1016/j.mehy.2004.09.005
Cuddy, L. L., Duffin, J. M., Gill, S. S., Brown, C. L., Sikka, R., & Vanstone, A. D. (2012). Memory for melodies and lyrics in Alzheimer's disease. *Music Perception, 29*, 479–491. doi:10.1525/MP.2012.29.5.479
Dean, R. T., & Bailes, F. (2016). Modeling perceptions of valence in diverse music: Roles of acoustic features, agency, and individual variation. *Music Perception, 34*, 104–117. doi:10.1525/mp.2016.34.1.104
Drayna, D., Manichaikul, A., de Lange, M., Snieder, H., & Spector, T. (2001). Genetic correlates of musical pitch recognition in humans. *Science, 291*, 1969–1972. doi:10.1126/science.291.5510.1969
El Haj, M., Antoine, P., Nandrino, J. L., & Kapogiannis, D. (2015). Autobiographical memory decline in Alzheimer's disease, a theoretical and clinical overview. *Ageing Research Reviews, 23*, 183–192. doi:10.1016/j.arr.2015.07.001
El Haj, M., Antoine, P., Nandrino, J. L., & Raffard, S. (2015). Self-defining memories during exposure to music in Alzheimer's disease. *International Psychogeriatrics, 27*, 1719–1730. doi:10.1017/S1041610215000812
El Haj, M., Fasotti, L., & Allain, P. (2012). The involuntary nature of music-evoked autobiographical memories in Alzheimer's disease. *Consciousness and Cognition, 21*, 238–246. doi:10.1016/j.concog.2011.12.005
El Haj, M., Postal, V., & Allain, P. (2012). Music enhances autobiographical memory in mild Alzheimer's disease. *Educational Gerontology, 38*, 30–41. doi:10.1080/03601277.2010.515897
El Haj, M., Kapogiannis, D., & Antoine, P. (2016). Phenomenological reliving and visual imagery during autobiographical recall in Alzheimer's disease. *Journal of Alzheimer's Disease, 52*, 421–431. doi:10.3233/JAD-151122
Eustache, M. L., Laisney, M., Juskenaite, A., Letortu, O., Platel, H., Eustache, F., & Desgranges, B. (2013). Sense of identity in advanced Alzheimer's dementia: A cognitive dissociation between sameness and selfhood? *Consciousness and Cognition, 22*, 1456–1467. doi:10.1016/j.concog.2013.09.009

Folstein, M. F., Folstein, S., & McHugh, P. (1975). "Mini-mental state": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189–198. http://dx.doi.org/10.1016/0022-3956(75)90026-6

Fornazzari, L., Castle, T., Nadkarni, S., Ambrose, M., Miranda, D., Apanasiewicz, N., & Phillips, F. (2006). Preservation of episodic musical memory in a pianist with Alzheimer disease. *Neurology, 66*, 610–611. doi:10.1212/01.WNL.0000198504.41315.B1

Gagnon, L., Gosselin, N., Provencher, V., & Bier, N. (2012). Perception and emotional judgments of music in dementia of the Alzheimer type: A short case study. *Music Perception, 29*, 509–519.

Grady, C. L. (2012). The cognitive neuroscience of ageing. *Nature Reviews Neuroscience, 13*, 491–505. doi:10.1038/nrn3256

Greene, J. D. W., Hodges, J. R., & Baddeley, A. D. (1995). Autobiographical memory and executive function in early dementia of Alzheimer type. *Neuropsychologia, 33*, 1647–1670. doi:10.1016/0028-3932(95)00046-1

Harris, C. B., Rasmussen, A. S., & Berntsen, D. (2014). The functions of autobiographical memory: An integrative approach. *Memory, 22*, 559–581. doi:10.1080/09658211.2013.806555

Henry, J. D., Rendell, P. G., Scicluna, A., Jackson, M., & Phillips, L. H. (2009). Emotion experience, expression, and regulation in Alzheimer's disease. *Psychology and Aging, 24*, 252–257. doi:10.1037/a0014001

Hsieh, S., Hornberger, M., Piguet, O., & Hodges, J. R. (2011). Neural basis of music knowledge: Evidence from the dementias. *Brain, 134*, 2523–2534. doi:10.1093/brain/awr190

Hunter, P. G., Schellenberg, E. G., & Schimmack, U. (2010). Feelings and perceptions of happiness and sadness induced by music: Similarities, differences, and mixed emotions. *Psychology of Aesthetics, Creativity, and the Arts, 4*, 47–56. doi:10.1037/a0016873

Irish, M., Cunningham, C. J., Walsh, J. B., Coakley, D., Lawlor, B. A., Robertson, I. H., & Coen, R. F. (2006). Investigating the enhancing effect of music on autobiographical memory in mild Alzheimer's disease. *Dementia and Geriatric Cognitive Disorders, 22*, 108–120. doi:10.1159/000093487

Jacobsen, J.-H., Stelzer, J., Fritz, T. H., Chételat, G., La Joie, R., & Turner, R. (2015). Why musical memory can be preserved in advanced Alzheimer's disease. *Brain, 138*, 2438–2450. doi:10.1093/awv148

Janata, P. (2009). The neural architecture of music-evoked autobiographical memories. *Cerebral Cortex, 19*, 2579–2594. doi:10.1093/cercor/bhp008

Janata, P., Tomic, S. T., & Rakowski, S. K. (2007). Characterisation of music-evoked autobiographical memories. *Memory, 15*, 845–860. doi:10.1080/09658210701734593

Kennedy, Q., Mather, M., & Carstensen, L. L. (2004). The role of motivation in the age-related positivity effect in autobiographical memory. *Psychological Science, 15*, 208–214. doi:10.1111/j.0956-7976.2004.01503011.x

Kopelman, M. D., Wilson, B. A., & Baddeley, A. D. (1989). The autobiographical memory interview: A new assessment of autobiographical and personal semantic memory in amnesic patients. *Journal of Clinical and Experimental Neuropsychology, 11*, 724–744. doi:10.1080/01688638908400928

Kramer, A. F., Humphrey, D. G., Larish, J. F., Logan, G. D., & Strayer, D. L. (1994). Aging and inhibition: Beyond a unitary view of inhibitory processing in attention. *Psychology and Aging, 9*, 491–512. doi:10.1037/0882-7974.9.4.491

Larsson, M., & Willander, J. (2009). Autobiographical odor memory. *Annals of the New York Academy of Sciences, 1170*, 318–323. doi:10.1111/j.1749-6632.2009.03934.x http://dx.doi.org/10.1111/j.1749-6632.2009.03934.x

Liegeois-Chauvel, C., Peretz, I., Babai, M., Laguitton, V., & Chauvel, P. (1998). Contribution of different cortical areas in the temporal lobes to music processing. *Brain, 121*, 1853–1867. http://dx.doi.org/10.1093/brain/121.10.1853

Mammarella, N., Di Domenico, A., Palumbo, R., & Fairfield, B. (2016). Noradrenergic modulation of emotional memory in aging. *Ageing Research Reviews, 27*, 61–66. doi:10.1016/j.arr.2016.03.004

Mather, M., & Carstensen, L. L. (2005). Aging and motivated cognition: The positivity effect in attention and memory. *Trends in Cognitive Sciences, 9*, 496–502. doi:10.1016/j.tics.2005.08.005

Mather, M., & Knight, M. (2005). Goal-directed memory: The role of cognitive control in older adults' emotional memory. *Psychology and Aging, 20*, 554–570. doi:10.1037/0882-7974.20.4.554

McKhann, G., Drachman, D., Folstein, M. F., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology, 34*, 939–939. doi:10.1212/WNL.34.7.939

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., … Chertkow, H. (2005). The montreal cognitive assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53*, 695–699. doi:10.1111/j.1532-5415.2005.53221.x

Omar, R., Hailstone, J. C., & Warren, J. D. (2012). Semantic memory for music in dementia. *Music Perception, 29*, 467–477. doi:10.1525/MP.2012.29.5.467

Parks, S. L., & Dollinger, S. C. (2014). The positivity effect and auditory recognition memory for musical excerpts in young, middle-aged, and older adults. *Psychomusicology: Music, Mind, and Brain, 24*, 298–308. doi:10.1037/pmu0000079

Peck, K., Girard, T. A., Russo, F., & Fiocco, A. J. (2016). Music and memory in alzheimer's disease and the potential underlying mechanisms. *Journal of Alzheimer's Disease, 51*, 949–959. doi:10.3233/JAD-150998

Prince, M., Wimo, A., Guerchet, M., Gemma-Claire, A., Wu, Y.-T., & Prina, M. (2015). World Alzheimer Report 2015. *Alzheimer's Disease International*. doi:10.1111/j.0963-7214.2004.00293.x

Rasmussen, A. S., & Berntsen, D. (2009). The possible functions of involuntary autobiographical memories. *Applied Cognitive Psychology, 23*, 1137–1152. doi:10.1002/acp

Reed, A. E., & Carstensen, L. L. (2012). The theory behind the age-related positivity effect. *Frontiers in Psychology, 3*, 339. doi:10.3389/fpsyg.2012.00339

Reed, A. E., Chan, L., & Mikels, J. A. (2014). Meta-analysis of the age-related positivity effect: Age differences in preferences for positive over negative information. *Psychology and Aging, 29*(1), 1–15. doi:10.1037/a0035194

Rosen, W. G. (1980). Verbal fluency in aging and dementia. *Journal of Clinical Neuropsychology, 2*, 135–146. doi:10.1080/01688638008403788

Rubin, D. C., Wetzler, S. E., & Nebes, R. D. (1986). Autobiographical memory across the lifespan. In D. C. Rubin (Ed.), *Autobiographical memory* (1st ed., pp. 202–222). New York, NY: Cambridge University Press. doi:10.1017/CBO9780511558313.018 http://dx.doi.org/10.1017/CBO9780511558313

Scheibe, S., & Carstensen, L. L. (2010). Emotional aging: Recent findings and future trends. *Journal of Gerontology: Psychological Sciences*. doi:10.1093/geronb/gbp132

Schlagman, S., Schulz, J., & Kvavilashvili, L. (2006). A content analysis of involuntary autobiographical memories: Examining the positivity effect in old age. *Memory, 14*. doi:10.1080/09658210544000024

Sheikh, J. I., & Yesavage, J. A. (1986). Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. *Clinical Gerontologist: The Journal of Aging and Mental Health, 5*, 165–173.
Tausczik, Y. R., & Pennebaker, J. W. (2009). The psychological meaning of words: LIWC and computerized text analysis methods. *Journal of Language and Social Psychology, 29*, 24–54. doi:10.1177/0261927X09351676
Vanstone, A. D., & Cuddy, L. L. (2010). Musical memory in Alzheimer disease. *Aging, Neuropsychology and Cognition, 17*, 108–128. doi:10.1080/13825580903042676
Vanstone, A. D., Wolf, M., Poon, T., & Cuddy, L. L. (2015). Measuring engagement with music: Development of an informant-report questionnaire. *Aging & Mental Health, 20*, 474–484. doi:10.1080/13607863.2015.1021750
Vink, A. C., Bruinsma, M. S., & Scholten, R. J. S. (2003). Music therapy for people with dementia (Review). *The Cochrane Library*. doi:10.1002/14651858.CD003477.pub2
Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063–1070. doi:10.1037/0022-3514.54.6.1063
Wright, C. I., Dickerson, B. C., Feczko, E., Negeira, A., & Williams, D. (2007). A functional magnetic resonance imaging study of amygdala responses to human faces in aging and mild alzheimer's disease. *Biological Psychiatry, 62*, 1388–1395. doi:10.1016/j.biopsych.2006.11.013
Wurm, L. H. (2011). Decreasing complexity of affective space in older adults lower on cognitive control: Affective effects in a nonaffective task and with nonaffective stimuli. *Psychology and Aging, 26*, 716–730. doi:10.1037/a0022513
Zebrowitz, L. A., Franklin, R. G., & Palumbo, R. (2015). Ailing voters advance attractive congressional candidates. *Evolutionary Psychology, 13*, 16–28.

Appendix A

Musical Excerpts (30 s)

Excerpt	Composer	Title	Start bar number
1	Khachaturian, Aram	Sabre Dance from Gayane	3
2	Miller, Glen	In the Mood	1
3	Irish Traditional Music	The Irish Washerwoman / The Washwoman	1 (pickup beat)
4	Boccherini, Luigi	Minuet from String Quintet in E Major, Op.11, No.5 (G275)	1
5	Mexican Folk Dance	La Raspa	1
6	Dukas, Paul	The Sorcerer's Apprentice (L'Apprenti Sorcier)	72
7	Thomas, Werner	The Chicken Dance	1
8	Tchaikovsky, Peter Ilich	Trepak (Russian Dance) from The Nutcracker	1
9	Vivaldi, Antonio	Concerto No.1. La Primavera, Spring, Frühling. Op.8, No.1, RV 269, Allegro	1 (pickup beat)
10	Strauss, Johann	An der schönen blauen Donau op. 314 ("Blue Danube Waltz")	45
11	Wagner, Richard	Bridal March (Lohengrin)	1
12	Beethoven, Ludwig von	Symphony No. 5 in C minor, Op. 67, 1st movement	1