**Comprehensive Project Outline + Reading List**

**General Summary**

With this review paper I would like to summarize the body of work related to how music affects cognition. The main portion of this paper will deal with a summary of the behavioural work completed since the last review on the topic in 2005. This section of the paper will group related behavioural studies and attempt to find clear storylines within each grouping. When possible (like within the musician/non-musician comparison) alternative frameworks for understanding the research will be proposed.

The secondary section of this paper will summarize the results of EEG studies into this field of research. This summary will pull from EEG studies on cognition and EEG studies related to music processing for a clearer understanding of how music’s effect on cognition could be explained.

**Detailed Summary**

There have been numerous studies over the last 60 years that have explored the effect music has on human cognitive abilities. In 2005, this body of work was summarized in a review by Rickard, et al (2005). A scan of the literature shows that this field of research started by exploring the effect music has on skills important for classroom learning. This includes skills like reading rate and comprehension, short term memory, and spatial manipulation tasks. The first series of studies produced conflicting results with different types of music affecting different types of skills. Researchers then began investigating third variables that might influence the cognitive results. One such third variable is the personality characteristic of introversion/extroversion. As a result, a number of studies have shown that the cognitive performance of introverts and extroverts is affected differently by music. There does not seem to be a clear storyline within this body of work, and I have compiled a selection of papers that cover the pre-2005 period of study in this field. This list can be found at the end of this outline.

Since the 2005 review much has been done to explore the effects that music has on cognition, and I propose that it is time for another survey of the literature. Since the last review, there have been a number of new avenues of research that have been explored. I will touch on each of these research areas in the following sections.   
(\* indicates a paper in more than one category)

**Preference**

Starting in 1999, researchers began exploring whether preference for music is related to how cognition is affected by music. Nantais & Schellenberg (1999) began by shedding doubt on the Mozart effect with results that showed that this effect was an artifact of preference – if participants liked the music they were listening to, then they performed better on a spatial-temporal task then if they didn’t like the music they heard. Since then, studies have continued to explore the role of preference in the music-cognition relationship and uncovered results that show preference has different effects on different types of tasks (disliked music increases serial recall performance, but decreases performance on reading comprehension). The relationship between cognition and music preference is still not clear.

Perham, N., & Sykora, M. (2012). Disliked Music can be Better for Performance than Liked Music. *Applied Cognitive Psychology*, *26*(4), 550–555. <http://doi.org/10.1002/acp.2826>

\*Perham, N., & Vizard, J. (2011). Can preference for background music mediate the irrelevant sound effect? *Applied Cognitive Psychology*, *25*(4), 625–631. <http://doi.org/10.1002/acp.1731>

Perham, N., & Currie, H. (2014). Does listening to preferred music improve reading comprehension performance? *Applied Cognitive Psychology*, *28*(2), 279–284. <http://doi.org/10.1002/acp.2994>

**Speech effect**

One of the most easily manipulable aspects of music is the presence or absence of lyrics. Using this manipulation it is possible to investigate the effect that the presence of speech in music has on cognition. The effect of music with lyrics has been studied for some time, but the current direction investigates the effects within the framework of the irrelevant sound effect. Using this model allows researchers to differentiate between the effects on cognition produced by tonal and speech information separately.

Kantner, J. (2009). Studying with music: Is the irrelevant speech effect relevant? *Applied Memory*, (May), 19–40.

\*Williamson, V. J., Mitchell, T., Hitch, G. J., & Baddeley, A. D. (2010). Musicians’ memory for verbal and tonal materials under conditions of irrelevant sound. *Psychology of Music*, *38*(3), 331–350. <http://doi.org/10.1177/0305735609351918>

\*Perham, N., & Vizard, J. (2011). Can preference for background music mediate the irrelevant sound effect? *Applied Cognitive Psychology*, *25*(4), 625–631. http://doi.org/10.1002/acp.1731

**Specific age groups**

Since the beginning of this field of research, experiments have covered a number of different age ranges. After finding an effect in the university-aged population, researchers looked for music’s effect on cognition in children (e.g. Hallam et al, 2002). This research in children has continued, but now the field has extended into the older aged population. This type of research has clinical implications to help older adults maintain stable levels of cognitive processing during aging. This research is separate from the investigations into music and the effects of memory retrieval.

Schellenberg, E., & Hallam, S. (2005). Music listening and cognitive abilities in 10 and 11 year-olds: The Blur effect. *Neurosciences and Music Ii From Perception to Performance*, *1060*(The Neurosciences and Music II: From Perception to Performance), 202–209. <http://doi.org/10.1196/annals.1360.013>

Anderson, S. a., & Fuller, G. B. (2010). Effect of music on reading comprehension of junior high school students. *School Psychology Quarterly*, *25*(3), 178–187. <http://doi.org/10.1037/a0021213>

Schellenberg, E. G., Nakata, T., Hunter, P. G., & Tamoto, S. (2007). Exposure to music and cognitive performance: tests of children and adults. *Psychology of Music*, *35*(1), 5–19. <http://doi.org/10.1177/0305735607068885>

Kotsopoulou, A., & Hallam, S. (2010). The perceived impact of playing music while studying: age and cultural differences. *Educational Studies*, *36*(4), 431–440. <http://doi.org/10.1080/03055690903424774>

Mammarella, N., Fairfield, B., & Cornoldi, C. (2013). Does music enhance cognitive performance in healthy older adults? The Vivaldi effect. *Aging Clinical and Experimental Research*, *19*(5), 394–399. http://doi.org/10.1007/BF03324720

**Other Variables**

As mentioned before, early research explored the relationship between extroversion/introversion and the effects of music on cognition. Recently, other characteristics have been explored to elucidate whether individual differences in other personality traits have an effect. One such trait is the level of a participant’s neuroticism.

Reynolds, J., McClelland, A., & Furnham, A. (2014). An investigation of cognitive test performance across conditions of silence, background noise and music as a function of neuroticism. *Anxiety, Stress, and Coping*, *27*(4), 410–21. <http://doi.org/10.1080/10615806.2013.864388>

Chamorro-Premuzic T, Furnham A. Personality and music: can traits explain how people use music in everyday life? *Br J Psychol*. 2007;98(Pt 2):175-185. doi:10.1348/000712606X111177.

**Musicians vs Non-Musicians**

The comparison between how music affects the cognitive performance of musicians and non-musicians is also explored. Recently, studies have found that music affects cognition differently for trained musicians and for those without any training. In general, results show that music negatively affects the cognitive performance of musicians more than non-musicians. However the extent of this difference is not well understood.

It is possible that these results are not being viewed through a suitable framework and I propose that perhaps these results need to be viewed through the framework of the educational theory of cognitive load.

Aheadi, A., Dixon, P., & Glover, S. (2010). A limiting feature of the Mozart effect: Listening enhances mental rotation abilities in non-musicians but not musicians. *Psychology of Music*, *38*(1), 107–117. http://doi.org/10.1177/0305735609336057

\*Williamson, V. J., Mitchell, T., Hitch, G. J., & Baddeley, A. D. (2010). Musicians’ memory for verbal and tonal materials under conditions of irrelevant sound. *Psychology of Music*, *38*(3), 331–350. <http://doi.org/10.1177/0305735609351918>

Patston, L. L. M., & Tippett, L. J. (2011). The Effect of Background Music on Cognitive Performance in Musicians and Nonmusicians. *Music Perception: An Interdisciplinary Journal*, *29*(2), 173–183. http://doi.org/10.1525/mp.2011.29.2.173

Yang, J., McClelland, A., & Furnham, A. (2016). The effect of background music on the cognitive performance of musicians: A pilot study. *Psychology of Music*, *44*(5), 1202–1208. <http://doi.org/10.1177/0305735615592265>

**Cognitive Load Theory**

Cognitive load theory (CLT) is an educational theory that tries to predict learning outcomes based on the capabilities and limitations of the human cognitive system. For example, to solve any problem there is a certain amount of effort needed to find a solution. This effort is called cognitive load. CLT states that there are three parts to cognitive load: intrinsic load, extraneous load, and germane load. Intrinsic load is the smallest amount of effort required to solve the problem. Intrinsic load is specific to each problem and can not be changed. Extraneous load describes the effort required to deal with unnecessary cognitive demands. Extraneous load can be reduced by for example, modifying instructions to create a more clearly formulated question. The last aspect to cognitive load is germane load. Germane load is an additional load, but with a positive outcome. This is the part of cognitive resources that when increased helps to solve the problem. Germane load plays an interesting part of an effect described by CLT as the expertise-reversal effect.

The expertise-reversal effect is a phenomenon that occurs as novices become experts at a task. As someone begins to learn a new task there are often strategies and scaffolds that can be put into place to help them learn. As they become less of a novice the strategies and scaffolds become increasingly unnecessary and at some point will begin to hinder learning. When this occurs it is called expertise-reversal.

I think that the differences seen in cognitive performance between musicians and non-musicians in the presence of music may be a type of expression of the expertise-reversal effect. Non-musicians, who are not experts in music, find that music can be a helpful tool to help learning/studying. On the other hand, expert musicians find that music hinders their performance on cognitive tasks. I think that CLT may provide an informative context that will allow for a closer look at the musician/non-musician results.

**Books**

Kalyuga, S. (2009). Cognitive load factors in instructional design for advanced learners. Nova Science Publishers.

Plass, J. L., Moreno, R., & Brünken, R. (2010). *Cognitive load theory*. Cambridge University Press.

**Papers**

DeLeeuw KE, Mayer RE. A comparison of three measures of cognitive load: Evidence for separable measures of intrinsic, extraneous, and germane load. *J Educ Psychol*. 2008;100(1):223-234. doi:10.1037/0022-0663.100.1.223.

Paas F, Tuovinen J, Tabbers H, Van Gerven PWM. Cognitive Load Measurement as a Means to Advance Cognitive Load Theory. *Educ Psychol*. 2010;1520(38):43-52. doi:10.1207/S15326985EP3801.

**Other Relevant Papers – Behavioural studies**

Although many of the papers within this field of research fall into one of a few categories, there are many papers that do not. Below is a list of some of these papers that will be relevant to get a full picture of this field of research:

Oakes, S., & North, A. C. (2006). The impact of background musical tempo and timbre congruity upon ad content recall and affective response. *Applied Cognitive Psychology*, *20*(4), 505–520. http://doi.org/10.1002/acp.1199

Perham, N., Banbury, S. P., & Jones, D. M. (2007). Reduction in auditory distraction by retrieval strategy. *Memory*, *15*(4), 465–473. http://doi.org/10.1080/09658210701288244

Greene, C. M., Bahri, P., & Soto, D. (2010). Interplay between affect and arousal in recognition memory. *PLoS ONE*, *5*(7). http://doi.org/10.1371/journal.pone.0011739

Cabanac, A., Perlovsky, L., Bonniot-Cabanac, M. C., & Cabanac, M. (2013). Music and academic performance. *Behavioural Brain Research*, *256*, 257–260. http://doi.org/10.1016/j.bbr.2013.08.023

Dowling, W. J., & Tillmann, B. (2014). Memory Improvement While Hearing Music: Effects of Structural Continuity on Feature Binding. *Music Perception: An Interdisciplinary Journal*, *32*(1), 11–32. http://doi.org/10.1525/mp.2014.32.1.11

Bell, T. P., McIntyre, K. A., & Hadley, R. (2016). Listening to classical music results in a positive correlation between spatial reasoning and mindfulness. *Psychomusicology: Music, Mind, and Brain*, *26*(3), 226–235. <http://doi.org/10.1037/pmu0000139>

**Other methods of investigation**

All of the papers mentioned above describe experiments that have used behavioural measures. However, some researchers are beginning to use electroencephalography to explore how music affects cognition. Below is a short summary of how EEG is currently being used in this field.

**EEG studies – music and cognition.** EEG has been used to look at the effect of music on cognition by exploring music’s effect on the EEG signal’s frequency bands. In most of these studies, the focus is on the changes seen in the alpha frequency band (8-12Hz). There are different types of changes in the alpha band that can be measured. Some studies have looked at overall alpha power, a measure of the amount of alpha activity in the EEG signal while others have used techniques called event related desynchronization (ERD) or event related synchronization (ERS). These techniques are a measure of the synchronicity of neural firing to a given stimulus, for example an increase in ERS indicates that neurons have become more synchronized as a result of a stimulus.

The changes seen in the EEG frequency bands can be related both to a participant’s performance on a cognitive task and to changes that occur while listening to music. Researchers have used this ability to explore neural correlates for the ‘Mozart Effect’. For example, Verrusio et al (2015) found that there was an increase in alpha power after listening to a Mozart piece. Jausovec et al have found that alpha ERS increased with Mozart music (2003), and that this coincided with an increase in performance on spatial rotation tasks but a decrease in performance on numerical tasks (2005). A review of this EEG literature has never been done.

Caldwell, G. N., & Riby, L. M. (2007). The effects of music exposure and own genre preference on conscious and unconscious cognitive processes: A pilot ERP study. *Consciousness and Cognition*, *16*(4), 992–996. <http://doi.org/10.1016/j.concog.2006.06.015>

Castro, M., Tillmann, B., Luaute, J., Corneyllie, A., Dailler, F., Andre-Obadia, N., & Perrin, F. (2015). Boosting Cognition With Music in Patients With Disorders of Consciousness. *Neurorehabilitation and Neural Repair*, *29*(8), 734–742. <http://doi.org/10.1177/1545968314565464>

Verrusio, W., Ettorre, E., Vicenzini, E., Vanacore, N., Cacciafesta, M., & Mecarelli, O. (2015). The Mozart Effect: A quantitative EEG study. *Consciousness and Cognition*, *35*, 150–155. <http://doi.org/10.1016/j.concog.2015.05.005>

Jaušovec, N., & Habe, K. (2003). The “Mozart Effect”: An Electroencephalographic Analysis Employing the Methods of Induced Event-Related Desynchronization/ Synchronization and Event-Related Coherence. *Brain Topography*, *16*(2), 73–84. http://doi.org/10.1023/B:BRAT.0000006331.10425.4b

Petsche, H., Richter, P., Von Stein, A., Etlinger, S. C., & Filz, O. (1993). EEG Coherence and Musical Thinking. *Music Perception: An Interdisciplinary Journal*, *11*(2), 117–151. http://doi.org/10.2307/40285613

Jaušovec, N., & Habe, K. (2005). The influence of Mozart’s sonata K. 448 on brain activity during the performance of spatial rotation and numerical tasks. *Brain Topography*, *17*(4), 207–218. http://doi.org/10.1007/s10548-005-6030-4

Jaušovec, N., & Habe, K. (2004). The influence of auditory background stimulation (Mozart’s sonata K. 448) on visual brain activity. *International Journal of Psychophysiology*, *51*(3), 261–271. http://doi.org/10.1016/S0167-8760(03)00227-7

Jaušovec, N., Jaušovec, K., & Gerlič, I. (2006). The influence of Mozart’s music on brain activity in the process of learning. *Clinical Neurophysiology*, *117*(12), 2703–2714. http://doi.org/10.1016/j.clinph.2006.08.010

Oknina, L. B., Kuptsova, S. V., Romanov, A. S., Masherow, E. L., Kuznetsova, O. A., & Sharova, E. V. (2012). Comparative analysis of changes in short EEG segments during music perception based on event-related synchronization/desynchronization and wavelet synchronicity. *Human Physiology*, *38*(4), 348–353. http://doi.org/10.1134/S0362119712040093

Overman, A. A., O G E, J. H., Dale, J. A., Cross, J. D., & C H I, A. (2003). Eeg Alpha Desynchronization in Musicians and Nonmusicians I N Response To Changes in Melody, Tempo. and Key in Classical Music ’. *O Perceptual and Motor Skills*, *97*, 519–532. http://doi.org/10.2466/pms.2003.97.2.519

**EEG studies – cognition.** EEG studies have also been conducted to investigate cognitive load and performance. It is important to have these results in mind when interpreting EEG results from studies where music and cognition are investigated concurrently. In general, when exploring cognition and the use of cognitive resources with EEG, alpha band power and alpha ERD/ERS are also used. In 1999, Klimesch wrote a review that describes how EEG signal frequencies are related to different cognitive processes. Using those results, researchers have been using fluctuations in the alpha band as a reliable measure of cognitive ability and workload. Relating the EEG results from cognitive studies to the EEG results from music studies may be a way to better understand how and why we see an effect of music on cognition.

Klimesch, W. (1999). EEG alpha and theta oscillations reflect cognitive and memory performance: A review and analysis. *Brain Research Reviews*, *29*(2–3), 169–195. <http://doi.org/10.1016/S0165-0173(98)00056-3>

Gevins, A., & Smith, M. E. (2000). Neurophysiological Measures of Working Memory and Individual Differences in Cognitive Ability and Cognitive Style. *Cerebral Cortex*, *10*(9), 829–839. <http://doi.org/10.1093/cercor/10.9.829>

Antonenko, P., Paas, F., Grabner, R., & van Gog, T. (2010). Using Electroencephalography to Measure Cognitive Load. *Educational Psychology Review*, *22*(4), 425–438. <http://doi.org/10.1007/s10648-010-9130-y>

**Behavioural Studies – pre-2005**

Freeburne, C. M., & Fleischer, M. S. (1952). The effect of music distraction upon reading rate and comprehension. *Journal of Educational Psychology*, *43*(2), 101–109. http://doi.org/10.1037/h0054219

Colle, H. A., & Welsh, A. (1976). Acoustic masking in primary memory. *Journal of Verbal Learning and Verbal Behavior*, *15*(1), 17–31. http://doi.org/10.1016/S0022-5371(76)90003-7

Arkes, H. R., Rettig, L. E., & Scougale, J. D. (1986). The effect of concurrent task complexity and music experience on preference for simple and complex music. *Psychomusicology: A Journal of Research in Music Cognition*, *6*(1–2), 51–60. http://doi.org/10.1037/h0094191

Martin, R. C., Wogalter, M. S., & Forlano, J. G. (1988). Reading comprehension in the presence of unattended speech and music. *Journal of Memory and Language*, *27*(4), 382–398. http://doi.org/10.1016/0749-596X(88)90063-0

SOGIN, D. W. (1988). EFFECTS OF THREE DIFFERENT MUSICAL STYLES OF BACKGROUND MUSIC ON CODING BY COLLEGE-AGE STUDENTS. *Perceptual and Motor Skills*, *67*(1), 275–280. http://doi.org/10.2466/pms.1988.67.1.275

Salamé, P., & Baddeley, A. (1989). Effects of background music on phonological short-term memory. *The Quarterly Journal of Experimental Psychology Section A*, *41*(1), 107–122. http://doi.org/10.1080/14640748908402355

Jones, D. M., Miles, C., & Page, J. (1990). Disruption of proofreading by irrelevant speech: Effects of attention, arousal or memory? *Applied Cognitive Psychology*, *4*(2), 89–108. http://doi.org/10.1002/acp.2350040203

Rauscher, F. H., Shaw, G. L., & Ky, K. N. (1993). Music and spatial task performance. *Nature*, *365*(6447), 611. http://doi.org/10.1038/365611a0

Crawford, H. J., & Strapp, C. M. (1994). Effects of vocal and instrumental music on visuospatial and verbal performance as moderated by studying preference and personality. *Personality and Individual Differences*, *16*(2), 237–245. http://doi.org/10.1016/0191-8869(94)90162-7

Furnham, A., & Bradley, A. (1997). Music while you work: the differential distraction of background music on the cognitive test performance of introverts and extraverts. *Applied Cognitive Psychology*, *11*(5), 445–455. http://doi.org/10.1002/(SICI)1099-0720(199710)11:5<445::AID-ACP472>3.0.CO;2-R

Beaman, C. P., & Jones, D. M. (1997). Role of serial order in the irrelevant speech effect: Tests of the changing-state hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*(2), 459–471. http://doi.org/10.1037/0278-7393.23.2.459

RAUSCHER, F. H., & SHAW, G. L. (1998). KEY COMPONENTS OF THE MOZART EFFECT. *Perceptual and Motor Skills*, *86*(3), 835–841. http://doi.org/10.2466/pms.1998.86.3.835

Furnham, A., & Allass, K. (1999). The influence of musical distraction of varying complexity on the cognitive performance of extroverts and introverts. *European Journal of Personality*, *13*(1), 27–38. http://doi.org/10.1002/(SICI)1099-0984(199901/02)13:1<27::AID-PER318>3.0.CO;2-R

Nantais, K. M., & Schellenberg, E. G. (1999). The Mozart Effect: An Artifact of Preference. *Psychological Science*, *10*(4), 370–373. http://doi.org/10.1111/1467-9280.00170

Thompson, W. F., Schellenberg, E. G., & Husain, G. (2001). Arousal, Mood, and The Mozart Effect. *Psychological Science*, *12*(3), 248–251. http://doi.org/10.1111/1467-9280.00345

Hallam, S., Price, J., & Katsarou, G. (2002). The Effects of Background Music on Primary School Pupils’ Task Performance. *Educational Studies*, *28*(2), 111–122. http://doi.org/10.1080/03055690220124551

Furnham, A., & Strbac, L. (2002). Music is as distracting as noise: the differential distraction of background music and noise on the cognitive test performance of introverts and extraverts. *Ergonomics*, *45*(3), 203–217. <http://doi.org/10.1080/00140130210121932>

**Other useful papers**

**Meta-analysis:**

Chabris, C. F. (1999). Prelude or requiem for the “Mozart effect”? *Nature*, *400*(6747), 826–827. <http://doi.org/10.1038/23608>

**Reviews:**

Schellenberg, E. G. (2005). Music and Cognitive Abilities. *Current Directions in Psychological Science*, *14*(6), 317–320. <http://doi.org/10.1111/j.0963-7214.2005.00389.x>

Rickard, N. S., Toukhsati, S. R., & Field, Simone, E. (2005). The Effect of Music on Cognitive Performance: Insight From Neurobiological and Animal Studies. *Behavioral and Cognitive Neuroscience Reviews*, *4*(4), 235–261. <http://doi.org/10.1177/1534582305285869>

Verrusio, W., Moscucci, F., Cacciafesta, M., & Gueli, N. (2015). Mozart Effect and Its Clinical Applications: A Review. *British Journal of Medicine and Medical Research*, *8*(8), 639–650. http://doi.org/10.9734/BJMMR/2015/17192