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New Technology for Studying the Impact of Regular Singing and Song Learning on Cognitive Function in Older Adults: A Feasibility Study

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As the proportion of older adults increase, there is a need to investigate ways to promote healthy cognitive aging. There is growing interest in longitudinal studies examining the impact of regular musical activity on nonmusical cognitive functions, but the financial and logistical challenges of such studies greatly limits the amount of research on this topic, especially in older adults. To surmount these challenges and stimulate the pace of research in this area we present a novel technology-based method for conducting longitudinal studies of regular singing and song learning in older adults. This method uses a tablet based app (SingFit-R) that is given to participants to take home and used for singing a specified number of songs per day. Participants choose the songs they will sing and then follow a singing schedule created by the experimenter. The app records a variety of data each time a song is sung, including song name, date and time of singing, an audio recording of the singer's voice, and the user-set volume levels of 2 mnemonic aids that facilitate song learning: a "guide singer" and "lyric coach" (the user reduces the volumes of these aids as a song is learned). By analyzing these data researchers can verify compliance and track song learning over the course of the study. We tested the feasibility of longitudinal research with SingFit-R in a 5-week study in which older adults sang 6 songs per day for 5 days per week. We examined measures of working memory and emotion regulation in this group before and after this intervention, and compared them to control groups that listened to music or had no musical activity. Based on measures of attrition, compliance, and enjoyment among users of the app, we conclude that this method is suitable for larger-scale studies on the cognitive impact of regular singing and song learning in older adults.

Keywords: singing, cognition, aging

In many countries the proportion of older adults is increasing. In the United States the proportion of adults over the age of 65 is projected to double in the next 50 years, with older Americans numbering over 83 million by the year 2050 (Ortman, Velkoff, & Hogan, 2014). Given the societal and familial costs incurred by age-related cognitive decline, there is increasing interest in identifying regular mental exercises that preserve or enhance cognitive function in older adults (Mahncke et al., 2006).

Most researchers agree that cognitive change is a nearly inevitable part of advancing age: the majority of individuals experience declines after an initial peak in their mid-20s. Age-related changes in the brain are associated with changes in cognitive processes such as control and maintenance of attention, maintenance and manipulation of information in working memory, and encoding and retrieval of information from long-term memory (for review see Craik & Bialystok, 2006). Because these changes can have a significant impact on the activities of daily living, the development of interventions to support cognitive functioning has recently broadened in scope (Mahncke et al., 2006). Researchers have begun to identify lifestyle practices such as education, leisure pursuits, intellectual engagement, and expertise that are associated with successful maintenance of cognitive abilities, and have begun to capitalize on those practices to abate age-related decline in cognition. For example, it has been established that education exerts protective effects on both memory and crystallized cognition (accumulated knowledge), with minor effects on fluid cognition (processing speed and abilities). Similarly, persons with cog-

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nitively stimulating occupations—college professors, pilots, physicians, musicians, and architects—maintain higher cognitive functioning with aging (Singh-Manoux et al., 2011).

There is also growing interest in knowing whether regular music-making could promote the maintenance of cognitive function in older adults. Playing an instrument or singing engages a broad range of complex cognitive and neural mechanisms, some specific to music (e.g., the production and perception of pitches with reference to an underlying scale) and some more domain-general (e.g., selective attention, working memory; Kraus & Slater, 2016; Peretz & Coltheart, 2003). Singing (the focus of the current article) combines vocal-motor, auditory, linguistic, cognitive, emotional, and social brain processing (Särkämö, Tervaniemi, & Huotilainen, 2013; Zarate, 2013), and engages widespread brain networks. Indeed, compared with speech it activates a broader and more bilateral set of brain regions (Callan et al., 2006; Özdemir, Norton, & Schlaug, 2006). Thus, music-making is a promising way of providing cognitive stimulation for older adults, particularly because many older adults already identify music as having a high degree of significance in their lives (Cohen, Bailey, & Nilsson, 2002) and, thus, may be predisposed to agree to a music-based program of "cognitive exercise."

A growing body of research with young adults and children points to positive associations between musical training and nonmusical aspects of cognitive function, including executive function, language processing, and visuospatial abilities (for a review see Schellenberg & Weiss, 2013). While most of this work is correlational (and unable to prove that music training causes these cognitive benefits), there are a small number of longitudinal studies that suggest that music training can play a causal role in enhancing nonmusical cognition, though more work is needed to better understand the mechanisms involved (Swaminathan & Schellenberg, 2016).

The purpose of this article is to introduce a new method for conducting longitudinal studies on the impact of regular music-making on cognitive function in healthy older adults, motivated by the demographic and societal issues implicated in the growing size of the aging population. Currently the number of such studies is very small, likely because they are expensive and logistically difficult to conduct. In one of the few studies examining the impact of music-making on cognition in older adults, Bugos et al. (2007) randomly assigned community-dwelling older adults (ages 60–85 years) to a piano instruction group and a passive control group (no training) for 6 months, and found that the music group showed significant improvements on two standardized cognitive tests, the Trail Making test and the Digit Symbols test. These findings are fascinating and call for further longitudinal studies. Yet, the challenges of conducting such research mean that relatively few researchers are in a position to pursue this topic, especially if an active control group with some other form of training is added to the study, to determine if the benefits are specific to music.

In this article we present a new method for studying the impact of regular music-making on cognitive function, which attempts to circumvent the normal financial and logistical obstacles to longitudinal research. This is accomplished by (a) focusing on singing rather than playing an instrument (thus, eliminating the cost of purchasing an instrument), (b) using a tablet-based app that facilitates singing and song learning in each participant's home (thus, eliminating the cost and logistics of music lessons). As discussed further below, the app also allows researchers to customize the singing schedule to each participant and to verify compliance via audio recordings of singing. This method is designed to be appealing to individuals with no musical training and who are not engaged in regular music-making (e.g., singing or playing an instrument).

We hasten to add that our protocol does not involve formal music lessons. That is, our protocol does not involve musical training in the sense of class-based lessons on vocal technique, breath control, pitch accuracy, and so forth, under the guidance of an experienced teacher. We recognize that real music lessons have numerous aspects and benefits that cannot be replicated with a computer program (including live human interaction and feedback). Thus, our protocol is better conceived of as a method for studying the impact of *regular singing and song learning* (vs. formal musical training) on cognitive function in older adults. Henceforth in this article, any reference to "musical training" should be regarded as shorthand for "regular singing and song learning."

Given that our protocol does not involve formal music lessons (e.g., unlike Bugos et al., 2007), why might one expect that it could have cognitive benefits for older adults? Here we draw an analogy to physical exercise. Such exercise can have substantial physical (and mental) benefits for individuals even if done privately and without the guidance of a professional trainer. We suggest that regular singing and song learning using our protocol can be regarded as a form of solo "cognitive exercise" for a number of important mental processes, such as working memory, long-term memory, sustained attention, and fine-grained sensorimotor processing. Furthermore, because of the strong links between music and emotion (Juslin & Västfjäll, 2008), regular singing has the potential to boost positive emotions and to benefit cognition indirectly through interactions between emotional and cognitive processing (cf. Särkämö et al., 2008).

Feasibility Issues Addressed in This Study

Because our protocol introduces a novel, technology-based method for longitudinal studies with older adults, it must address three key feasibility issues, namely enjoyment, attrition, and compliance. In terms of enjoyment, would older adults find singing with a tablet-based computer app enjoyable? Unlike informal singing (e.g., with the radio), our protocol requires participants to learn to use novel software and then to use it regularly in their own at home, as well as to keep a journal related to their experiences. In terms of attrition, will older adults stick with this protocol over an extended period of time? We had participants use the software for about one half hour per day, 5 days a week for 5 weeks. By determining what proportion of participants completed the study and by conducting exit interviews, we aimed to discover whether the singing intervention was enjoyable and what kind of attrition can be expected using our protocol.

In terms of compliance, will older adults sing the daily list of songs specified in the protocol, including unfamiliar songs that had to be learned de novo? Our protocol asked participants to try to memorize the words and melodies of 12 songs over the course of the singing schedule: 4 familiar songs, 4 somewhat familiar songs, and 4 new songs. By analyzing audio recordings of the participant's singing, we could determine to what extent participants complied with the protocol.

If older adults did not enjoy our protocol or showed high levels of attrition or noncompliance, then our protocol would be of little use for future research. Fortunately, our method proved feasible for use with older adults. It is our hope that this report will motivate future researchers to pursue larger-scale studies using this method (e.g., with more participants and lasting several months, as in Bugos et al., 2007).

Cognitive Tasks

As part of our study, we administered cognitive tasks pre and post intervention to the song-learning group as well as to two control groups: a music listening group and passive control group with no assigned activities (further details about the different groups are in the Method section). Three tasks were of primary interest, including two tasks that assessed working memory and one that assessed the ability to regulate emotions.

The degree to which any kind of cognitive training can improve general cognition is a hotly debated topic. Recent research calls into question whether such training can do more than result in improvements in the practiced task (e.g., Simons et al., 2016). Our goal was to select cognitive measures that would assess underlying cognitive constructs hypothesized to be influenced by regular singing. Researchers have consistently argued that improvements in cognitive tasks beyond the trained tasks are more likely to be demonstrated when the two tasks share processing components (cf., Jonides, 2004). We hypothesized that if regular singing were to result in more general cognitive improvements, those would likely be demonstrated in measures of working memory. The singing protocol implemented in the present study required participants to memorize lyrics and melodies. In addition, research has suggested that musicians demonstrated better verbal and visuospatial working memory performance when musicians were compared with nonmusicians (e.g., Clayton et al., 2016; Weiss et al., 2014; Zuk et al., 2014).

Two measures of working memory were used. The Forward Digit Span from the Wechsler Adult Intelligence Scale (WAIS, multiple versions; Wechsler, 1950) requires the participant to remember and reproduce in order the digits read aloud by the examiner. With continuously correct responses, the total number of items in the set is increased. Thus, individuals are required to maintain a goal state, and that maintenance is directly related to frontal functioning. A subtle decrease in performance is demonstrated when young adults (under age 55) are compared with older adults (over age 55; see WMS-III and WAIS-III norms). The Forward Digit Span task is a simple measure of short term memory. We also used a measure of visuospatial working memory (cf., Thomas, Bonura, Taylor, & Brunyé, 2012), to determine whether regular singing leads to domain-general enhancements in working memory, as suggested by some authors who found enhanced visuospatial working memory in musicians (e.g., Weiss et al., 2014). Thus, we hypothesized that participants who completed the singing protocol would show enhanced visuospatial working memory performance. We also hypothesized that this improvement would not be because of changes in simple short term memory span, but would more specifically reflect enhanced *working* memory, reflecting the cognitive demands imposed by song learning.

In addition to two tasks that assessed both simple and complex visuospatial working memory, we also administered a task that assessed the impact of singing training on emotion regulation. Emotion regulation refers to the processes we use to influence the experience and expression of our emotions (Gross, 1998). According to Gross' (1998) process model, emotion regulation represents a heterogeneous set of processes including situation selection, situation modification, attentional deployment, cognitive reappraisal, and response modulation. Because emotion regulation has been linked to both mental and physical health outcomes (DeSteno, Gross, & Kubzansky, 2013), it is an important set of processes to understand in its own right. In this particular research context, our inspiration for including an emotion regulation task stems from three key observations as follows (Schmeichel & Tang, 2015; Urry, 2016): (a) that many forms of emotion regulation depend on cognitive resources (e.g., working memory capacity, inhibitory control, and fluid cognitive ability), (b) that there are age differences in some forms of emotion regulation, and (c) that age differences in some forms of emotion regulation may come about as a result of declines in cognitive resources, including working memory. All together, if, as proposed above, singing training enhances visuospatial working memory, it is reasonable to expect that this training might also have an effect on the ability to regulate emotions. Thus, we also administered a test of emotion regulation pre- and postintervention. We hypothesized that participants assigned to the singing protocol would exhibit improved emotion regulation compared with participants assigned to music listening or to no activity.

It is important to note that the particular cognitive tasks we chose to use are not part of the singing protocol, and that future researchers should choose tests suited to the particular hypotheses that they want to investigate.

Method

Participants

Participants were healthy community-dwelling older adults living in the greater Boston area between 65 and 84 years of age (M = 71.0, SD = 5.1). The majority of participants were female (77%) and White (92%). Participants were cognitively healthy, with Mini Mental Status Exam (MMSE) scores above 26 (M = 28, SD = 1.1), and a mean Mill Hill vocabulary score of 14.4 (out of 19, SD = 2.3). All participants completed high school, with an average of 16 years of education (SD = 2.89), and all had participated in at least three prior studies at Tufts University. All participants had been prescreened with a music experience survey over the phone to verify that they were currently musically inactive (not playing an instrument or singing regularly) and had little or no musical training. Participants who were currently musically active, were musically active in the past 40 years, or had extensive musical training were not invited to participate. Those with little or no musical activity or training were scheduled to attend the first of two laboratory sessions. In this group, 58% of participants had "little" musical training, with 12 or fewer years of training (M = 3.8, SD = 3.4), and nearly all stopped musical participation after age 20, at least 40 years before study participation. Individuals who came to the laboratory were randomly assigned to a Sing, Listen, or Control group (the numbers in each group that were included in the analysis were 15, 16, and 17, respectively; see Table 1). Members of the Sing group were asked to learn to sing 12 songs over the course of the protocol, as detailed below. The Listen group was matched to the Sing group in the amount of time they were asked to use the app, except they used it only to listen to songs and were instructed not to sing. Members of the Control group were neither assigned to sing nor to regular music listening.

All recruitment and enrollment procedures were approved by the Social, Behavioral, and Educational Research Institutional Review Board at Tufts University. Participants received 20 US dollars for each of two laboratory sessions of cognitive testing, as well as 50 US dollars for the singing or listening intervention. If a participant withdrew from the study during the intervention, they were compensated based on the number of completed days.

The SingFit Application

The tablet-based app introduced here is a research version of a commercial product called SingFit, which is designed to promote singing in populations such as older adults, incorporating an easy-to-use interface (SingFit.com, Los Angeles, CA; henceforth, the research version is referred to as SingFit-R; see Figure 1). The standard SingFit app allows a user to sing along with songs by providing a high-quality instrumental accompaniment while providing two mnemonic vocal guides. One voice, the "guide singer," sings the words and melody in time with the accompaniment, and emulates the voice of the song's original singer (e.g., Frank Sinatra). Singing along with the instrumental accompaniment and Guide Singer is like singing along with a recorded version of a song (as one might hear on the radio). The other voice, the "lyric coach," speaks the words of each upcoming phrase just before it is to be sung (like a vocal karaoke). Crucially, the user can independently control the volumes of the guide singer and lyric coach, and can gradually eliminate both vocal guides as the song is learned. In our paradigm, use of the guide singer and lyric coach was encouraged at the beginning of the protocol (to make the singing easy), but participants were asked to challenge themselves by singing as independently as possible from the guides by the end of the protocol.

Participants in the Listen group received a modified version of the SingFit-R application. This version did not include the lyric coach, and participants were unable to change the volume of the guide singer. The resulting application simply played the songs as a typical audio track (i.e., as one would hear them on a CD or radio).

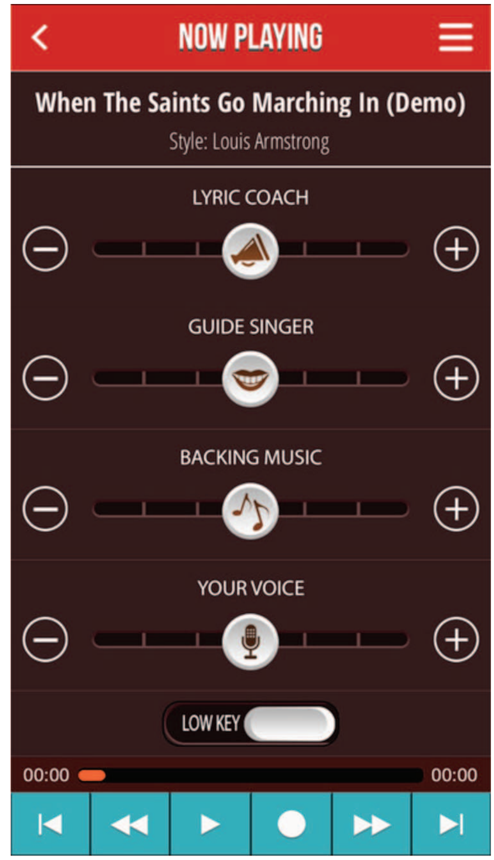

Figure 1. Screenshot of the SingFit app, adapted with permission. Note the adjustable volumes of the two mnemonic guides: the guide singer (a voice that sings the words of the song), and the lyric coach (a voice that speaks each phrase just before it is to be sung). Singers were encouraged to sing as independently as possible from these two guides by the end of the intervention. Note that the research version of the SingFit app prevented participants from fast-forwarding or rewinding songs. Copyright 2017 by SingFit Inc. See the online article for the color version of this figure.

Table 1
Demographic and Music Training Information for Participants Included in the Final Analysesl—Means (and SDs)

Demographic information	Control $n = 17$	Listen $n = 16$	Sing $n = 15$
Age	70.7 (5.1)	69.9 (4.0)	72.6 (6.0)
Gender (% female)	88.2%	76.4%	73.3%
Years of education	16.3 (2.6)	16.9 (3.4)	16.9 (2.8)
% Without music training	23.5%	43.8%	33.3%
Years of music training	2.3 (1.4)	3.8 (2.3)	4.8 (4.6)

Note. All participants with music training were musically inactive for at least 40 years before study participation.

SingFit-R differed from the standard SingFit app in that it automatically recorded several types of data whenever a user sang a song; all Sing and Listen sessions were recorded. These included the user-set volume levels of the guide singer, lyric coach, and instrumental accompaniment; two recordings of the participant's singing voice (one combined with the background music, the other separated from the background music and a capella); and the date and amount of time a participant spent singing/listening to a specific song during that trial. These data were stored locally on the tablet, and were downloaded for analysis by the researcher after protocol ended.

These data were used to verify compliance in several ways. For example, the date and time information for each song were used to verify that the protocol schedule was followed (e.g., that the assigned songs were sung on the correct days), and recordings were used to verify that the singers sang every song and that the listeners did not sing. Volume levels for the lyric coach and guide singer for each song were tracked across protocol to see if these mnemonic aids were eventually turned down, indicating that participants gradually relied more on their memory for the melody and lyrics. Recordings made at the end of protocol were used to see if the lyrics and melody of each song were actually learned. Because participants were asked to use headphones to listen to the music and to sing in quiet settings (e.g., alone in a room), the user's singing was essentially recorded a capella. This can greatly ease acoustic analyses of singing. We used recordings to check compliance and to verify that new songs were learned (by listening to recordings, with a focus on correct production of lyrics). Future work could go much further in terms of studying song learning, for example, by quantifying the number of correctly produced lyrics and analyzing pitch and timing patterns over the course of the singing protocol, to measure how singing changes over time.

Singing Materials

Members of the Sing and Listen groups were provided with an iPad (Apple, Inc., Cupertino, CA), preinstalled with the SingFit-R application, and Superbeam headphones (Andrea Electronics, Bohemia, NY), which were chosen for their comfort and for their built-in microphone. Participants also received a binder, which included a singing schedule, an instruction manual for the iPad and the application, and a singing journal to record comments about experiences.

Singing schedule. Sing participants were allowed to choose 12 songs from a menu of songs, most of which were popular during their young adulthood. They were asked to choose songs based on self-rated level of familiarity: 4 songs that were "new" (relatively unfamiliar), 4 that were "familiar" (knew a few lyrics), and 4 that were "old" (knew many lyrics; see Appendix A for an example of a participant's self-rated song choices). These songs were then inserted into a calendar that listed which songs to sing on each day (Figure 2: note that the singing schedule included listening to each song before singing it for the first time). Singers sang six songs per weekday. The calendar organized the songs such that over the course of the 5 weeks, new songs were practiced the most and old songs the least (new songs were sung a total of 13 times, familiar, 11, and old, 9; see Figure 2). Participants were also instructed to challenge themselves by gradually diminishing their reliance on the mnemonic guides over the course of the schedule (the lyric coach and guide singer).

Participants in the Listen group chose five playlists to listen to, each containing five songs. They selected songs from the same options provided to the Singers, and listened to the songs with the guide singer turned on and with no lyric coach. (This was essentially like listening to a radio or CD version of the song.) The

Weekly Singing Schedule
Please check off a box when you finish a song

Week + Instructions	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	□ Listen: Old 1	□ Listen: Old 3	□ Sing: Old 1	□ Listen: Familiar 4	□ Listen: Familiar 1
Singing Instructions	□ Sing: Old 1	□ Sing: Old 3	□ Sing: Old 2	□ Sing: Familiar 4	□ Sing: Familiar 1
Lyric Coach: On	□ Listen: Old 2	□ Listen: Old 4	□ Sing: Old 3	□ Listen: New 1	□ Listen: New 2
Guide Singer: On	□ Sing: Old 2	□ Sing: Old 4	□ Sing: Old 4	□ Sing: New 1	□ Sing: New 2
Background Music: On	□ Listen: Familiar 1	□ Listen: Familiar 2	□ Listen: Familiar 3	□ Listen: New 1	□ Listen: New 2
	□ Sing: Familiar 1	□ Sing: Familiar 2	□ Sing: Familiar 3	□ Sing: New 1	□ Sing: New 2
Week 2	□ Listen: Familiar 2	□ Listen: Familiar 3	□ Listen: Familiar 4	□ Sing: Familiar 1	□ Sing: Familiar 3
Singing Instructions	□ Sing: Familiar 2	□ Sing: Familiar 3	□ Sing: Familiar 4	□ Sing: Familiar 2	□ Sing: Familiar 4
Lyric Coach: On	□ Listen: New 3	□ Listen: New 4	□ Listen: New 1	□ Listen: New 3	□ Sing: New 1
Guide Singer: On	□ Sing: New 3	□ Sing: New 4	□ Sing: New 1	□ Sing: New 3	□ Sing: New 2
Background Music: On	□ Listen: New 3	□ Listen: New 4	□ Listen: New 2	□ Listen: New 4	□ Sing: New 3
	□ Sing: New 3	□ Sing: New 4	□ Sing: New 2	□ Sing: New 4	□ Sing: New 4
Week 3	□ Sing: Old 1	□ Sing: Familiar 1	□ Sing: New 1	□ Sing: Old 1	□ Sing: Old 3
Singing Instructions	□ Sing: Old 2	□ Sing: Familiar 2	□ Sing: New 2	□ Sing: Old 2	□ Sing: Old 4
Lyric Coach: Off	□ Sing: Old 3	□ Sing: Familiar 3	□ Sing: New 3	□ Sing: Familiar 1	□ Sing: Familiar 3
Guide Singer: On (if needed)	□ Sing: Old 4	□ Sing: Familiar 4	□ Sing: New 4	□ Sing: Familiar 2	□ Sing: Familiar 4
Background Music: On	*Practice 2 of these songs again*	*Practice 2 of these songs again*	*Practice 2 of these songs again*	□ Sing: New 1	□ Sing: New 3
	□ □	□ □	□ □	□ Sing: New 2	□ Sing: New 4
Week 4	□ Sing: Old 1	□ Sing: Old 3	□ Sing: Any 6 Songs	□ Sing: Old 1	□ Sing: Old 3
Singing Instructions	□ Sing: Old 2	□ Sing: Old 4	□ Sing:	□ Sing: Old 2	□ Sing: Old 4
Lyric Coach: Off	□ Sing: Familiar 1	□ Sing: Familiar 3	□ Sing:	□ Sing: Familiar 1	□ Sing: Familiar 3
Guide Singer: Off	□ Sing: Familiar 2	□ Sing: Familiar 4	□ Sing:	□ Sing: Familiar 2	□ Sing: Familiar 4
Background Music: On	□ Sing: New 1	□ Sing: New 3	□ Sing:	□ Sing: New 1	□ Sing: New 3
	□ Sing: New 2	□ Sing: New 4	□ Sing:	□ Sing: New 2	□ Sing: New 4
Week 5	□ Sing: Old 1	□ Sing: Old 3	□ Sing: Any 6 Songs	□ Sing: Old 1	□ Sing: Old 3
Singing Instructions	□ Sing: Old 2	□ Sing: Old 4	□ Sing:	□ Sing: Old 2	□ Sing: Old 4
Lyric Coach: Off	□ Sing: Familiar 1	□ Sing: Familiar 3	□ Sing:	□ Sing: Familiar 1	□ Sing: Familiar 3
Guide Singer: Off	□ Sing: Familiar 2	□ Sing: Familiar 4	□ Sing:	□ Sing: Familiar 2	□ Sing: Familiar 4
Background Music: On	□ Sing: New 1	□ Sing: New 3	□ Sing:	□ Sing: New 1	□ Sing: New 3
	□ Sing: New 2	□ Sing: New 4	□ Sing:	□ Sing: New 2	□ Sing: New 4

Figure 2. Example weekly singing schedule. Singers chose 12 songs to learn, which were then inserted into this 5-week schedule. Note that each week's instructions regarding the use of the guide singer and lyric coach were not strictly enforced. However, the volume of these mnemonic aids was logged each time a song was learned, allowing quantification of their use. See the online article for the color version of this figure.

Table 2
Example Weekly Listening Schedule

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1	Playlist A	Playlist B	Playlist C	Playlist D	Playlist E
2	Playlist C	Playlist A	Playlist D	Playlist E	Playlist B
3	Playlist E	Playlist C	Playlist B	Playlist A	Playlist D
4	Playlist D	Playlist E	Playlist A	Playlist B	Playlist C
5	Playlist B	Playlist D	Playlist E	Playlist C	Playlist A

Note. Listeners selected five playlists, each consisting of five songs. participants listened to each playlist once per week.

calendar instructed Listeners to listen to one playlist a day, and each playlist once a week (see Table 2). To ensure adherence to procedures, the app recorded the ambient sound during the listening sessions, allowing us to verify (via these recordings) that the listeners did not sing. For a list of songs available to Sing and Listen participants, see Appendix B.

Both the Sing and Listen groups were asked to do five sessions a week for 5 weeks, with each session lasting about one half hour.

Postintervention Questionnaire

On the completion of the singing or listening intervention, Singers and Listeners were asked to complete a questionnaire about their experiences in the study. This questionnaire asked how enjoyable the experience was, how easy or difficult the software was to use, and how often participants missed a daily session.

Cognitive Tasks

Memory tasks. As a measure of working memory, we used a Visuospatial Working Memory test (VSWM) developed by Thomas et al. (2012). This task examined participants' memory for identity and location of shapes, randomly located on a 5 × 5 grid. Each grid presented had between 2 and 5 shapes. After seeing a grid for 3 s, participants were asked to provide a subjective judgment of how well they learned the grid, and were then immediately tested on memory for shape, location, or the combination of both shape and location. Test question type was randomized to prevent strategic processing. Participants were presented with 144 trials over the course of approximately 40 min, and all participants were offered break time halfway through the task.

To distinguish improvements in working memory from changes to simple short term memory span, we also tested Digit Span forward (DS) as a measure of simple memory span. The DS test was delivered via prerecorded audio stimuli. Digits were randomly generated for each trial, and each test ended after two mistakes were made on a given level.

Emotion regulation task. As this task is likely to be less familiar to readers than our memory tasks, we describe it in some detail. Our emotion regulation task assessed the impact of two emotion regulation strategies—cognitive reappraisal and attention deployment—on the intensity of responses to emotional pictures (our task is a variant of the task used by Opitz et al., 2014). In brief, in this task participants viewed 48 pictures selected to engender mild sadness. These included contents such as withdrawn, lonely, or sad older and younger adults and/or injured, solitary, or apparently sad animals. Upon viewing each picture, participants followed specific emotion regulation instructions, described below. The emotion regulation task was designed by crossing two within-subjects factors, cognitive reappraisal condition (view, decrease) and attention deployment condition (gaze directed to arousing or nonarousing region of the picture). The task lasted approximately 20 min.

Before completing the emotion regulation task, participants received in-depth training to ensure that they understood the cognitive reappraisal (CR) and gaze direction instructions as well as how to rate the intensity of their emotional response on each trial. For the CR manipulation, participants were trained to decrease their emotional response to the pictures. This could be done by considering the personal relevance of the depicted situation (self-focused reappraisal) or by imagining alternative outcomes (situation-focused reappraisal). Cues to begin using CR were presented via single-word audio recording, "decrease" 3 s after picture onset. As part of their training, participants saw a picture of a man lying in a hospital bed, seemingly in pain. For the decrease instruction, participants were told that they could imagine that "you are simply observing the man objectively, or that he will get better soon." A second audio recording, "view," served as a cue to respond naturally without trying to change how they felt. For both conditions, participants were instructed not to think of the pictures as fake or unreal.

For the gaze direction manipulation, the participant's gaze was directed to an emotionally arousing or nonarousing (neutral) area of each picture beginning 4 s after picture onset. Gaze was directed using a white box superimposed over the target area of the picture. This gaze direction manipulation enabled us to control the ways in which participants deployed their visual attention to the emotional information in the pictures during the 8-s regulation period of interest. In our previous studies (Opitz et al., 2014; Urry, 2010), eye tracking data confirmed that participants follow the gaze direction instructions equally across the CR conditions, that looking time in the designated areas of interest increases after the gaze direction instruction, and that, without instruction, participants spend more time looking at the arousing than nonarousing area.

At the end of each trial, participants provided a self-report rating of the intensity of their response to the pictures. They provided the rating on a 9-point scale ranging from 1 = *not very intense*, to 9 = *very intense*. This 9-point numeric scale was illustrated with five figures based on the arousal scale of the Self-Assessment Manikin (Lang et al., 2008). Figures ranged from a relaxed, sleepy figure at the left (not at all intense) to an excited, wide-eyed figure at the right (very intense). Our dependent variable for the analyses reported below was the average rating of intensity across all six trials in each cell of the design. The pictures of interest are all unpleasant; thus, we were assessing the extent to which cognitive reappraisal and attentional deployment regulated the subjective experience of unpleasant emotional arousal.

Baseline cognitive functioning. The Mini Mental Status Exam (MMSE; Folstein et al., 1975) and the Mill Hill Vocabulary Scale (MHVS; Raven, 1958) were used to measure baseline cognitive functioning and to screen for potential cases of dementia. All recruited participants passed these measures, resulting in zero screen outs.

Procedure

Participants in the Sing, Listen and Control groups took part in two cognitive testing sessions (before and after the intervention). The first session lasted approximately 1.5 hr, with short breaks (~5 min) provided in between tests. During this session, participants completed the cognitive assessments in the following order: digit span, visuospatial working memory, and emotion regulation. An experimenter read aloud the instructions for each test. For the memory tests, the experimenter entered the participants' verbal responses. To account for response time and to allow for emotional privacy, participants entered their own responses for the emotion regulation task. All participants completed the same tests and questionnaires, regardless of group assignment.

After cognitive testing, the MHVS and MMSE were administered. Then (in the first session) Sing and Listen participants received training related to their experimental condition. Participants were trained until they could confidently use the technology without instruction (i.e., navigate the SingFit application, operate iPad controls, properly use headphones). During this session, participants selected 12 songs (Sing group) or 5 playlists, each consisting of 5 songs (Listen group; see Appendix B). Participants were also given a manual with information about the application and the tablet, and a journal to take notes about their experiences. Once a week, an experimenter conducted check-ins via phone or email to answer any questions participants had regarding the technology or procedure. During these check-ins, Sing participants were reminded to try to decrease their dependence on the singing guides, and Listen participants were reminded not to sing.

The second session took place 5 to 6 weeks after the first, once participants had completed the protocol. During this second session, participants completed the working memory and emotion regulation tasks a second time. Sing and Listen participants were also asked to complete a survey regarding their experiences. The MHVS and MMSE were not readministered.

Results

Feasibility Analyses

To determine if it realistic to use our protocol in future studies with older adults, we examined attrition, compliance, and enjoyment.

Attrition. Seventy-seven older adults provided consent to join the study. Eight were excluded from participation either because of too much musical experience (5) or to being outside of the studied age range (3), four withdrew for health issues unrelated to the study, and four were unable to complete the study because of an error in the application programming. These were not counted as attrition since their nonparticipation was not because of voluntary withdrawal. One subject withdrew because of issues during cognitive testing (this subject found the CR task upsetting). Of the remaining 60 participants, 17 were in the Control group and the remaining 43 were in the Sing or Listen groups. Of these 43, 5 withdrew during the study because they did not wish to complete the study. All participants who chose to withdraw came from the Sing group, but only one withdrawal was because of group assignment. Reasons for withdrawing from the study included difficulty learning how to use the technology (2), not wanting to sing (1), and scheduling difficulties (i.e., too busy to complete the protocol) (2). Thus, among participants using the app (Sing and Listen groups), 38 out of 43 completed the study and the attrition rate was 5 out of 43, that is, about 12%.

Compliance. To verify compliance with the protocol, recordings were used to verify that Singers actually sang and that Listeners did not. Also, recordings were examined to ensure that participants sang or listened to the correct songs on the correct days. Of the 38 participants in the Sing and Listen groups who completed the study, 7 were excluded for not adequately complying with the protocol (2 Listeners and 5 Singers), meaning that the noncompliance rate was 7 out of 38 or about 18%.

Enjoyment. Based on reports from journal entries, phone check-ins, and the exit survey, the majority of participants in the Sing and Listen groups reported that they enjoyed and looked forward to the sessions, did not find the protocol or app difficult to understand, and rarely missed a session. Singers tended to note frustration regarding their memory for lyrics of a song, or sometimes complained of their own singing ability. Listeners occasionally complained that the vocal artist did not sound like the original, or that they found the task boring. In both groups, it was frequently mentioned that learning to use new technology was inconvenient. However, this did not stop them from using the app, and from making positive comments in the exit survey, which included noting favorite songs, descriptions of memories or emotions associated with the songs, or expressions of enjoyment of the task.

Song Learning

To check whether participants in the Sing group actually learned new songs over the course of the 5-week protocol, we measured the volume of their guide singer and lyric coach settings for the four new songs they were asked to learn. We reasoned that if they turned down the volume of these vocal guides over the course of the study, this would indicate learning of the words and melody of the song. Thus, we checked these settings at two time points: the first and last time they sang each of the four new songs (we also checked the recordings to ensure that they actually did sing on these occasions). As can be seen in Figure 2, the first and last singings of these songs were about 3 weeks apart.

Because of an application error (fixed too late to be of use in the current study), volume settings were not stored for 4 of the 15 participants in the Sing group. In the remaining 11 participants, the average volume of the guide singer was .63 on first singing and .37 on last singing ($p < .05$, paired t test), and the average volume of the lyric coach was .66 on first singing and .11 on last singing ($p < .001$, paired t test; for both of these measures, the possible range of values is 0 to 1, where 0 = off and 1 = full volume). Thus, participants in the Sing group showed evidence of learning new songs during the singing protocol.

Working Memory

We had hypothesized that visuospatial working memory would be enhanced by regular singing and learning new songs, whereas simple memory span would not be affected. For our measure of simple memory span (the forward digit span task) a 3 (Group: Sing, Listen, Control) $\times$ 2 (preintervention, postintervention) mixed design analysis of variance (ANOVA) found no significant effects, *F*s < 1. That is, pretraining digit span for each group (Sing: $M = 6.82$, $SD = 1.82$; Listen: $M = 7.28$, $SD = 1.27$; Control: $M = 6.52$, $SD = 1.01$) did not differ from posttraining digit span (Sing: $M = 6.64$, $SD = 1.11$; Listen: $M = 7.00$, $SD = 1.41$; Control: $M = 6.53$, $SD = 1.23$).

For the visuospatial working memory (VSWM) task, memory for shape identity, location of shapes, and the combination of shape identity and location were measured. Although a measure of span was also embedded in this task (the number of items presented in a grid, between two and five items), since simple memory span was unaffected by the intervention, we opted to collapse performance across different levels of grid span.

The VSWM task requires participants to make yes or no recognition decisions. We measured accuracy on this task using the average proportion of hits minus the average proportion of false alarms (thus, all references to "accuracy" below refer to this measure; maximum accuracy = 1, chance performance = 0). Data were analyzed separately for the three different types of trials: memory for shape, location, and the combination of shape and location. Ten participants in the Sing condition, 11 in the Listen condition, and 11 in the Control condition successfully completed the VSWM task in both sessions and produced data for analysis.

A 3 (Group: Sing, Listen, Control) × 2 (Session: Pre-Combination, Post-Combination) mixed design ANOVA was performed using accuracy in the combination condition (memory for both shape and location) as the dependent measure. No significant effects were found, *F*s < 1. As Table 3 demonstrates, the intervention had no effect on performance on combination trials. A 3 (Group: Sing, Listen, Control) × 2 (Session: Pre-Shape, Post-Shape) mixed design ANOVA using accuracy in the shape condition as the dependent measure did find a significant main effect of Session, $F(1, 29) = 6.47$, $p = .02$, $\eta_p^2 = .18$. As Table 3 demonstrates, performance on shape memory trials significantly improved between Session 1 ($M = .43$, $SD = .23$) and Session 2 ($M = .53$, $SD = .22$), across all groups. However, the interaction between Group and Session was not significant, suggesting that the intervention did not result in this improvement. That said, the average data presented in Table 3 clearly demonstrates that participants in the Control condition demonstrated no change in performance between sessions for shape memory, but Listeners and Singers did demonstrate an improvement. Finally, a 3 (Group: Sing, Listen, Control) × 2 (Session: Pre-Location, Post-Location) mixed design ANOVA using accuracy in the location condition as the dependent measure found a marginally significant main effect of Session, $F(1, 29) = 3.29$, $p = .08$, $\eta_p^2 = .10$. Although marginal, Table 3 demonstrates a numerical improvement across all groups between the first ($M = .44$, $SD = .22$) and second ($M = .50$, $SD = .25$), postintervention, session on location memory trials. In addition, we found a marginally significant interaction between Session and Group, $F(2, 29) = 2.82$, $p = .075$, $\eta_p^2 = .16$. As Table 3 demonstrates, control participants demonstrated a decrement in performance between the first and second session. Listeners demonstrated a modest improvement in performance. Singers demonstrated the largest increase in location memory performance.

Table 3
Means and SDs for Accuracy (Proportion Hits Minus Proportion False Alarms) on the Visuospatial Working Memory Task

Task	Control	Listen	Sing
Preintervention			
Combination	.37 (.22)	.40 (.16)	.41 (.08)
Shape	.48 (.25)	.44 (.21)	.36 (.25)
Location	.46 (.22)	.51 (.16)	.35 (.27)
Postintervention			
Combination	.43 (.22)	.40 (.17)	.45 (.24)
Shape	.47 (.26)	.55 (.23)	.56 (.17)
Location	.42 (.25)	.57 (.27)	.52 (.23)

Emotion Regulation

Based on our hypothesis that singing would enhance working memory and links between working memory capacity and emotion regulation (Opitz et al., 2014; Schmeichel & Tang, 2015), we had hypothesized that emotion regulation success would be enhanced in the Sing group relative to the Listen and Control groups at posttest, with no differences between the three groups at pretest. For cognitive reappraisal, success would be evidenced by lower mean reported intensity when using reappraisal to decrease emotional responding versus when simply viewing the pictures and responding naturally. For attentional deployment, success would be evidenced by lower mean reported intensity when gaze was directed to a nonarousing area in the pictures versus an arousing area in the pictures.

To test our hypothesis we conducted a generalized linear model analysis examining ratings of intensity. There were three within-subjects factors in the analysis each with two levels as follows: Cognitive Reappraisal (decrease, view), Gaze Direction (arousing, nonarousing), and Session (pretest, posttest). Additionally, there was one between-subjects factor, Group (Control, Listen, Sing). Support for the hypothesis would be found in a significant three-way interaction between Group, Cognitive Reappraisal or Gaze Direction, and Session, or possibly a four-way interaction between all four of these variables. Contrary to the hypothesis, however, none of these interactions were significant, all three *p*s > .50.

The absence of these critical interactions does not signal a general lack of regulation success in this sample. To the contrary, there were significant main effects of Cognitive Reappraisal, $F(1, 44) = 12.11$, $p < .001$, and Gaze Direction, $F(1, 44) = 12.55$, $p < .001$, on ratings of reported intensity. As would be expected with successful implementation of instructions, participants reported lower intensity when following the decrease instruction than when following the view instruction. Similarly, participants reported lower intensity when gaze was directed to a nonarousing area of the pictures than when gaze was directed to an arousing area of the pictures. Descriptive statistics for all cells are reported in Table 4.

Notably, there were some hints that group assignment had a differential effect on emotional responses to the pictures from pretest to posttest. Specifically, there was a significant Group × Session interaction effect on ratings of intensity, $F(2, 44) = 3.41$, $p = .042$, $\eta_p^2 = .134$. As shown in Figure 3, participants in the Control group reported lower intensity in response to the pictures at posttest than at pretest, $p = .039$ (Fisher's Least Significant Difference). A similar pattern was evident for participants in the Listen group, although the difference was not significant, $p = .077$. Participants in the Sing group, however, reported *greater*

Table 4
Means (and SDs) for Ratings of Arousal for All Cells in the Design

Task	Control		Listen		Sing		All groups	
	Decrease	View	Decrease	View	Decrease	View	Decrease	View
Preintervention								
Arousing	5.01 (1.09)	5.28 (1.11)	4.79 (1.57)	5.48 (1.76)	4.78 (1.18)	4.92 (1.79)	4.87 (1.27)	5.24 (1.55)
Nonarousing	4.27 (1.69)	4.59 (1.82)	4.51 (1.77)	4.84 (1.91)	4.00 (1.38)	4.08 (1.58)	4.27 (1.61)	4.52 (1.77)
Postintervention								
Arousing	4.34 (1.43)	4.64 (1.51)	4.17 (1.36)	5.10 (1.91)	4.58 (1.14)	5.43 (1.56)	4.35 (1.31)	5.03 (1.67)
Nonarousing	3.86 (1.63)	4.06 (1.67)	4.00 (1.71)	4.38 (2.21)	4.48 (1.61)	4.80 (1.71)	4.09 (1.64)	4.39 (1.87)

intensity at posttest than at pretest, a difference that also was not significant, $p = .203$.

Discussion

Our aims in this study were to introduce a new technology-based method for conducting longitudinal studies of the impact of regular singing and song learning on cognitive function in healthy older adults, and to test its feasibility for use with this population. This work was motivated by the fact that the proportion of older adults is rapidly growing in many countries, and the current interest in researching activities that promote/preserve cognitive function in the face of normal age-related cognitive decline. Music-making is a promising candidate because it places numerous demands on cognitive processing (e.g., memory, attention) in the context of a behavior that is emotionally rewarding and likely to motivate repeated practice, if music-making is made sufficiently easy for participants (cf. Patel, 2014). Thus, the current article fits into a larger literature examining how singing can influence well-being across the life span (Cohen, 2011).

The new SingFit-R aims to make regular singing and song-learning easy and appealing for older adults, particularly for those with little or no prior training in music (cf. Reifinger, 2016). It also aims to make the singing protocol easy to conduct and relatively inexpensive for researchers. This is done by focusing on singing (rather than playing a musical instrument), and by using an app designed to encourage the learning of new songs without the need for teacher-led training. While training with a live teacher is no doubt the best form of music instruction, the use of portable technology that can be taken home and used at one's convenience circumvents several practical challenges that arise when training with live teachers (e.g., scheduling, transportation, and the cost of live lessons). We emphasize at the outset that the protocol described here focuses on regular singing and the learning of songs (i.e., lyrics and melodies), not on training singing skills (e.g., pitch accuracy, timbre, breath control, etc.). Thus, it is not a replacement for teacher-led singing training aimed at improving the quality of singing. The focus instead is on providing a form of memory training in the context of an ecologically natural human activity (singing). Because most people learn songs through exposure without feedback from a teacher, song learning with SingFit emulates a natural human behavior while also providing researchers a number of measures of that behavior.

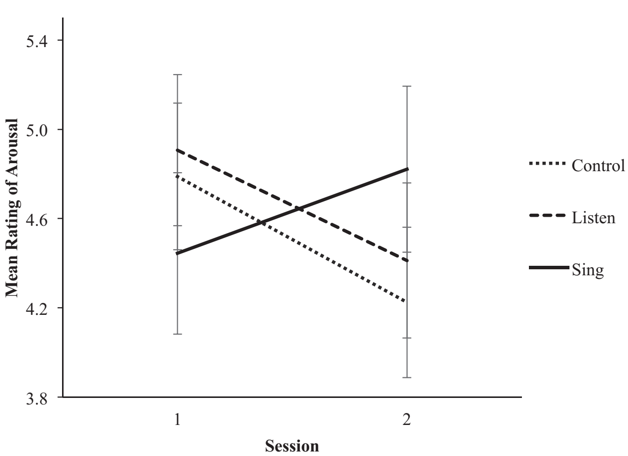

Figure 3. Effect of group and session (1 = preintervention and 2 = postintervention) on ratings of arousal during the emotion regulation task.

Specifically, Singfit-R allows researchers to verify compliance with the protocol because it logs date, time, and song name for each song that is sung and records the participant's voice as s/he sings with the app. It also allows researchers to quantify song learning by logging the user-set volume of two vocal mnemonic aids each time a song is sung. These aids (the guide singer and lyric coach) help the user learn the song, and are meant to be gradually turned down in volume as a song is learned. It should be noted that while we used recordings only to verify compliance, future work could analyze recordings in a more detailed way (e.g., for accuracy of pitch and timing patterns) if finer-grained measures of musical learning were desired. Such analysis is greatly facilitated by the fact that the singer's voice is recorded a capella, because they hear the accompanying music over headphones but their voice is recorded by an external microphone that does not pick up this accompaniment.

We tested the feasibility of conducting longitudinal research with Singfit-R by enrolling a population of healthy older adults (average age 71) in a 5-week singing protocol involving one half hour per day of singing, 5 days a week. Our participants were randomly assigned to a Sing group (that used the SingFit-R app), a Listen group (that used a modified version of the app to listen to a similar amount of songs, without singing), and a Control group (that neither sang nor listened to songs). Members of all three groups took tests of working memory and emotion regulation before and after the 5-week intervention period.

In terms of feasibility, we found that older adults were able to learn to use the app in a single lab-based training session, and then to use it at home on their own in accordance with the protocol schedule, with the occasional phone call for assistance. In terms of attrition, we found that 12% of older adults who used the app (Sing and Listen groups) chose not to complete the study. Among participants that completed the study, 18% did not comply with the assigned protocol. The majority of participants who completed the study reported enjoying the experience and looked forward to their sessions with the app.

While these attrition and noncompliance rates may seem high, it is important to remember that daily use of the app required participants to be self-motivated, as they participated in their own homes and did not receive daily prompting to engage in the study. This greatly lessens the time demands on researchers, with the tradeoff of significant degree of attrition and noncompliance. Based on our attrition and noncompliance rates, about 70% of adults who started the study completed it and produced usable data. Based on these findings, we feel that SingFit-R is feasible to use in larger-scale or longer-lasting studies than ours, though it would behoove researchers to think about ways to lower attrition and noncompliance (e.g., perhaps through larger financial incentives than we provided in the current work). We note that larger-scale studies will require a modified protocol relative to ours (e.g., a greater variety of songs to learn). However, like our study, we recommend that such studies should include weekly contact between researchers and participants (e.g., via phone) to check on participation and to answer questions.

In terms of cognitive tasks, we did not find a significant enhancement of visuospatial working memory in the Sing group compared with other groups, even though other studies have reported that visuospatial working memory is enhanced in musicians (Weiss et al., 2014). It may be that 5 weeks of singing (at one half hour per day) is not enough to produce measurable benefits in this ability, though we note that the Sing group showed the largest numerical improvement in memory for spatial location compared with the other groups. Given the lack of a significant "far transfer" enhancement in working memory, it is perhaps not surprising that we also did not see a significant enhancement in an emotion regulation task that is thought to depend on working memory resources. Other research with older adults points to lasting emotional benefits of regular engagement with music, using different measures (e.g., levels depression or fatigue; Särkämö et al., 2008), and we suggest that such measures of emotional well-being be explored in future longitudinal research.

While the lack of effects in our cognitive and emotional tasks did not support our hypotheses, it is important to note that this could well be because of the short duration of our protocol compared with other music training studies with older adults (e.g., 6 months in Bugos et al., 2007), and our relatively small sample size. We feel that the most significant finding of our study is that a novel, technology-based singing and song learning protocol was shown to be feasible for use with older adults. This makes longitudinal cognitive studies of music-making much easier and less expensive to conduct than traditional music training studies. Also, the use of a tablet-based app for singing and song learning makes it easy to design active control conditions which use the same tablet for other types of mentally stimulating activities (e.g., puzzles, memory games, etc.). We suggest that future studies using our protocol use singing programs that extend over multiple months and recruit significantly larger numbers of participants.

It is worth addressing an important difference between singing using SingFit-R and the experience one would get with learning songs in the context of group singing (such as in a community choir). Unlike group singing, the use of SingFit-R is a solitary experience. While participants may enjoy this experience (as found in the current study), the results obtained in cognitive studies using SingFit-R may not be the same as would be found in studies group singing, which have a social component (in addition to coaching aimed at improving singing quality). While this can be seen as a limitation of the current approach, it also means that individuals who would normally shy away from singing in groups can participate in (and enjoy) a singing-based protocol. Indeed, though exit interviews we found that some participants were even motivated to further pursue singing after the protocol ended.

We close by noting that singing and song learning provide several practical advantages for cognitive training with older adults. First, singing is a widespread behavior, and many people already engage in informal singing, for example, with the radio (cf., Cohen, 2011; Elmer, 2011). Thus, willingness to enroll in a singing and song-learning study (among musically untrained individuals) may be greater than willingness to enroll in other types of cognitive training, especially for those with limited time to devote to training. Second, older adults often have a rich fund of songs that they know and love from a lifetime of listening to music, and some of these can be incorporated into the singing regimen to help motivate practicing. Third, because music has a strong relationship to the reward circuitry of the brain (Zatorre & Salimpoor, 2013), the pleasure older adults get from singing may increase the chance that they will complete a singing and song-learning program that lasts for an extended period of time (vs. a program based on other types of cognitive exercises, such as computer-based "brain games"). In summary, it is our hope that the new methods introduced in this article will motivate larger-scale studies of the impact of regular singing and song learning on cognitive function in healthy older adults.

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Appendix A

Example of a Participant's Self-Rated Song Choices

New (relatively unfamiliar)	Familiar (knew a few lyrics)	Old (knew many lyrics)
As Time Goes By	Always on My Mind	Can't Help Falling in Love
Various Artists	*Willie Nelson*	*Elvis Presley*
Don't Give Up on Us	Don't Know Why	God Bless America
David Soul	*Norah Jones*	*Traditional*
On Broadway	How Sweet It Is	New York New York
The Drifters	*James Taylor*	*Frank Sinatra*
Something to Talk About	It's Not Unusual	Stand By Me
Bonnie Raitt	*Tom Jones*	*Ben E. King*

Note. These songs were entered into the weekly singing schedule (see Figure 2). The singing schedule instructs singers to sing each new song 13 times, familiar songs 11 times, and old songs 9 times.

Appendix B

The List of Songs to Be Selected by Singers and Listeners

Song	Artist
(Sittin' On) The Dock of the Bay	Otis Redding
A Kiss To Build A Dream On	Louis Armstrong
Above All	Michael W. Smith
Act Naturally	Buck Owens
Ain't That a Shame	Fats Domino
Always On My Mind	Willie Nelson
Amazing Grace	Traditional
America The Beautiful	Traditional
As Time Goes By	Various
At Last	Etta James
At This Moment	Billy Vera & The Beaters
Autumn Leaves	Traditional
Baby Don't Get Hooked On Me	Mac Davis
Baby I Need Your Loving	The Four Tops
Be My Baby	The Ronettes
Before You Accuse Me	Eric Clapton
Bewitched, Bothered and Bewildered	Frank Sinatra
Blue Eyes	Elton John
Blueberry Hill	Fats Domino
Born To Be Wild	Steppenwolf
Buffalo Soldier	Bob Marley & The Wailers
By The Light of the Silvery Moon	Doris Day
Can't Help Falling In Love (With You)	Elvis Presley
Chain of Fools	Aretha Franklin
Chanson D'amour	Art and Dotty Todd
Crazy	Patsy Cline
Don't Give Up On Us	David Soul
Don't Know Why	Norah Jones
Easy	Commodores
Feel Like Making Love	Bad Company
Fly Me to the Moon	Frank Sinatra
Free Bird	Lynyrd Skynyrd
God Bless America	Traditional
God of Wonders	Third Day
Hang On Sloopy	The McCoys
Hella Good	No Doubt
Holiday	Madonna

(*Appendices continue*)

Appendix B (*continued*)

Song	Artist
Hound Dog	Elvis Presley
How Sweet It Is (To Be Loved By You)	James Taylor
I Believe I Can Fly	R. Kelly
I Can't Help Myself (Sugar Pie Honey Bunch)	The Four Tops
I Left My Heart in San Francisco	Tony Bennett
I Love Paris	Frank Sinatra
I Still Miss Someone	Johnny Cash
Inseparable	Natalie Cole
It's Not Unusual	Tom Jones
Just The Way You Are	Billy Joel
Lean On Me	Bill Withers
Lost Highway	Hank Williams
Love is a Battlefield	Pat Benatar
Love Me Tender	Elvis Presley
Midnight Special	Creedence Clearwater Revival
My Bonnie	Traditional
My Special Angel	Bobby Helms
New York New York	Frank Sinatra
On Broadway	The Drifters
One Fine Day	The Chiffons
Over the Rainbow	Katherine Mcphee
Rikki Don't Lose That Number	Steely Dan
She Never Cried In Front of Me	Toby Keith
Some Enchanted Evening	Bing Crosby
Something To talk About	Bonnie Raitt
Stand By Me	Ben E. King
Sugar, Sugar	The Archies
Summer Wind	Frank Sinatra
Sweet Home Alabama	Lynyrd Skynyrd
Swing Low Sweet Chariot	Johnny Cash
The Lady is a Tramp	Frank Sinatra
The Rose	Bette Midler
The Twist	Chubby Checker
Tiny Dancer	Elton John
Under The Boardwalk	The Drifters
Use Somebody	Kings of Leon
We've Only Just Begun	The Carpenters
What's Your Name	Lynyrd Skynyrd
Wild Thing	The Troggs
Wind Beneath My Wings	Bette Midler
Working for the Weekend	Loverboy
You Are So Beautiful To Me	Joe Cocker
You Don't Have To Say You Love Me	Dusty Springfield
You Make Loving Fun	Fleetwood Mac

Note. Singers chose 12 songs: 4 of which were unfamiliar to them, 4 of which were somewhat familiar, and 4 of which were familiar to them. Listeners chose 5 preset playlists (not shown here), each containing 5 songs (25 songs total).

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