

**The effects of music on mood and cognition: supporting the national drive to marry up music and medicine**

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## **Introduction**

This essay explores how music affects mood and cognition, documenting the process of learning and how memories are formed and stored, specifically looking at regions of the brain involved in this process. Music has been found to have a profound impact on different groups of psychiatric patients, including those with Alzheimer's Disease (AD), where the benefits of music therapy are visibly apparent. By evaluating different components of psychiatric conditions, specifically AD, and how these can influence a person's mental state, we can address how music can improve and alleviate features associated with these conditions, supporting the current national drive for marrying up music and medicine.

## **Singing Memories**

When I was in my final year of school, I volunteered for a local community music group for people with AD. It invited individuals and their families who were affected by AD to come along for an hour, pick up a song sheet and reminisce through music, singing hits from the 40s through to the 70s; prominent pop music from their adolescence and young adulthood. I formed part of a three-person accompaniment, the other two being the professional community musician and a fellow student-volunteer. A single drum kept the rhythm with guitar and ukulele (played by the other student and I) reinforcing the melody. There was always an impressive turnout and bubbling enthusiasm from group members who enjoyed and embraced the range of music being offered.

The hour always began with a rendition of 'Singin' in the Rain' carried by an improvised drum rhythm and the contagiously cheerful, booming voice of the group leader which encouraged everybody else to join in. In some sessions, group participation was expected and anticipated with the use of various musical instruments – usually percussion - such as maracas and castanets which added new texture and movement to the group.

The most evocative part of the experience was witnessing the transformation in mental state that occurred in people. Before the group started many individuals were distracted and unengaged, in a 'world of their own' which is often how patients with AD are perceived. However, once music was played, they did not require a song sheet to prompt their memory, for the most part, everything appeared to come flowing back to them.

There are several different charities and initiatives that offer music as a form of respite from the challenges that dementia and other mental health conditions present. What is it about music that can cause such a dramatic improvement in mental state in these patients – affecting cognition and memory particularly in AD patients? Is there a neurochemical foundation that facilitates the emotional and physiological response music elicits?

### **An Arts and Health Collaboration**

Across the nation there has been a push to improve mental health beyond current services that are in place. This has arguably never been more important than now, with the COVID-19 pandemic having a pervasive and destructive impact on the mental wellbeing of the entire population. At the Queen Elizabeth University Hospital (QEUH), the 'Animating Public Spaces Programme' which is ran by National Health Service Greater Glasgow and Clyde (NHSGGC), is a way to promote physical and mental wellbeing through the use of arts. Since 2017, this has successfully implemented a series of musical concerts, art exhibitions and solo performances platformed across hospitals in the GGC area. The aim is to make hospitals a more positive and welcoming place and the use of various visual and auditory stimuli can contribute to this. (1) For example, in the QEUH the design of the building itself is colourful and engaging; inside, the walls are saturated with bright block colours and artwork is displayed in large open spaces. In day centres and residential care homes for those with dementia, often colourful pictures and patterns – some of a tactile nature – are painted along the walls as a method for engaging different senses of the individual. In fact, some dementia wards have their own sensory room for and occupied by residents. For dementia, the 'Playlist for Life' charity founded by the writer and broadcaster Sally Magnusson incorporates the benefit of music in alleviating distress often caused by and associated with the disease. The charity offers a number of voluntary roles which aim to augment awareness and support for its cause. The aim is to make a playlist - built on songs important to them and their past; songs they enjoy; ultimately songs of their own choosing - for every person suffering from dementia across the UK, and to provide an accessible format to these patients from which they can listen to their playlist at their own leisure. (2)

## **Alzheimer's Disease**

As with all types of dementia, AD features a progressive cognitive decline that can significantly impair day to day functioning. The hallmark pathological features are neurofibrillary tangles and amyloid plaques. MRI imaging shows sulci widening, ventricular enlargement and degeneration most severely in the medial temporal lobe (MTL) where the hippocampal cortex and entorhinal cortex reside. The MTL is important in long-term declarative memory. These structures form part of the brain's limbic system which plays a role in emotional memory. Interestingly, the hippocampus is not involved in procedural memory, which may explain why AD patients can play an instrument they learned as a child with ease or sing an old classic by their favourite artist, that was released decades ago. (3)

## **Neuroanatomy involved in processing memory and emotion**

When considering the function of memory and emotion and where it comes from, the neuroanatomy of various regions in the brain can be outlined first. Important in emotion and memory is the limbic system which can be defined as the limbic cortex and the subcortical nuclei associated with it, most important of which is the amygdala. The limbic cortex includes parts of the hippocampal cortex and parahippocampal gyrus, the cingulate complex and the insula. The anterior cingulate complex which forms part of the Papez circuit (originally proposed back in 1937 by James Papez to be the neural basis for emotional processing from sensory experiences and involving the pathways of 'thought' and 'feeling') contains the amygdala. The ACC can be split into six functional areas including an emotional area. During a study where participants were asked to think 'happy thoughts' and 'sad thoughts', activity in this area of the ACC increased and decreased respectively, inhibiting the amygdala, and the reverse. (3)

Breaking it down further, the hippocampal cortex itself consists of the subiculum, hippocampus proper and the dentate gyrus. The entorhinal complex forms the anterior of the parahippocampal gyrus and serves as an interface between neocortical structures and the hippocampal cortex, essentially exchanging sensory and cognitive content temporarily to the hippocampus to be consolidated and then back to the neocortex to be processed as memory traces. (3)

Auditory information also enters the hippocampus via the association cortex of the superior and middle temporal gyri, found in the neocortex. (3) It is therefore straight-forward to assume that some form of music memory must be stored in the hippocampus, seeing as music is perceived in the form of an auditory stimulus.

### **Process of learning**

In order to understand memory function, we need to look at how we learn. The pathway of learning and forgetting is useful from an evolutionary standpoint as it allows our bodies to conserve energy that would otherwise be wasted in 'trial and error' responses fired by neurons to environmental stimuli, in an attempt to function well psychosocially. (4)

Long term potentiation (LTP) is 'learning at the synaptic level'. It is an example of synaptic plasticity which is the ability for the neuron to change the strength of its signal. When the pre-synaptic neuron is repeatedly exposed to the same stimulus, neurotransmitter release increases and intensifies, and the post-synaptic neuronal receptors respond by lowering their activation thresholds and increasing in number and sensitivity. (5) This increase in strength can last from hours to years and ultimately allows us to more easily recall information from what we have previously experienced. (3)

At the molecular level, neurotransmitters, neuromodulators, and hormones all influence psychological processes that contribute to one's overall mental state. They underpin development of self and other, affirm personality traits and impact long-term health. (4) Thus, their stimulation whether it be from an endogenous or exogenous source must also have an impact on mental state.

Acetylcholine (Ach) is an important neurotransmitter involved in learning, and in AD, Ach activity is extensively depleted. It mediates the effects of neurotransmitters gamma-aminobutyric acid (GABA), serotonin and adrenaline which are supplied to the hippocampus via various nuclei and structures, all of which result in enhancing memory and comprehension. (4) Memory consolidation is considered to be the result of LTP in pyramidal and granule cells, which are the principal cells of the hippocampus and subiculum, and dentate gyrus respectively. With acetylcholine stimulation and subsequent stimulation of other networks, encoding and recall are greatly improved. In fact, this contributes towards

hippocampal-independent memory consolidation as the encoded content is transmitted back to the prefrontal cortex. (3)

### **Music and its effect on the brain**

Music engages almost all areas of the known brain. Subcortical structures such as the cochlear nuclei (which are located in the pons and form part of the auditory system) and the cerebellum process the music being listened to first, then the auditory cortices are engaged. Active listening engages the hippocampus and frontal lobe, in particular the inferior frontal cortex. Playing music incorporates frontal lobe executive functions such as planning; motor and sensory cortices are used in relation to physically feeling and playing the instrument (tactile senses would have been processed and incorporated via sensory pathways when using the percussive instruments during the music group I attended, the cerebellum would also provide input into musical rhythm when playing); the visual cortex is required for reading music. (6) Although there are many technical components to performing and perceiving music, it is formally considered a creative domain; therefore the amygdala and more reptilian regions of the brain are also utilised.

The medial prefrontal cortex (mPFC) offers insight into the role of music in emotional regulation. One study investigating the possibility of a sensitivity period in childhood for prefrontal cortex-dependent processes - in this case the higher order function, emotional regulation - found that music shapes responses which regulate how we react to acute stress in adulthood. It found that when exposed to stress, those participants who were exposed to the music they listened to during their childhood felt calmer as a result, which was also backed up by physiological evidence recording data regarding autonomic arousal. The mPFC is linked to areas of the limbic system, particularly in this case the amygdala and the supragenual anterior cingulate cortex (supraACC). These structures contribute to emotional regulation; an increase in supraACC activity corresponded with a decrease in negative affect after music exposure. It shows that -albeit entangled and complex- music engages neural circuits that ultimately have influence over our emotions, and therefore music can regulate and positively impact on our mood. The supraACC is also associated with the feeling of nostalgia. (7) This association along with its functions in emotional regulation and memory reinforces the links between emotion, memory and music, because music is often the stimulus for evoking feelings of nostalgia.

Music is also closely associated with the language centres in the brain. The neural circuits for processing music overlap in these regions, however some pathways remain independent. Various case studies of patients who lost one system while the other remained intact support these claims. For example, after suffering from herpes encephalitis which caused irreparable brain damage, Clive Wearing lost all memories except his musical memory and memories of his wife. Because of damage to regions such as the hippocampus, he cannot recall previous musical knowledge due to impairment of his declarative memory. (6) However, he retains procedural memory and can still play challenging pieces of music on the piano and organ; as well as being able to sight-read. (8)

We could also suggest that music has such a pervasive influence over cortical structures that the impairment of one brain region associated with music may not completely inhibit its effect upon elsewhere in the brain. For example, the composer Ravel who lost various aspects of his sense of pitch (through left cortical degeneration) yet retained his sense of timbre, shifted his musical focus towards exploring the qualities of timbre; thus wrote 'Bolero', arguably his most recognised and celebrated piece. (6)

Autobiographical memory appears to decline throughout the Alzheimer's disease process. (9) This can manifest as a loss of self-identity and difficulty in defining one's own life history. These processes underpin the importance of charities like Playlist for Life which allow the patient to reminisce musically-charged, rosy moments of their youth and secure them into a playlist that represents them and their personal life experience, which can be accessed with ease at any time. Furthermore, evidence suggests that autobiographical memory retrieval is more enhanced when patients have control over their own music choice, which supports the cause even more. (10)

Patients with AD retain some of their autobiographical memory when prompted by songs they listened to during youth and adulthood; songs which helped shape their experiences. Music-related memory is emotionally driven therefore it makes sense that AD patients can access these memories more easily as music provides another layer of attachment to whichever emotional life experience is being remembered, therefore the foundational neuronal connections will be stronger. (10)

One study found that people suffering from major depressive disorder preferred listening to sad music because they found it soothing and more relaxing in nature. Backing this up, was a study carried out in 2013 where adults were asked the fill in an online survey enquiring why they listen to sad music. Answers suggested that people had the desire to feel

connected whether it be to feelings they weren't ready to let go of or by using music as an empathic device: one lady justified her response by saying she felt 'befriended by the music...lyrics of understanding friendship, comfort and confidence...surely they would be your best friend.' Although the reasoning is different for each individual, responses have one significant similarity: they share a therapeutic outcome. (11) This again suggests that music can modulate mood and affect and ultimately lead to a more uplifting, positive outcome for the individual.

Another point to be considered is that humans naturally feel the need to belong. (12) Often psychiatric patients can be misunderstood and excluded as a result. Music group therapy can be a positive way to establish new connections with people going through similar experiences. These groups provide a safe space to perform and engage musical skills which has a positive effect in itself. There are several musical programmes within the community setting which also gives patients a chance to absorb a new environment and to get off the ward for a while. Physically playing an instrument increases psychomotor activity; something that is slow and diminished in patients with depression. Goal-directed behaviour improves as new levels of musical recognition and performance are achieved; attention and concentration can be heightened when engrossed in practising a new or complex piece of music and reward circuits in the brain involving dopamine can be activated when effort is recognised by the gain or improvement of a valuable skill. (12)

### **Theory of memory storage and retrieval**

Multiple trace memory model is a theory proposed and accepted by many memory researchers regarding how memory is stored and accessed. This model suggests that every experience is encoded in memory somewhere in the brain, not in particular regions, but in groups of neurons that can be accessed when the right stimulus presents itself to us. As we access a particular memory more often, the easier it becomes to retrieve it as the neural pathways we are essentially exercising, strengthen. When considering how this functions in music therapy for AD, songs act as the cues for unlocking memories from the past. Nevertheless, there are restrictions to this pathway: the more contexts that the cue is associated with, the less effective it becomes at memory retrieval. For instance, if the person has been exposed to a particular song throughout their entire adult lives then despite it being associated with their personal experiences, it will not be effective at recovering forgotten memories associated with it. (6)



## **Conclusion**

Music can be seen as an extension of self and is often used as a form of expression. People listen to music and find their own meaning within it. Preference is subjective, and selection of tracks depends on a number of things: mood; situation; previous musical experience... the list goes on. With a disease like AD, where patients are faced with such frightening prospects like losing their identity, their core and 'self', therapies through the likes of music are paramount in providing some form of respite. Patients can recover fragments of themselves attached to these songs and the fond memories associated with them and ultimately improve their mood which then influences their friends and family, carers, other patients and their relatives, creating a happy domino effect. We use music to portray ourselves, as a reflection of our moods and character and often as a haven when life becomes overwhelming. It is conflictingly personal and popular; can be both private and shared; and can be categorized while remaining abundantly eclectic. Music certainly is not a cure for mood and cognitive disorders however it can provide a gateway to better communication and connections with patients that suffer from these conditions. The use of music therapy in conjunction with pharmacological, psychological, and arts therapies should continue to provide sustainable positive outcomes, even if it is just a day to day improvement that is seen. Embedded in the fabric of human nature is an urge to belong. We all seek approval from peers, the end goal being able to view ourselves as valued members of society and integrate within the community – what better way to facilitate this within psychiatry, than by providing an art form which has intricately spread throughout communities and has brought people together for generations, in grief and celebration.

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