

# Bibliography

- [1] Daniel A Abrams, Srikanth Ryali, Tianwen Chen, Parag Chordia, Amirah Khouzam, Daniel J Levitin, and Vinod Menon. Inter-subject synchronization of brain responses during natural music listening. *European Journal of Neuroscience*, 37(9):1458–1469, may 2013.

KEY: Abrams2013

ANNOTATION: FMRI - ISS

Participants listened to 4 different baroque symphonies in the scanner - regular, and phase-scrambled versions.

We found that a highly distinctive and distributed set of brain regions was synchronized between subjects during Natural Music listening, including subcortical and cortical auditory structures as well as structures in frontal, parietal and insular cortices. More synchronization in natural music than in control conditions.

- [2] Amee Baird and Séverine Samson. Memory for music in Alzheimer’s disease: Unforgettable? *Neuropsychology Review*, 19(1):85–101, 2009.

KEY: Baird2009

ANNOTATION: REVIEW (with table describing studies)

A distinction can be made between implicit and explicit musical memory, but the practical assessment of musical memory does not currently reflect these distinct memory forms.

Lesion case studies suggest existence of a memory system specialized for music that involves the temporal lobe regions. Learning and recognition involves both left and right. Recognition mainly involves right. Imaging studies have shown involvement of the bilateral superior temporal gyrus, and frontal lobes. Predominantly left sided activation is associated with familiar music.

Non-musicians have increased activity in motor cortices (compared to pianists) when performing complex finger tasks. This may reflect the efficiency of a pianists’s motor cortex. However, pianists have more secondary motor cortex activity when listening to music. These areas are typically not affected by AD pathology. It is likely that the nature of musical memory representations and their neural correlates differ between these two groups.

There are 3 ways to assess explicit memory for familiar music: 1. familiarity judgements, 2. recall or completion task, 3. listening followed by yes/no

recognition task. Recognition (explicit) is impaired in AD patients. Neural correlates of **implicit** musical memory are relatively unknown. Two forms of implicit memory have been assessed in AD patients: mere exposure effect (MEE tests liking judgements), and procedural musical memory (PMM - preserved ability to play instruments). MEE - inconsistent results, may only be preserved in early stages of AD. PMM - even in severe AD the ability to play an instrument can be preserved.

**Hypothesis that dementia is less common among musicians than the regular population**

Music seems to have a facilitatory effect, but methodological rigour is lacking in studies that investigate this issue (music therapy studies). Enhanced autobiographical recall associated with music listening may be due to the emotional and/or arousal effects of the music. Considering differences between musicians and non-musicians will be important in researching this issue. It is also important to consider other dementias.

- [3] Amee Baird and Séverine Samson. Music evoked autobiographical memory after severe acquired brain injury: Preliminary findings from a case series. *Neuropsychological Rehabilitation*, 24(1):125–143, 2014.

KEY: Baird2014

- [4] Amee Baird and Séverine Samson. Music and Dementia. In *Progress in Brain Research*, volume 217, chapter 11, pages 207–235. Elsevier B.V., 2015.

KEY: Baird2015

- [5] Amee Baird, Séverine Samson, Laurie Miller, and Kerry Chalmers. Does music training facilitate the mnemonic effect of song? An exploration of musicians and nonmusicians with and without Alzheimer’s dementia. *Journal of Clinical and Experimental Neuropsychology*, 3395(June):1–13, jun 2016.

KEY: Baird2016

ANNOTATION: BEHAVIOURAL

Musicians with AD showed better learning of sung information than nonmusicians with AD. No differences in delayed recall and recognition accuracy in either modality. Nonmusicians - Total learning was worse for sung than spoken information - may be more cognitively demanding for this group.

- [6] James C Bartlett and Paul Snelus. Lifespan Memory for Popular Songs. *The American Journal of Psychology*, 93(3):551, sep 1980.

KEY: Bartlett1980

ANNOTATION: BEHAVIOURAL

Cued recall of lyrics was higher in response to melodies than in response to titles. Temporal placement of a song was more accurate when recognized than when not recognized. Accurate lifespan memory for popular songs exists

- temporal judgements are based on episodic memory for information at least partially independent of lyric representations.

- [7] Amy M. Belfi, Brett Karlan, and Daniel Tranel. Music evokes vivid autobiographical memories. *Memory*, pages 1–11, 2015.

KEY: Belfi2015

ANNOTATION: BEHAVIOURAL

Are the memories evoked by music more vivid than the memories evoked by other stimuli?

Highly familiar, popular songs were played from the time the participant was between 15-30 years old. Familiar faces were chosen based on the same age range. Participants were presented with 30 songs and 30 faces and then verbally described the memory that was evoked (if there was an autobiographical association). The description were coded and details were divided into internal (events, places, times, perceptions, emotions/thoughts) or external (semantic statemnts, repetitions, external events, other details) details.

Memory vividness was operationalized as the number of perceptual details. It was also operationalized as a higher ratio of internal to total details.

There was more vividness in the music than the face condition - larger number of perceptual details in memories evoked by music and a higher ratio of internal to total details. There were a larger number of external details in the Face condition.

More vividness could be achieved because music elicits a stronger emotional response than face pictures.

An interesting question for future research will be to investigate the effects of age on autobiographical memories evoked by various cues.

- [8] J a Bugos, W M Perlstein, C S McCrae, T S Brophy, and P H Bedenbaugh. Individualized Piano Instruction enhances executive functioning and working memory in older adults. *Aging & Mental Health*, 11(4):464–471, 2007.

KEY: Bugos2007

ANNOTATION: BEHAVIOURAL

Music education naturally coordinates motor activity with short-term planning and long-term cognitive strategies. It is also related to intrinsic enjoyment and sense of self-esteem that stem from skilled musical performance. The goal of this study is to evaluate the role of musical instruction as a potential cognitive intervention to prevent or maintain cognitive skills in normal aging.

39 participants - healthy, older adults with less than 5 years of music experience were placed in individualized piano instruction (IPI) or control group. Cognitive testing was done pre-training, post-training (6 months), and after 3 month delay (during which no lessons or practice occurred).

Scores increased during training and during post-training interval - control group did not show such a pattern. IPI may increase cognitive abilities related to attention and concentration. Effects of IPI transfered to not musically

specific cognitive domains and were sustained. However, cognitive benefits in digit span went away when practice and lessons were discontinued.

- [9] Sandra L. Calvert and Maureen Tart. Song versus verbal forms for very-long-term, long-term, and short-term verbatim recall. *Journal of Applied Developmental Psychology*, 14(2):245–260, 1993.

KEY: Calvert1993

ANNOTATION: BEHAVIOURAL

In conclusion, songs present content in a musical form that can be memorable for years to come. Songs provide students with an encoding, a rehearsal, and a retrieval strategy that can assist their verbatim recall. People have a capacity to utilize songs as a mnemonic device that remains largely untapped, particularly by literate societies who rely on written words as their primary form of communication

Used school house rock song about the constitution

- [10] Alessandra Campanelli, Lidia Rendace, Francesco Parisi, Fabrizia D’Antonio, Letizia Imbriano, Carlo de Lena, and Alessandro Trebbastoni. Musical cognition in Alzheimer’s disease: application of the Montreal Battery of Evaluation of Amusia. *Annals of the New York Academy of Sciences*, 1375(1):28–37, jul 2016.

KEY: Campanelli2016

ANNOTATION: BEHAVIOURAL

The main aim of the study was to assess melodic and temporal perception of music and musical memory in subjects with mild-to-moderate AD, compared with age-matched healthy controls. Hypothesized that there would be more musical memory and perceptual deficits in patients.

music abilities were assessed using the complete version of the Montreal Battery of Evaluation of Amusia (MBEA). 3 tasks - are patients able to distinguish pitch changes in melodies. 3 tasks - ability to discriminate rhythmic changes, meter, and memory. Memory is tested using an incidental memory task (Episodic memory - The subjects are asked to distinguish 15 melodies heard during the previous tasks from other completely novel melodies by stating whether they have or have not heard them before)

Patients scored significantly lower in all MBEA tasks than controls. 76.6melodic discrimination. 52.4processing task. The melodic and the temporal systems for processing music are affected differently in AD. Melodic information impairment is much more severe then temporal information impairment. May have to do with the structures involved in these systems and the order in which atrophy occurs in AD.

Musical memory does not appear to have been affected by musical perception defects. Musical perception deficits could be unrelated to memory deficits.

- [11] Lola L. Cuddy and Jacalyn Duffin. Music, memory, and Alzheimer’s disease: Is music recognition spared in dementia, and how can it be assessed? *Medical Hypotheses*, 64(2):229–235, 2005.

KEY: Cuddy2005

ANNOTATION: CASE STUDY

EN suffers from severe dementia but was though to have normal memory for music. Music was a big part of her life from childhood - deeply devoted amateur. Doesn't currently play music, but enjoys listening to it. Doesn't currently play music but will sing spontaneously. Given a few simple notes of a song she can recall the words. Sometimes of many verses.

Familiarity task - EN responded to familiar melodies by singing along. Distorted tunes test - EN sang along to the tunes and would respond to distortions with facial expressions, or exclamations. Famous melodies test - some difficulties, but within the normal range.

Musical memory can be detected and assessed through behavioural observation in patients with dementia. **how does music sparing relate to the sparing of other cognitive skills?** Case studies may detect patterns of loss and sparing.

- [12] Lola L. Cuddy, Jacalyn M. Duffin, Sundeep S. Gill, Cassandra L. Brown, Ritu Sikka, and Ashley D. Vanstone. Memory for Melodies and Lyrics in Alzheimer's Disease. *Music Perception: An Interdisciplinary Journal*, 29(5):479–491, jun 2012.

KEY: Cuddy2012

ANNOTATION: BEHAVIOURAL

The musical lexicon contains a perceptual representation system for isolated tunes, much in the same way as the mental word lexicon represents isolated words. It also contains the rules of musical syntax. The music-recognition model proposed by Peretz and Coltheart (2003) provides a functional architecture for the study of musical semantic memory. In the case of brain damage the flow of information to the musical lexicon may be selectively impaired or spared. The model also queries the relationship between memory for music and for lyrics - proposes close associative links. Thus, if memory for spoken lyrics is impaired, there still may be sufficient activation in the phonological lexicon to co-activate the musical lexicon. Lyric recognition through association.

150 controls, 50 AD patients with varying levels of dementia - they completed: familiarity decision test, familiar lyrics test, distorted tunes test, distorted lyrics test, lyrics prompt test, proverbs completion test

No test was immune to the presence of dementia. 1. long-term familiarity for melody was present even at severe AD. 2. melodic distortions were detected at mild and moderate AD 3. The ability to sing a melody when prompted with lyrics was retained by some with severe AD. 4. long-term familiarity with lyrics was found even at severe AD 5. detection of grammatical distortions in the lyrics of familiar melodies and the ability to complete familiar proverbs were affected even at mild AD.

The musical lexicon as part of the music recognition system (musical semantic memory) may be spared in early to moderate AD and even in severe.

- [13] Mohamad El Haj, Luciano Fasotti, and Philippe Allain. The involuntary nature of music-evoked autobiographical memories in Alzheimer’s disease. *Consciousness and Cognition*, 21(1):238–246, 2012.

KEY: ElHaj2012

ANNOTATION: BEHAVIOURAL

Our paper aims to investigate the involuntary nature of the music-enhanced autobiographical recall in AD patients. Therefore, AD patients and older adults were asked to generate autobiographical memories in two conditions: in silence and after music exposure. In general, we predicted that memories evoked after music exposure would have a more involuntary nature than memories evoked in silence. More specifically, and in line with previous research investigating the nature of involuntary memories, we hypothesized that music-evoked autobiographical memories would: (1) be more specific, (2) be accompanied with more emotional content and impact on mood, (3) be retrieved faster, and (4) engage fewer executive processes than memories evoked in silence.

In the music condition, participants listened to music chosen by themselves. music-evoked autobiographical memories were found to be more specific, to be accompanied by more emotional content, and impact mood. ”Our study supports the notion that music- evoked autobiographical memories contain all the features of involuntary memories.”

- [14] Baptiste Fauvel, Mathilde Groussard, Francis Eustache, Béatrice Desgranges, and Hervé Platel. Neural implementation of musical expertise and cognitive transfers: could they be promising in the framework of normal cognitive aging? *Frontiers in human neuroscience*, 7(October):693, 2013.

KEY: Fauvel2013

ANNOTATION: REVIEW

Musical practice induces functional and anatomical changes in the brain. Previous studies have shown positive correlation with IQ levels/executive functioning and music lessons in children. Music practice may build up ”reserves” that counteract cerebral atrophy. There is good reason to speculate that musical practice could have a positive influence on cognition during aging.

- [15] Damien Gabriel, Thian Chiew Wong, Magali Nicolier, Julie Giustiniani, Coralie Mignot, Nicolas Noiret, Julie Monnin, Eloi Magnin, Lionel Pazart, Thierry Moulin, Emmanuel Haffen, and Pierre Vandell. Don’t forget the lyrics! Spatiotemporal dynamics of neural mechanisms spontaneously evoked by gaps of silence in familiar and newly learned songs. *Neurobiology of Learning and Memory*, 132:18–28, 2016.

KEY: Gabriel2016

ANNOTATION: EEG

Investigated spontaneous mental imagery (time-locked to silence). Goal: to

determine when, where, and how familiarity processes occur to trigger musical imagery.

At time 1 participants listened to familiar and unknown songs, they then listened to the unknown songs for two weeks. At time 2 participants listened to same familiar songs and newly learned songs. EEG was recorded at both times during listening. Gaps of silence were randomly placed into the songs. After listening participants rated their ability to mentally complete the gaps. Time periods of stable electric configuration were first determined by segmenting together grand-mean EEG signals under the four conditions. By testing the global field power from all electrodes, the segmentation revealed TW of interest where map topography remained stable for a certain period of time and then abruptly switches to a new configuration in which it remains stable again. 9 ROIs were chosen.

Behavioural: They remained less capable of completing the gaps in learned songs than in familiar songs after a two-week learning phase. EEG: 6 stable TWs. ERP: N100 smaller for unknown than for familiar/newly learned (smaller MMN). Source localization: frontal and temporal regions, and SMA. Spectral analysis: A significant phase difference between familiar and unfamiliar songs, predominantly between 5 and 10 Hz, corresponding to both higher theta (5–7 Hz) and lower alpha (8–10 Hz) band, was observed in the central region.

- [16] J.D.W. Greene, Alan D. Baddeley, and J.R. Hodges. Analysis of the episodic memory deficit in early Alzheimer’s disease: Evidence from the doors and people test. *Neuropsychologia*, 34(6):537–551, 1996.

KEY: Greene1996

ANNOTATION: BEHAVIOURAL

Episodic memory deficit in Alzheimer’s is general in nature and primarily reflects impaired learning rather than accelerated forgetting or disrupted retrieval. Tested using delayed prose recall, word learning test, and the doors and people test of visual and verbal recall and recognition

- [17] M. Groussard, G. Rauchs, B. Landeau, F. Viader, B. Desgranges, F. Eustache, and H. Platel. The neural substrates of musical memory revealed by fMRI and two semantic tasks. *NeuroImage*, 53(4):1301–1309, 2010.

KEY: Groussard2010

ANNOTATION: FMRI

To determine the brain regions mainly involved in semantic retrieval. Used a congruence and a familiarity task. Congruence task: verbal and musical content - does the second half match the first half of the melody/proverb. These were contrasted with a perceptual reference condition (are the note sequences/syllable sequences the same)

Familiarity task: rate the level of familiarity of 60 melodies and 60 expressions. Songs with lyrics were not included as well as songs that might elicit

strong autobiographical memories. Tasks were completed in a 3T scanner. Musical semantic contrast bilaterally activated the STG, superior and middle TG, inferior frontal gyrus, SMA. Verbal semantic contrast revealed only left-sided activation in angular gyrus, middle and inferior temporal gyri. Familiarity - bilateral activation to music, left activation to verbal. Results confirm a distinction between networks responsible for musical and verbal semantic memory. music recognition process can be broken down into two stages: access and selection. We suggest that the left superior temporal gyrus subserves the access stage and the inferior frontal area the selection one. Overall, our present data suggest that the temporal cortex is organized along an inferior/superior axis depending of the nature of the material being retrieved. The musical material mainly activated the superior temporal cortex, whereas the middle and inferior temporal cortex was activated by the verbal material. . This inferior/superior organization within the left temporal cortex could help in understanding the clinical dissociations that are observed (Piccirilli et al., 2000) and the disproportionate preservation of musical knowledge in semantic dementia contrasting with severely impaired verbal skills (Hailstone et al., 2009).

- [18] Mathilde Groussard, Caroline Mauger, and Hervé Platel. La mémoire musicale à long terme au cours de l'évolution de la maladie d'Alzheimer. *Geriatric et Psychologie Neuropsychiatrie du Vieillissement*, 11(1):99–109, 2013.

KEY: Groussard2013

- [19] Andrea R. Halpern. Dementia and Music: Challenges and Future Directions. *Music Perception: An Interdisciplinary Journal*, 29(5):543–545, jun 2012.

KEY: Halpern2012

- [20] Brenda Hanna-Pladdy and Alicia MacKay. The relation between instrumental musical activity and cognitive aging. *Neuropsychology*, 25(3):378–386, 2011.

KEY: Hanna-Pladdy2011

ANNOTATION: BEHAVIOURAL

Objective—Intensive repetitive musical practice can lead to bilateral cortical reorganization. However, whether musical sensorimotor and cognitive abilities transfer to nonmusical cognitive abilities that are maintained throughout the life span is unclear. In an attempt to identify modifiable lifestyle factors that may potentially enhance successful aging, we evaluated the association between musical instrumental participation and cognitive aging.

Method—Seventy older healthy adults (ages 60–83) varying in musical activity completed a comprehensive neuropsychological battery. The groups (non-musicians, low and high activity musicians) were matched on age, education, history of physical exercise, while musicians were matched on age of instrumental acquisition and formal years of musical training. Musicians were classified in the low (1–9 years) or high ( $\geq 10$  years) activity group based on years



of musical experience throughout their life span.

Results—The results of this preliminary study revealed that participants with at least 10 years of musical experience (high activity musicians) had better performance in nonverbal memory ( $2 = .106$ ), naming ( $2 = .103$ ), and executive processes ( $2 = .131$ ) in advanced age relative to nonmusicians. Several regression analyses evaluated how years of musical activity, age of acquisition, type of musical training, and other variables predicted cognitive performance. Conclusions—These correlational results suggest a strong predictive effect of high musical activity throughout the life span on preserved cognitive functioning in advanced age. Cognitive functioning in advanced age is linearly related to the number of years of musical participation.

- [21] J.R. Hodges and K Patterson. Is semantic memory consistently impaired early in the course of Alzheimer's disease? Neuroanatomical and diagnostic implications. *Neuropsychologia*, 33(4):441–459, apr 1995.

KEY: Hodges1995

ANNOTATION: BEHAVIOURAL

All patients showed profound deficit in episodic memory, while minimal, mild, and moderate AD resulted in heterogenous deficits in semantic memory.

These data are in keeping with recent neuropathological studies demonstrating that the transentorhinal region is consistently involved at a very early stage. Lesions in this site cause a functional disconnection of the hippocampus, and hence a profound episodic memory disorder. The fact that many, but not all, patients with early disease also show impairment of semantic memory suggests that damage to the transentorhinal region is not sufficient to produce significant disruption of semantic memory. Such disruption reliably occurs, we hypothesize, only when the pathology extends to the temporal neocortex proper,

- [22] Michael J. Hogan, Gregory R.J. Swanwick, Jochen Kaiser, Michael Rowan, and Brian Lawlor. Memory-related EEG power and coherence reductions in mild Alzheimer's disease. *International Journal of Psychophysiology*, 49(2):147–163, aug 2003.

KEY: Hogan2003

ANNOTATION: EEG

In AD, the earliest spectral changes at rest are an increase in theta activity, accompanied by a decrease in beta activity, which are followed by a decrease in alpha activity. Delta frequency increases later during the course of the disease. Studies have shown that EEG interhemispheric coherence at rest decreases with age, and patients with AD have further reductions in alpha and delta band coherence (at rest). Objective: To examine memory-related EEG power and coherence over temporal and central recording sites in patients with early Alzheimer's disease (AD) and normal controls.

Participants: 10 patients with mild AD with a matched control group Method: EEG was recorded from central (Fz, Cz and Pz) and temporal (T3 and T4)

electrodes while ten very mild AD patients and ten controls performed a Sternberg-type memory scanning task with three levels of working memory load. Spectral power in delta (0–3 Hz), theta (3–5 Hz), lower alpha1 (5–7 Hz), lower alpha2 (7–9 Hz), upper alpha (9–11 Hz) and beta (15–30 Hz) was averaged for temporal and central electrodes. Coherence was averaged between central electrodes, between central and right temporal electrodes and between central and left temporal electrodes.

Results: While behavioral performance of very mild AD patients did not differ significantly from that of normal controls, findings suggest that normal controls but not AD patients respond to memory demands by increasing upper alpha power over temporal cortex. When compared with normal controls, AD patients had reduced upper alpha coherence between central and right temporal cortex.

Discussion: Results are consistent with previous research on the role of upper alpha in semantic memory and suggest that very mild AD may inhibit selective synchronization of upper alpha in temporal lobes.

- [23] Jörn-henrik Jacobsen, Thomas Fritz, Johannes Stelzer, and Robert Turner. Why musical memory can be preserved in advanced Alzheimer ' s disease. *Brain : a journal of neurology*, pages 1–13, 2015.

KEY: Jacobsen2015

ANNOTATION: IMAGING

Look up how Baird and Samson (2009) hypothesis can be supported experimentally.

Experimenters had healthy participants passively listen to familiar, unknown, and recently heard songs in 7T fMRI scanner. Also analyzed Alzheimer's disease progression using disease biomarkers: grey matter atrophy, hypometabolism, and amyloid-B deposition. Compared the ROI obtained from passive listening experiment to biomarker values. **Found musical memory ROI is relatively spared in AD.** Less Grey matter loss and hypometabolism in ROI. Not true of amyloid-B deposition.

Ventral pre-SMA and the caudal anterior cingulate gyrus are crucial for encoding of long-term musical memory. They are not sensitive to autobiographical relevance of the pieces heard. These findings suggest that while the temporal lobes may be involved in explicit musical memory, their role in long-term musical memory processing may not be essential to maintain long-term representations of music - i.e., needed for encoding, not retrieval.

Supports suggestion by Baird and Samson (2009) that mostly implicit musical memory is spared in musical memory. These results show a possible explanation for preservation after severe bilateral temporal lobe damage (like in AD) - long-term musical memory representations rely heavily on ventral pre-SMA and caudal anterior cingulate gyrus. May also give an explanation for the split between implicit and explicit memory (SMA vs temporal lobes)

- [24] Petr Janata. The neural architecture of music-evoked autobiographical memories. *Cerebral Cortex*, 19(11):2579–2594, 2009.

KEY: Janata2009

ANNOTATION: The medial prefrontal cortex (MPFC) is regarded as a region of the brain that supports self-referential processes, including the integration of sensory information with self-knowledge and the retrieval of autobiographical information. I used functional magnetic resonance imaging and a novel procedure for eliciting autobiographical memories with excerpts of popular music dating to one’s extended childhood to test the hypothesis that music and autobiographical memories are integrated in the MPFC. Dorsal regions of the MPFC (Brodmann area 8/9) were shown to respond parametrically to the degree of autobiographical salience experienced over the course of individual 30 s excerpts. Moreover, the dorsal MPFC also responded on a second, faster timescale corresponding to the signature movements of the musical excerpts through tonal space. These results suggest that the dorsal MPFC associates music and memories when we experience emotionally salient episodic memories that are triggered by familiar songs from our personal past. MPFC acted in concert with lateral prefrontal and posterior cortices both in terms of tonality tracking and overall responsiveness to familiar and autobiographically salient songs. These findings extend the results of previous autobiographical memory research by demonstrating the spontaneous activation of an autobiographical memory network in a naturalistic task with low retrieval demands.

- [25] Stefan Koelsch. Brain correlates of music-evoked emotions. *Nature Reviews Neuroscience*, 15(3):170–180, 2014.

KEY: Koelsch2014

ANNOTATION: REVIEW

From a Meta-analysis: Clusters of changes in activity in various regions in response to music: nuclei in the amygdala, the hippocampal formation, right ventral striatum (including nucleus accumbens) extending into the ventral pallidum, the head of the left caudate nucleus, the auditory cortex, the pre-supplementary motor area (SMA), the cingulate cortex and the orbitofrontal cortex. Thus, music can evoke activity changes in the core brain regions that underlie emotion.

The amygdala has high network centrality within emotion networks: it has high structural centrality, and is connected with several other computational hubs. The nucleus accumbens shows activity during intense feelings of music-evoked pleasure and reward (musical frissons). Dopamine availability has been shown to increase in the dorsal striatum during the anticipation of a musical frisson and in the ventral striatum during the experience of the frisson. Hippocampus is involved with music-evoked tenderness, peacefulness, joy, frissons, or sadness.

Musical expectancy and emotional contagion - emotional effects that are due to the music itself (not due to associated memories).

The fact that music elicits activity changes in limbic and paralimbic brain structures opens up the possibility of numerous applications for music-based therapy.

- [26] Stefan Koelsch. Music-evoked emotions: principles, brain correlates, and implications for therapy. *Annals of the New York Academy of Sciences*, 1337(1):193–201, 2015.

KEY: Koelsch2015

ANNOTATION: This paper describes principles underlying the evocation of emotion with music: evaluation, resonance, memory, expectancy/tension, imagination, understanding, and social functions. Each of these principles includes several subprinciples, and the framework on music-evoked emotions emerging from these principles and subprinciples is supposed to provide a startingpoint for a systematic, coherent, and comprehensive theory on music-evoked emotions that considers both reception and production of music, as well as the relevance of emotion-evoking principles for music therapy.

- [27] Aline Moussard, Emmanuel Bigand, Sylvie Belleville, and Isabelle Peretz. Music as an Aid to Learn New Verbal Information in Alzheimer’s Disease. *Music Perception: An Interdisciplinary Journal*, 29(5):521–531, jun 2012.

KEY: Moussard2012

ANNOTATION: BEHAVIOURAL - CASE STUDY

Are new lyrics better learned and memorized when presented in a spoken or sung form? In normal young adults, mixed results have been reported, with studies showing a positive, a negative, or a null effect of singing on verbal recall. This may be because of differences in familiarity or learning sessions (successive vs long-term retention). These two factors are considered here in a hlcase study of a participant who suffers from mild Alzheimer’s disease. As expected, initial learning of new lyrics showed better performance for the spoken condition over the sung version unless the lyrics are learned on a familiar melody. After repeated learning episodes, learning sung lyrics – even on an unfamiliar melody – led to better retention of words. Thus, music may provide a more robust aid for consolidation in memory than spoken lyrics alone.

- [28] Aline Moussard, Emmanuel Bigand, Sylvie Belleville, and Isabelle Peretz. Learning sung lyrics aids retention in normal ageing and Alzheimer’s disease. *Neuropsychological rehabilitation*, 0(June):1–24, 2014.

KEY: Moussard2014

ANNOTATION: BEHAVIOURAL

Previous studies have suggested that presenting to-be-memorised lyrics in a singing mode, instead of a speaking mode, may facilitate learning and retention in normal adults. Seven healthy older adults and eight participants with mild Alzheimer’s disease (AD) learned and memorised lyrics that were either sung or spoken. We measured the percentage of words recalled from these

lyrics immediately and after 10 minutes. Moreover, in AD participants, we tested the effect of multiple learning sessions for one spoken and one sung excerpt, as well as long-term retention after a four week delay. Sung conditions did not influence lyrics recall in immediate recall but increased delayed recall for both groups. In AD, learning slopes for sung and spoken lyrics did not show a significant difference across successive learning episodes. However, sung lyrics showed a slight advantage over spoken ones after a four week delay. These results suggest that singing may increase the load of initial learning but improve long-term retention of newly acquired verbal information.

- [29] Lorina Naci, Rhodri Cusack, Mimma Anello, and Adrian M Owen. A common neural code for similar conscious experiences in different individuals. *Proceedings of the National Academy of Sciences of the United States of America*, 111(39):14277–82, 2014.

KEY: Naci2014

ANNOTATION: FMRI - ISS

brain-wide synchronization during movie watching

- [30] Rohani Omar, Julia C. Hailstone, and Jason D. Warren. Semantic Memory for Music in Dementia. *Music Perception: An Interdisciplinary Journal*, 29(5):467–477, jun 2012.

KEY: Omar2012

ANNOTATION: REVIEW

Outline a scheme for the brain organization of musical semantic memory based on emerging evidence in dementia diseases and suggest a program of future work. Knowledge of melodies is rather variable among patients with semantic dementia, in contrast to the more or less uniform impairment of other modalities of knowledge exhibited by this disease group.

Available evidence in the dementias suggests that distributed, bi-hemispheric cerebral networks are likely to support particular dimensions of musical semantic memory, and within these networks, subregions of peri-Sylvian, anterior temporal and inferior frontal cortex are likely to play critical roles

List suggestions for future work.

- [31] Juliette Palisson, Caroline Roussel-Baclet, Didier Maillet, Catherine Belin, Joël Ankri, and Pauline Narme. Music enhances verbal episodic memory in Alzheimer’s disease. *Journal of Clinical and Experimental Neuropsychology*, 37(5):503–517, 2015.

KEY: Palisson2015

ANNOTATION: BEHAVIOURAL

Interested in examining the effect of music on memory of words by contrasting performance on words learned with a melody to words learned in the context of a movie (visual) clip (texts were spoken and associated with a silent movie sequence). Tested healthy controls and patients with mild AD. Based on previous literature - there is likely to be a detrimental effect in the encoding phase (short term), but a positive effect of music on verbal learning during retrieval (long-term - in this study 5min).

METHODS: 12 patients and 12 healthy controls. Using a pilot test they chose Ode to Joy as the familiar melody and Modern Time by Charlie Chaplin as the familiar movie. Three texts were written and recorded - one spoken only, one spoken with movie, one sung with ode to joy. Participants read along with the recordings - asked to memorize to recall the text later. Line-by-line memorization method allowed for scoring of how easily participants memorized texts under three conditions. After 5 minutes participants were asked to free recall texts - score = percentage of words accurately recalled.

RESULTS: healthy controls encoded more lines than patients with better encoding occurring in musical association than other 2 conditions. Movie association was better than words alone. In immediate recall: All participants recalled a higher percentage of words in the musical association condition than the other 2 conditions. In delayed recall: healthy controls recalled higher percentage of words than patients - main effect due to higher recall in musical condition than other 2 conditions. Looking at individual patients: generally learned more lines and recalled more words in the musical than in the other 2 conditions. Significant correlation between patient's working memory and delayed free recall with music.

DISCUSSION: main results showed that a musical association during the encoding stage facilitates learning and retention in AD. This advantage is enhanced by music. The benefit of music is robust and was observed in more than 90% of the AD sample on all three measures (number of lines learned, immediate and delayed recall). In contrast to other studies they found that music helps in the encoding phase (short-term) as well as the retrieval phase (long-term). Music may play a facilitating role by providing a richer context for encoding.

Future studies are needed to better understand how patients' working memory performance may be linked to musical mnemonics strategies. It could be particularly interesting to assess short-term feature binding abilities and how they may be related to the benefit of music on verbal learning.

There is hippocampal atrophy in AD and hippocampal sclerosis has been shown to weaken lyric/melody integration. This could explain why AD patients don't benefit from music as much as controls. Could investigate the role of the hippocampus in lyric/melody integration. Investigate lyric/melody integration in AD.

- [32] Isabelle Peretz and Robert J Zatorre. Brain organization for music processing. *Annual review of psychology*, 56:89–114, 2005.

KEY: Peretz2005

ANNOTATION: REVIEW

- [33] Yoko Saito, Kenji Ishii, Naoko Sakuma, Keiichi Kawasaki, Keiichi Oda, and Hidehiro Mizusawa. Neural Substrates for Semantic Memory of Familiar Songs: Is There an Interface between Lyrics and Melodies? *PLoS ONE*, 7(9), 2012.

KEY: Saito2012

ANNOTATION: PET

Investigation of the neural substrates of song recognition via direct comparison between three types of sound stimuli: lyrics, melody, and song. Based on previous research they expected to see distinct neural pathways involved in lyrics and melody processing in the stage of lexical lookup of songs. The lexical lookup of songs takes place after the perceptual and phonological processing.

METHODS: 24 familiar and 24 unfamiliar songs. 3 conditions - original lyrics+original melody, original lyrics and rhythm+single tone, sung 'la' to original melody. During PET scanning, participants listened to stimuli and determined if the stimulus came from a familiar or unfamiliar song.

RESULTS: reaction time for responding was significantly faster in the full song condition than in lyrics or melody only. Some activated regions in the Song contrast were common to those found in the lyrics and melody contrast. This may represent verbal lexical processing and melodic lexical processing in song recognition, respectively. Demonstrates essentially separate neural networks controlling verbal processing and melodic processing during lexical lookup of songs. The left PITC appears to play a crucial role in lexical lookup of songs as an interface area between lyrics and melody to facilitate the recognition of familiar songs.

- [34] T. Sarkamo, Mari Tervaniemi, Sari Laitinen, Ava Numminen, Merja Kurki, Julene K. Johnson, and Pekka Rantanen. Cognitive, Emotional, and Social Benefits of Regular Musical Activities in Early Dementia: Randomized Controlled Study. *The Gerontologist*, 54(4):634–650, aug 2014.

KEY: Sarkamo2014

ANNOTATION: BEHAVIOURAL

Purpose of the Study: During aging, musical activities can help maintain physical and mental health and cognitive abilities, but their rehabilitative use has not been systematically explored in persons with dementia (PWDs). Our aim was to determine the efficacy of a novel music intervention based on coaching the caregivers of PWDs to use either singing or music listening regularly as a part of everyday care.

Design and Methods: Eighty-nine PWD– caregiver dyads were randomized to a 10-week singing coaching group ( $n = 30$ ), a 10-week music listening coaching group ( $n = 29$ ), or a usual care control group ( $n = 30$ ). The coaching sessions consisted primarily of singing/listening familiar songs coupled occasionally with vocal exercises and rhythmic movements (singing group) and reminiscence and discussions (music listening group). In addition, the intervention included regular musical exercises at home. All PWDs underwent an extensive neuropsychological assessment, which included cognitive tests, as well as mood and quality of life (QOL) scales, before and after the intervention period and 6 months later. In addition, the psychological well-being of

family members was repeatedly assessed with questionnaires.

Results: Compared with usual care, both singing and music listening improved mood, orientation, and remote episodic memory and to a lesser extent, also attention and executive function and general cognition. Singing also enhanced short-term and working memory and caregiver well-being, whereas music listening had a positive effect on QOL.

Implications: Regular musical leisure activities can have long-term cognitive, emotional, and social benefits in mild/moderate dementia and could therefore be utilized in dementia care and rehabilitation

- [35] Masayuki Satoh, K. Takeda, K. Nagata, E. Shimosegawa, and S. Kuzuhara. Positron-emission tomography of brain regions activated by recognition of familiar music. *American Journal of Neuroradiology*, 27(5):1101–1106, 2006.

KEY: Satoh2006

- [36] Masayuki Satoh, Toru Yuba, Ken-ichi Tabei, Yukari Okubo, Hirotaka Kida, Hajime Sakuma, and Hidekazu Tomimoto. Music Therapy Using Singing Training Improves Psychomotor Speed in Patients with Alzheimer’s Disease: A Neuropsychological and fMRI Study. *Dementia and Geriatric Cognitive Disorders Extra*, 8507:296–308, 2015.

KEY: Satoh2015

ANNOTATION: BEHAVIOURAL and fMRI

Investigated the effect of singing training on the cognitive function in Alzheimer’s disease (AD) patients.

Methods: Ten AD patients participated in music therapy using singing training once a week for 6 months (music therapy group). Each session was performed with professional musicians using karaoke and a unique voice training method (the YUBA Method). Before and after the intervention period, each patient was assessed by neuropsychological batteries, and functional magnetic resonance imaging (fMRI) was performed while the patients sang familiar songs with a karaoke device. As the control group, another 10 AD patients were recruited and neuropsychological assessments were performed twice with an interval of 6 months.

Results: In the music therapy group, the time for completion of the Japanese Raven’s Colored Progressive Matrices was significantly reduced ( $p = 0.026$ ), and the results obtained from interviewing the patients’ caregivers revealed a significant decrease in the Neuropsychiatric Inventory score ( $p = 0.042$ ) and a prolongation of the patients’ sleep time ( $p = 0.039$ ). The fMRI study revealed increased activity in the right angular gyrus and the left lingual gyrus in the before-minus-after subtraction analysis of the music therapy intervention.

Conclusion: Music therapy intervention using singing training may be useful for dementia patients by improving the neural efficacy of cognitive processing.

- [37] Nora K. Schaal, Amir-Homayoun Javadi, Andrea R. Halpern, Bettina Pollok, and Michael J. Banissy. Right parietal cortex mediates recognition memory for melodies. *European Journal of Neuroscience*, 42(February), 2015.



KEY: Schaal2015

ANNOTATION: TDCS

Functional brain imaging studies have highlighted the significance of right-lateralized temporal, frontal and parietal brain areas for memory for melodies. The present study investigated the involvement of bilateral posterior parietal cortices (PPCs) for the recognition memory of melodies using transcranial direct current stimulation (tDCS).

Participants performed a recognition task before and after tDCS. The task included an encoding phase (12 melodies), a retention period, as well as a recognition phase (24 melodies). Experiment 1 revealed that anodal tDCS over the right PPC led to a deterioration of overall memory performance compared with sham. Experiment 2 confirmed the results of Experiment 1 and further showed that anodal tDCS over the left PPC did not show a modulatory effect on memory task performance, indicating a right lateralization for musical memory. Furthermore, both experiments revealed that the decline in memory for melodies can be traced back to an interference of anodal stimulation on the recollection process (remember judgements) rather than to familiarity judgements.

Taken together, this study revealed a causal involvement of the right PPC for memory for melodies and demonstrated a key role for this brain region in the recollection process of the memory task.

- [38] Katrin Schulze and Stefan Koelsch. Working memory for speech and music. *Annals of the New York Academy of Sciences*, 1252(1):229–236, 2012.

KEY: Schulze2012

- [39] Sofia Seinfeld, Heidi Figueroa, Jordi Ortiz-Gil, and Maria V. Sanchez-Vives. Effects of music learning and piano practice on cognitive function, mood and quality of life in older adults. *Frontiers in Psychology*, 4(NOV):1–13, 2013.

KEY: Seinfeld2013

ANNOTATION: BEHAVIOURAL - training

Reading music and playing a musical instrument is a complex activity that comprises motor and multisensory (auditory, visual, and somatosensory) integration in a unique way. Music has also a well-known impact on the emotional state, while it can be a motivating activity. For those reasons, musical training has become a useful framework to study brain plasticity. Our aim was to study the specific effects of musical training vs. the effects of other leisure activities in elderly people. With that purpose we evaluated the impact of piano training on cognitive function, mood and quality of life (QOL) in older adults. A group of participants that received piano lessons and did daily training for 4-month ( $n = 13$ ) was compared to an age-matched control group ( $n = 16$ ) that participated in other types of leisure activities (physical exercise, computer lessons, painting lessons, among other). An exhaustive assessment that included neuropsychological tests as well as mood and QOL questionnaires was

carried out before starting the piano program and immediately after finishing (4 months later) in the two groups. We found a significant improvement on the piano training group on the Stroop test that measures executive function, inhibitory control and divided attention. Furthermore, a trend indicating an enhancement of visual scanning and motor ability was also found (Trial Making Test part A). Finally, in our study piano lessons decreased depression, induced positive mood states, and improved the psychological and physical QOL of the elderly. Our results suggest that playing piano and learning to read music can be a useful intervention in older adults to promote cognitive reserve (CR) and improve subjective well-being.

- [40] Nicholas R. Simmons-Stern, Andrew E. Budson, and Brandon A. Ally. Music as a memory enhancer in patients with Alzheimer’s disease. *Neuropsychologia*, 48(10):3164–3167, aug 2010.

KEY: Simmons-Stern2010

ANNOTATION: BEHAVIOURAL

The present study sought to investigate the effect of music at encoding on the subsequent recognition of associated verbal information. Lyrics of unfamiliar children’s songs were presented bimodally at encoding, and visual stimuli were accompanied by either a sung or a spoken recording. Patients with AD demonstrated better recognition accuracy for the sung lyrics than the spoken lyrics, while healthy older adults showed no significant difference between the two conditions.

Main effect of group - healthy adults performed better overall, but AD patients performed better with music

Are musical brain areas spared in AD? does music heighten arousal in patients with AD, allowing better attention/improved memory?

- [41] Nicholas R. Simmons-Stern, Rebecca G. Deason, Brian J. Brandler, Bruno S. Frustace, Maureen K. O’Connor, Brandon A. Ally, and Andrew E. Budson. Music-based memory enhancement in Alzheimer’s Disease: Promise and limitations. *Neuropsychologia*, 50(14):3295–3303, dec 2012.

KEY: Simmons-Stern2012

ANNOTATION: BEHAVIOURAL

Patients with AD and healthy older adults studied visually presented novel song lyrics related to instrumental activities of daily living (IADL) that were accompanied by either a sung or a spoken recording. Overall, participants performed better on a memory test of general lyric content for lyrics that were studied sung as compared to spoken. However, on a memory test of specific lyric content, participants performed equally well for sung and spoken lyrics. We interpret these results in terms of a dual-process model of recognition memory such that the general content questions represent a familiarity-based representation that is preferentially sensitive to enhancement via music, while

the specific content questions represent a recollection-based representation unaided by musical encoding. Additionally, in a test of basic recognition memory for the audio stimuli, patients with AD demonstrated equal discrimination for sung and spoken stimuli.

- [42] D Tromp, F Bernard, a Dufour, S Lithfous, T Pebayle, and O Després. Episodic memory in normal aging and Alzheimer Disease: Insights from imaging and behavioral studies. *Ageing Research Reviews*, 2015.

KEY: Tromp2015

ANNOTATION: REVIEW

- [43] Wiebke Trost, Sascha Frühholz, Tom Cochrane, Yann Cojan, and Patrik Vuilleumier. Temporal dynamics of musical emotions examined through intersubject synchrony of brain activity. *Social Cognitive and Affective Neuroscience*, 10(12):1705–1721, dec 2015.

KEY: Trost2015

ANNOTATION: FMRI - ISS

investigated emotions induced by music using fMRI and Inter-subject correlations. Results revealed synchronous activations in left amygdala, left insular, and right caudate nucleus - associated with higher arousal. Positive valence ratings correlated with decreases in amygdala and caudate activity. Synchronous amygdala responses were driven by energy-related features in the music, while synchrony in insula were sensitive to acoustic event density.

- [44] Tomomi Ueda, Yoshimi Suzukamo, Mai Sato, and Shin-Ichi Izumi. Effects of music therapy on behavioral and psychological symptoms of dementia: A systematic review and meta-analysis. *Ageing Research Reviews*, 12(2):628–641, 2013.

KEY: Ueda2013

- [45] Ashley D Vanstone and Lola L Cuddy. Musical memory in Alzheimer disease. *Neuropsychology, development, and cognition. Section B, Aging, neuropsychology and cognition*, 17(1):108–128, 2010.

KEY: Vanstone2010

ANNOTATION: This study examines musical memory in 12 patients with moderate or severe AD and 12 healthy, older adult controls. Participants were asked to distinguish familiar from novel tunes, to identify distortions in melodies, and to sing familiar tunes. Comparison of the AD and control groups showed significant impairment of the AD participants. However, a more complex picture emerged as we compared each individual case to the control group. Five of the AD group performed within the control group range on most tasks. An additional four participants showed partial sparing in that they performed below the range of control participants, but their scores were above the level of chance. The final three participants showed near complete loss of musical memory, as their performance was consistently at or near the

level of chance. These results are discussed in terms of the literature on the heterogeneity of cognitive presentation in AD.

- [46] Ashley D. Vanstone, Ritu Sikka, Leila Tangness, Rosalind Sham, Angeles Garcia, and Lola L. Cuddy. Episodic and Semantic Memory for Melodies in Alzheimer’s Disease. *Music Perception: An Interdisciplinary Journal*, 29(5):501–507, jun 2012.

KEY: Vanstone2012

ANNOTATION: The present study addressed episodic and semantic memory for melodies in three groups of participants: 35 younger adults, 40 older adults, and 10 individuals with mild to moderate Alzheimer’s disease (AD). To assess episodic memory, a study list of eight novel target melodies was presented three times, followed by a test trial in which target melodies were mixed with foil (previously unheard) melodies. Both explicit and implicit measures were obtained. Explicit memory was assessed by the accuracy of discrimination of the target melodies from the foils. Younger adults were significantly more accurate than older adults, who in turn had significantly higher scores than AD adults. Implicit memory was assessed by examining the difference in pleasantness ratings between target and foil melodies. Younger adults showed significantly greater differences in pleasantness ratings than older adults and AD adults; scores for the two latter groups did not differ. To assess semantic memory, participants were asked to identify traditional melodies within a series of traditional and novel melodies. In contrast to the episodic memory results, all three groups showed very high scores on the semantic memory task with no significant differences among groups. The results support the notion that, though other forms of musical memory may be compromised, semantic memory for melody may be preserved in normal aging and in AD

- [47] Wanda T. Wallace. Memory for music: Effect of melody on recall of text. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20(6):1471–1485, 1994.

KEY: Wallace1994

ANNOTATION: BEHAVIOURAL

The melody of a song, in some situations, can facilitate learning and recall. The experiments in this article demonstrate that text is better recalled when it is heard as a song rather than as speech, provided the music repeats so that it is easily learned. When Ss heard 3 verses of a text sung with the same melody, they had better recall than when the same text was spoken. However, the opposite occurred when Ss heard a single verse of a text sung or when Ss heard different melodies for each verse of a song; in these instances, Ss had better recall when the text was spoken. Furthermore, the experiments indicate that the melody contributes more than just rhythmical information. Music is a rich structure that chunks words and phrases, identifies line lengths, identifies stress patterns, and adds emphasis as well as focuses listeners on surface characteristics. The musical structure can assist in learning, in retrieving, and if necessary, in reconstructing a text.

- [48] Lillian Yang. *fMRI Comparison of Response to Familiar and unfamiliar music in AD*. PhD thesis, University of British Columbia, 2015.

KEY: Yang2015