# *MUSIC IN MIND*

– exploring how music listening and individual characteristics affect attention

Ella Laakso

Leevi Saukkola

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Department of Psychology

University of Jyväskylä

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Music has the ability to impact human activity from day-to-day life to more specific cognitive processes. The impact of background music has been an area of interest in the field of music psychology for many years. This study concentrated on the influence of background music listening on attention. An attention test (d2-R) was conducted by the participants in three auditory settings; music, noise and silence. In addition, we wanted to find out whether individual differences in mind-wandering and inattentiveness, measured with two different questionnaires (ASRS and MWQ), affect attention while music was played in the background. Third, we clarified whether musical training or the habit of listening to music had an impact on how music listening influenced attention.

15 participants, between 21 and 28 years of age, participated in the study. They completed a computerised attention test with three different sound settings on three different days. On one test trial self-selected background music was played, on the other there was cafe murmur and on the third test trial the participant carried out the test in silence. The participants performed these different conditions in a randomised order to counterbalance the learning effect. The attention test (d2-R) measures three components of attention: concentration, working speed and working accuracy. At the end of the final test trial, participants filled out questionnaires measuring mind-wandering (MWQ) and ADHD characteristics (ASRS-v.1.1).

There were no differences in the attention scores between the three different auditory conditions. Neither mind-wandering nor inattentiveness influenced the relationship between auditory conditions and attention test results. Similarly, musical training or the usage of music did not impact the overall test scores. In contrast, test scores improved as a function of test trial regardless of the auditory setting, suggesting the presence of learning effect. This was unpredictable since d2-R has usually been shown to adequately and independently control learning effects.

Altogether the results illustrate no clear evidence about the effects of background music to attention. This may be the result of low sample size, various elements of the study design or the attention test conducted. A more sophisticated research paradigm could reveal the possible effects of music if those effects are to be found.

Key words: Background music, attention, d2-R, mind-wandering, inattentiveness

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Musiikki vaikuttaa ihmisiin monella eri osa-alueella arkipäiväisestä elämästä kognitiivisiin toimintoihin. Musiikin kuuntelun vaikutus kognitioon onkin kiinnostanut tutkijoita jo pitkään. Tässä tutkimuksessa keskitytttiin siihen, miten taustamusiikin kuuntelu vaikuttaa suoriutumiseen tarkkaavuuden tehtävässä (d2-R). Musiikin vaikutuksia verrattiin saman tehtävän suorittamiseen hälyn ja hiljaisuuden aikana. Lisäksi tutkimuksessa haluttiin selvittää, vaikuttavatko yksilöllisesti vaihteleva ajatusten harhailu (mind-wandering) ja tarkkaamattomuuden määrä, mitattuna kahdella eri kyselyllä (ASRS ja MWQ), tarkkaavuuteen musiikin soidessa. Kolmantena haluttiin selvittää, voiko musikaalinen harrastuneisuus tai musiikin käyttö opiskellessa vaikuttaa tarkkaavuuteen eri ääniympäristöissä.

Tutkimukseen osallistui 15 21–28-vuotiasta tutkittavaa. He suorittivat verkkopohjaisen tarkkaavuustestin kolmessa erilaisessa ääniympäristössä kolmena eri päivänä. Yhdellä tutkimuskerralla taustalla soi itse valittu musiikki, toisella kahvilahäly ja kolmannella kerralla tutkittava teki testin hiljaisuudessa. Äänitaustojen järjestystä vaihdettiin jokaisen tutkittavan kohdalla oppimisvaikutuksen kontrolloimiseksi. Tarkkaavuustesti (d2-R) mittaa kolmea eri tarkkaavuuden osa-aluetta, jotka ovat keskittyminen, nopeus ja tarkkuus. Viimeisen kerran lopuksi tutkittava täytti ajatusten harhailua (MWQ) ja ADHD piirteitä (ASRS-v.1.1) mittaavat kyselylomakkeet.

Tutkimuksessa ei löydetty merkitseviä eroja ääniympäristöjen ja tarkkaavuustestin tulosten välillä. Myöskään ajatusten harhailun tai tarkkaamattomuuden määrän ei havaittu olevan yhteydessä ääniympäristöjen ja tarkkaavuustestin tulosten yhteyteen. Musikaalinen harrastuneisuus tai musiikin käyttö opiskellessa ei vaikuttanut myöskään tuloksiin. Ainoa merkitsevä yhteys löydettiin verrattaessa tarkkaavuustestien tuloksia perättäisinä tutkimuskertoina. Huomattiin, että testin tulokset paranivat joka kerralla riippumatta äänitaustasta, mikä viittaisi oppimisvaikutukseen. Tämä oli yllättävä löydös, sillä d2-R-testin on tutkimuksissa huomattu kontrolloivan hyvin oppimisvaikutusta.

Tämän tutkimuksen mukaan taustamusiikki ei vaikuttanut tarkkaavuuteen. Tulosten löytymättömyyden taustalla voivat olla pieni otoskoko, koeasetelmaan liittyvät tekijät tai käytetty tarkkaavuustesti. Tarkemmin kontrolloitu tutkimusasetelma voisi tuoda musiikin vaikutukset paremmin esille, mikäli niitä on löydettävissä.

Avainsanat: taustamusiikki, tarkkaavuus, d2-R, ajatusten harhailu, tarkkaamattomuus

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## 1. INTRODUCTION

Music has influenced the human body and mind ever since music has existed, maybe even before language (see for example Miller, Miller, Turner & Evans, 2017; Dissanayake, 2005). Because of its various characteristics, it has long been used in numerous different situations such as gatherings, shows and different work environments (Shih, Huang & Chiang, 2012, see also Tarr, Launay & Dunbar, 2014). In modern days, music has reached almost every corner of the world and most of the social media we use today revolves around music (Crupnick, 2018). Music is played in the background in many different places, in stores, cafés and also at home. Hence music has become one of the most important factors that affects us and gets our attention on a day-to-day basis. Listening to music also is easier than ever with different streaming services offering music anywhere and anytime. It is common for students to listen to music while studying, numbers varying from 59 % (Calderwood, Ackerman & Conklin, 2014) to 81% (Johansson, Holmqvist, Mossberg & Lindgren, 2011). Streaming services provide playlists that are designed to improve attention while performing cognitively demanding tasks like studying. These playlists are widely used: for example in Spotify many playlists under the category "focus" have over a million followers. In our research, we studied whether background music helps the ability to focus and maintain attention during a demanding and unknown task. In addition, we focused on individual differences in mind-wandering and attentiveness and their impact on the attention task performance when auditory condition is altered from music to noise and silence. We were also interested in whether musical training or the habit of using music while studying could affect this connection.

The influence of background music on cognition has been studied previously in various research projects. Multiple studies have played music before the actual task hence concentrating on the priming effect of music (Cassidy & MacDonald, 2007). Here priming effect means the neurophysiological state which is created by listening to music prior to the actual task (Tulving, Schacter & Stark, 1982). This state is thought to influence, usually in a facilitative manner, different cognitive processes and the performance in the task (Cassidy & McDonald, 2007). Küssner (2017) proposed that the influence of music listening is more significant if it happens before the task performance. However, we wanted to concentrate on the influence of music listening while performing the task because it imitates more everyday situations. Our study investigates whether background music helps to concentrate better on the task at hand therefore validating the usage of concentration playlists while studying. Some previous studies have played music during the task performance and compared the influence of background music to noise or silence with varying results (e.g., Cassidy & MacDonald, 2007). Similarly, we provided three different auditory conditions (music, noise and silence) for the task performance.

### 1.1 Background music and cognition

The connection between music and different cognitive abilities has interested researchers throughout many years (Küssner, 2017) but there is no consensus whether listening to music facilitates or hinders cognitive processes (Kämpfe, Sedlmeier & Renkewitz, 2011). There are studies that have found music listening beneficial for cognitive processes (Caldwell & Riby, 2007; Rauscher, Shaw & Ky, 1993) and for example Kiger (1989) found that background music enhances reading comprehension. Other cognitive areas such as visual search (Crust, Clough & Robertson, 2004), spatial processing, linguistic accuracy (Angel, Polzella & Elvers, 2010) and working memory processing (Mammarella, Fairfield & Cornoldi, 2007) have also been found to improve with background music. However, other studies have discovered music to be distracting for cognitive performance (Cassidy & MacDonald, 2007; Furnham & Strbac, 2002; Furnham & Bradley, 1997). Gonzalez and Aiello (2019) found that background music impaired the performance in a complex task (in this study complex task being a difficult attention test). In addition, writing fluency deteriorates when background music is played (Ransdell & Gilroy, 2001). There are also studies that found no improvement in cognitive processes while listening to music (Furnham & Allass, 1999). However, most of these studies are relatively old and conducted with a rather small participant group. New studies are therefore necessary.

Some studies have even found specific music to be helpful for cognitive processes, originally found by Rauscher, Shaw and Ky (1993) by using Mozart's piano sonata (K448 for two pianos in D major). This phenomenon is still known as the Mozart-effect. Rauscher and others (1993) found that listening to Mozart's music helps to obtain better results in a spatial task compared to relaxation tape and silence. More recent studies have discovered that Mozart's music improves linguistic and spatial processing (Angel et al., 2010; Rauscher, Shaw & Ky, 1995). However, Rauscher and others (1993) utilised only Mozart's sonata and compared it to silence and relaxation tape which both are calming background noises. To be able to say that music is the explaining factor behind this phenomenon, there should first be comparison between two activating background noises. In our study, we considered this by using background noise and music in addition to silence. It has been argued that the activating and stimulating power of Mozart's music in task-relevant brain areas could be behind this Mozart-effect (Jaušovec, Jaušovec & Gerlič, 2006). The alleged power of Mozart's music created an interest in other composers as well, and for example Mammarella and others (2007) found that Vivaldi's music, namely "the Vivaldi-effect", enhanced working memory performance. Studies afterwards have tried to verify or dispute these phenomena (Angel et al., 2010; Pietschnig, Voracek & Formann, 2010) and a meta-analysis by Pietschnig and others (2010), composed of 39 studies, found no supporting evidence for the Mozart-effect. In fact, the influence of Mozart's music was not significantly different from any other kinds of music (Pietschnig et al., 2010). Many studies have also struggled with reliability issues. Some topics have been oversimplified and although statistically significant results have been found, the conclusions and implications have sometimes been exaggerated (see for example Campbell, 2009; Gilleta, Vrbancic, Elias & Saucier, 2003; Nantais & Schellenberg, 1999; Crumpei & Rotaru, 2012).

Since there is no agreement about the influence of background music, studies have tried to find the determinant in different music styles. Focus playlists contain low-information music and the purpose is that the background music activates the brain and improves learning (Küssner, 2017). Even though music complexity is difficult to define (see for example Streich, 2006, pp. 37-39), Kiger (1989) argued that low-information music improves performance by lowering arousal levels which provides better conditions for cognitive processing. However, Cassidy and MacDonald (2007) found that even though low-arousal music is better than high-arousal music, it still disrupts performance compared to silence. The influence of lyrics to cognitive processing is also unclear (Furnham, Trew & Sneade, 1999), though the general consensus is that vocal music disrupts cognitive processes more than instrumental music (Crawford & Strapp, 1994; Cassidy & MacDonald, 2007; Shih et al., 2012). This might be the reason why focus-playlists usually contain instrumental low-information music.

### 1.1.1 Theoretical framework of background music and cognition

There are multiple different theories on why and how background music affects cognitive processes. Some theories have tried to explain why the impact of music varies so much on different people and in different situations. Yerkes and Dodson (1908) argued that there is an optimal level of arousal for every task and this optimal level varies depending on the complexity and difficulty of the task. If the optimal level is exceeded, it causes the performance to deteriorate which indicates that a higher level of arousal is not always better for the performance (Yerkes & Dodson, 1908). This theory, also known as the "inverted-U" -model (Smith, 1983; Anderson, 1990; Sapolsky, 2015), is also important in the field of music psychology. Küssner (2017) hypothesised that individual levels of cortical arousal could be one reason why people react differently to music. Individual optimal levels of arousal could explain why low-arousal music is better than high arousal music for some people in different situations. We addressed this in our study by examining how individual levels in mind-wandering and inattentiveness impact attention.

In line with Yerkes and Dodson (1908), Rauscher and others (1993) proposed that listening to music could act as a priming effect hence optimising arousal to the best possible level. Later Rauscher and others (1995) proposed that this optimising happens also at the neural level and since then many studies have supported this idea. Verrusio and others (2015) were able to modulate neuronal oscillations linked to cognitive functions using Mozart's music (see also Chen, Wong, Kuo, Liao & Ke, 2008). Since the physiological and neurological effects are well established, (Jaušovec et al., 2006; Geethanjali, Adalarasu & Rajsekaran, 2012; Bennet & Bennet, 2008; Bhattacharya & Petsche, 2001; Morton, Kershner & Siegel, 1990), it could well be that music affects the brain in a stimulating manner, activating and inhibiting specific areas of the brain making cognitive processing more efficacious. Some researchers have even called music "to be among the greatest neuromodulators of all" (Miller et al., 2017).

Individual levels of cortical arousal have been linked to personality as well (Eysenck, 1967), especially to extroversion and introversion (Cassidy & MacDonald, 2007; Furnham & Allass, 1999; Furnham & Bradley, 1997; Furnham & Strbac, 2002; Küssner, 2017). Introverts are more exposed to the detrimental impacts of music on cognition than extraverts (Furnham & Bradley, 1997; Furnham

& Strbac, 2002; Furnham & Allass, 1999), especially if the music is high on arousal (Cassidy & MacDonald, 2007). Extraverts are more inclined to listen to music while studying (Crawford & Strapp, 1994). According to Eysenck's theory of personality (1967), extraverts and introverts have different levels of cortical arousal hence they need different amounts of stimulation to reach their optimal level. However, Gonzalez and Aiello (2019) argued that the research has been too focused on extraversion–introversion dimension and other personality traits should be taken into account as well. In our study we concentrated on the individual levels of arousal in light of individual attentional capabilities, namely mind-wandering and proneness to hyperactivity.

Another theory for the influence of music is that music listening affects cognition by acting as a mediator (Thompson, Schellenberg & Husain, 2001). In addition to increasing arousal, music acts as a mood-lifting factor which then affects cognition (Thompson et al., 2001). This way music does not affect cognition directly but through arousal and mood (Thompson et al., 2001). This mood-arousal hypothesis has been examined in various studies (see Gonzalez & Aiello, 2019; Hallam, Price & Katsarou, 2002; Husain, Thompson & Schellenberg, 2002; Schellenberg & Hallam, 2005). The hypothesis could also explain why Mozart's sonata, being a positive and energetic piece, enhances cognitive performance (Thompson et al., 2001). Hallam and others (2002) found that calming and pleasant background music, compared to arousing and unpleasant one, enhanced task performance in mathematics and memory in a group of children aged 10-12 years. This would indicate, together with the other studies, that music affects cognition through arousal and mood.

In respect to arousal-mood hypothesis, the individual preferences of listening to music while performing cognitive tasks, like studying, has been found to affect cognitive performance (Johansson et al., 2011). Majority of the students in Johansson and other's (2011) study believed that background music helps them to perform better in their studies. Students scored more poorly in the reading comprehension test when they listened to non-preferred music compared to silence. However, listening to preferred music did not have an impact on the test scores (Johansson et al., 2011; see also Perham & Vizard, 2011). Other studies have found listening to music while performing verbal and reading comprehension tests to enhance the scores of people who usually study with music (Crawford & Strapp, 1994). They also reported having better attentional resources in a self-inventory questionnaire (*Differential Attentional Processes Inventory*) (Crawford & Strapp, 1994). Crawford and Strapp (1994) argued that these phenomena could be explained with optimal arousal levels. Schellenberg & Hallam (2005) found that listening to preferred music enhanced cognitive performance and they argued that individual preferences influence how different music affects cognition.

Priming effect and mood-arousal -hypotheses have both gained widespread support. While Glenn Schellenberg and other researchers named earlier have promoted for the mood-arousal hypothesis (Nantais & Schellenberg, 1999; Thompson et al., 2001; Schellenberg, Nakata, Hunter & Tamoto, 2007), other researchers such as Perham and Sykora (2012) have pointed out multiple discrepancies in the theory. Also the priming hypothesis has received critique. Pietschnig and others (2010) found only a minor music-induced effect which was comparable to no stimulus -situations. Altogether, the lack of consistency has led to a continuing debate and there are multiple studies that have not found any significant results when combining cognitive performance and short-term music listening (Newman et al., 1995; Steele, Bass & Crook, 1999; McKelvie & Low, 2002; McCutcheon, 2000; see also Levitin & Tirovolas, 2009).

### 1.2 Background music, attention and individual differences in inattentiveness

In our study, we focused on the influence of background music on attention. Attention is crucial for many cognitive functions like perception and memory (Jehkonen & Nurmi, 2019, p. 71) and it facilitates many everyday functions including studying. The research about the influence of music on attention is as controversial as in other parts of cognition (see for example Gonzalez & Aiello, 2019). Some studies have found music listening to be detrimental to vigilance (Alikonis et al., 2002). Other studies indicate that background music enhances attention (Gonzalez & Aiello, 2019; Jaušovec & Habe, 2003; Morton et al., 1990) and especially vigilance during complex tasks (Davies, Lang, & Shackleton, 1973). These varying results may be due to varying attentional processes or as Baldwin and Lewis (2017) pointed out, originating from the usage of different kinds of music in the studies. The differing result may also be because there are many different components in attention (vigilance, sustained attention, visual and auditory attention). In our study, we focus primarily on visual attention.

Shih, Huang & Chiang (2009) found that music has a different influence on attention depending on whether people listen to it prior or during the attention test. When participants listened to music prior to the attention test, they performed better compared to during the task and no music - conditions. However, the test scores varied more when listening to music during the test (Shih et al., 2009). These results indicate that music could act as a priming variable (Rauscher et al., 1995) facilitating attention performance. However, listening to music prior to a cognitive task like studying is not what people usually do but rather they listen to music while studying (Calderwood et al., 2014; Johansson et al., 2011; Perham & Vizard, 2010; Ransdell & Gilroy, 2001). Therefore in this study we played music during the attention test performance.

As seen before, many individual differences affect attention. Therefore we included individual differences in mind-wandering and inattentiveness to the study. We studied the influence of mind-wandering to the connection between background music and attention. Mind-wandering is defined as the proneness to be interrupted by task-irrelevant thoughts (Smallwood & Schooler, 2006). One criterion for mind-wandering is that task irrelevant thoughts divert the attention away from the task at hand into internal thoughts (Mrazek, Phillips, Franklin, Broadway & Schooler, 2013; Smallwood & Schooler, 2006). The main difference between mind-wandering and daydreaming is the context where this attention shift is happening. Mind-wandering occurs simultaneously with a primary task and inner thoughts capture the attention away from it, while daydreaming is context-independent and there is no primary task from which the attention moves away from (Mrazek et al., 2013). Shifting attention plays an important role in mind-wandering and mind-wandering affects one's task performance considerably (Franklin, Smallwood & Schooler, 2011). Mind-Wandering Questionnaire (MWQ) is the first validated questionnaire to measure the frequency of mind-wandering (Mrazek et al., 2013). The questionnaire does not evaluate whether mind-wandering is deliberate or unintentional but it merely focuses on its prevalence (Mrazek et al., 2013).

Mind-wandering has been associated with different attention deficits, mainly to Attention Deficit Hyperactivity Disorder (ADHD) because of their similar core elements like impulsivity, hyperactivation and problems to sustain attention in the task at hand (Seli, Smallwood, Cheyne & Smilek, 2015). Mind-wandering is one of the central characteristics of ADHD (Seli et al., 2015). And it is closely linked with the inattention (not the hyperactivity) side of ADHD, higher inattention scores leading to more mind-wandering (Jonkman, Markus, Franklin & van Dalfsen, 2017). Hence, we included both MWQ and World Health Organization Adult ADHD Self-Report Scale (ASRS-v1.1) into our study. ASRS is a screener which was developed based on the ADHD criteria in Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) to screen ADHD characteristics (Adler et al., 2006).

The influence of music has also been linked to mind-wandering. Gonzalez and Aiello (2019) argued that using music during simple tasks prevents mind-wandering because background music uses attentional capacity and therefore prevents boredom. This indicates that music helps to create an optimal level of arousal proposed by the Yerkes-Dodson law (Yerkes & Dodson, 1908). Taruffi, Pehrs, Skouras and Koelsch (2017) found that mind-wandering is more likely to happen when listening to sad than happy music. Sad music draws attention to inwards to inner thoughts whereas happy music helps to sustain attention in the task at hand (Taruffi et al., 2017). Sad and fast music elicited more mind-wandering than happy and slow music and this could be the reason why relaxation music is usually low-arousal and pleasant (Taruffi et al., 2017). This would explain why concentration playlists also contain low-arousal, pleasant music.

Some previous studies have focused on the relation between music and attention modified by the individual inattentive characteristics (Hallam & Price, 1998; Zentall, 1975). Calming music has been found to improve mathematical performance and behavior especially for children who had proneness to overactivity and a need for continuous stimulus seeking (Scott, 1970; Hallam & Price, 1998). Also memory performance in children is improved when listening to calming background music (Hallam et al., 2002). Hallam and others (2002) hypothesised that calming music in the background creates a non-verbal interference which is not as disturbing as other distractions. Compared to other distractions music has the power to create a space where attention returns back to the task at hand (Hallam, et al., 2002). This implicates that music helps children with concentration problems to reach their optimal level of arousal, therefore improving their attention (Zentall, 1975). As the studies above have shown, distractions are not always bad but on the contrary, can sometimes help to perform better (Gonzalez & Aiello, 2019). This is something we also hypothesised to see in our study.

### 1.3 Aims of the study

The overall aim of this study was to examine whether background music affects performance in an attention test. Only a few previous studies have concentrated on the characteristics of music and individual differences at the same time (Gonzalez & Aiello, 2019). We focused on this question by using three different auditory settings (music, noise and silence) for the attention test. We also included the individual differences in mind-wandering and attentional processes. In this study all participants went through all three auditory conditions in a randomised order which controlled the effect of familiarity and individual variance in performance. Many researchers have studied the mood-arousal hypothesis by playing music prior to the cognitive task, however most people listen to music while studying (Perham & Vizard, 2010). We provided a situation that was as authentic as possible and therefore music and noise were both chosen as auditory settings. Present study is able to assess some of the main elements of modern music listening, attention, and individual variability in a scientific and controlled setting.

In this study, we focused on three different topics about music and attention.

1. First research question was whether attention test (d2-R) scores vary between three auditory situations: music, noise and silence. Based on the previous research (and especially on the Yerkes-Dodson law) we hypothesised that the participants' performance is the best during the music condition.
2. Second research question was whether individual differences in mind-wandering and inattentiveness affect the attention task performance in different auditory conditions. Based on previous research the hypothesis was that background music improves the performance of the participants with high scores in MWQ and ASRS the most hence providing higher test results in music condition compared to silence and noise.
3. Our third research question was whether the habit of listening to music while studying or musical training affects the performance in the d2-R test in the three auditory situations. Our hypothesis was that those participants who listen to music while studying perform better in the attention test. This hypothesis was based on previous research (Schellenberg & Hallam, 2005; Crawford & Strapp, 1994). It has also been shown that musicians' and non-musicians'

auditory processing and music-related abilities are different (Patston & Tippett, 2011; Brandler & Rammsayer, 2003; Yang, McClelland & Furnham, 2016; Wu & Shih, 2019) and so we hypothesised that auditory stimuli would affect these groups differently, musicians being more affected (positively or negatively) than non-musicians.

## 2. METHODS

### 2.1 Participants

There were 15 participants (3 males, 12 females) aged between 21 and 28 (mean = 23.9) in this study. Majority of them (*n* = 14) were students at the department of Psychology in the University of Jyväskylä. Participants were recruited via email using a recruitment letter sent to university mailing lists. Exclusion criteria included motor or hearing dysfunctions and medication that influences perception or attention. Participants were also instructed to postpone the test if they were feeling sick or unwell. The participants were all volunteers and did not receive any reward from the participation. The study was performed following guidelines for responsible conduct of research and the privacy policy of University of Jyväskylä.

At the beginning of the first session participants were asked to fill out a preliminary information questionnaire (appendix 4) about their musical training and the usage of music while studying. Half (*n* = 7) of the participants had plenty of experience in music (over 5 years of formal musical training) while the rest had only a little (*n* = 4) or none (*n* = 4) musical background. Three participants listened music often or really often while studying whereas six participants reported using music only rarely while studying. The rest (*n* = 6) reported using music occasionally. More descriptive statistics in table 1.

### 2.2 Experimental design

The research measurements were carried out by the authors during spring 2020. The testing was carried out in the quiet rooms of the Department of Psychology to avoid distractions during the attention tests. Participants were asked to perform the attention test on three different days to provide them three different auditory conditions for the performance: music, noise and silence. Because of the intensive nature of the test, it was better for the participants and the test results to complete the tests on separate days. The test trials were mostly conducted on consecutive days but occasionally there were one to five days between the trials. The participants performed different auditory conditions in a randomised order to counterbalance the learning effect and the impact of alertness or differing moods.

Before any tests, participants signed a written consent form after receiving information about the study. They also had the opportunity to ask questions. After this participants were asked to fill out a preliminary information form about their musical training and the usage of music while studying. To create an authentic situation and to acknowledge the individual auditory thresholds, the participants adjusted the volume individually within the allowed range (from 10 to 20% in a Windows 10 Enterprise -software, ranging from 40 to 55 dB) so that the volume felt suitable. The same volume was applied in both music and noise conditions. During silence condition participants wore 3M Peltor Optime 3 -earmuffs. Before the attention test participants fitted a Polar H7 -heart rate monitor and a one-minute baseline heart rate variability (HRV) was logged. During the attention test music or noise was played through Sony mdr-xd150-headphones using either Spotify or an online player (www.coffitivity.com, Lunchtime Lounge). HRV was also logged from all three trials. However due to low validity and already high amount of variables, HRV-scores were excluded from the analysis. After completing the third and final test trial, participants filled out an ADHD questionnaire (ASRS) (appendix 3) and Mind-Wandering Questionnaire (MWQ) (appendix 2). The questionnaires were filled out at the end of the research so that they would not affect the attention test scores.

We did not want preference or familiarity to affect the results so we provided a combined playlist of concentration music (appendix 1) from different concentration playlists and asked the participants to choose between 3 to 5 pieces that they would like to listen to during the performance. This way we provided all participants musical pieces that were self-selected but not too familiar. Hence the situation was the same to all participants. The music was selected from multiple different playlists to cover a broad variety of different musical pieces. Still, the main issue was to find music that was simple and familiar in terms of loudness, variety, complexity and tonal range (see Kiger, 1989; Furnham & Bradley, 1997; Temperley, 2019).

### 2.2.1 The d2-R

The d2-R is a test of visual attention developed by Hogrefe Ltd (Brickenkamp, Schmidt-Atzert & Liepmann, 2010) and in this study we used the Revised online version which was published in 2016. The test platform by Hogrefe Ltd advised the participants from start to finish, which prevented varying instructions by the measurers. The d2-R is a widely used test of attention in Europe (Brickenkamp et al., 2010) and there are versions in many different languages, including Finnish, which was applied in this study. The test is normed with a European group ($n$ = 2100) and Finnish group ($n$ = 199) and there are norms for ages 18 to 55 (Brickenkamp et al., 2010).

The d2-R measures sustained, focused and selective attention (Brickenkamp et al., 2010). The d2-R requires also other cognitive processes such as processing speed, controlling attention, cognitive flexibility, visual scanning and inhibitory control (Brickenkamp et al., 2010). Motivation and obeying rules are important factors in d2-R and all of these processes are crucial for attention (Brickenkamp et al., 2010). The procedure in d2-R is simple and in the online version, conducted in this study, practice runs are offered before the test itself. In the d2-R participant is presented altogether with 14 screens which all contain 60 symbols (Brickenkamp et al., 2010). The symbols are either letter ´d´ or ´p´ with one to four dashes around the letter. The goal is to find all target symbols which consist of the letter ´d´ with two dashes around it. There is a 20-second time frame for each screen and the participant tries to find as many correct symbols as possible while ignoring the other symbols. When the time is up, the next screen will appear. The whole test takes approximately 10 minutes including the practice at the beginning.

When the test is complete, the scores are accessible in Hogrefe's secure online testing platform which only the experimenters had access to. The program calculates scores automatically and then provides scores in three different categories. These variables of attention are concentration, working speed and working accuracy (Brickenkamp et al., 2010). Concentration (C) is computed by subtracting missed target symbols and incorrect picks from the amount of target symbols the participant went through. Working speed (WS) indicates how many symbols the participant went through. Working speed score does not take into account how many of them are correct or incorrect. In other words, working speed does not account for the correctness of the answers. High scores in C and WS indicate better attention than low scores. Third variable is working accuracy (WA) or in other words, error percentage. To compute working accuracy, the amount of errors is divided by the total amount of target symbols and then multiplied by 100 to get a percentage. The lower the points are the better working accuracy is in the test. The program also computes standard values for these three variables and compares them to standard population. In our statistical analysis, we utilised raw scores in these three categories of attention as variables.

### 2.2.2 Questionnaires

Attentional processes were assessed by using MWQ and ASRS-v1.1. MWQ includes five different questions and the answer options are arranged in 6-point Likert scale (1 = almost never, 2 = very infrequently, 3 = somewhat infrequently, 4 = somewhat frequently, 5 = very frequently and 6 = almost always) (Mrazek et al., 2013). Higher scores indicate more mind wandering. Since there is no official translation of MWQ in Finnish, we translated the questionnaire ourselves (appendix 2) to provide an equal situation for every participant. ASRS is also a self-report questionnaire which includes 18 questions, all in 5-point Likert scale (Adler et al., 2006). There is also an official Finnish version of ASRS-v1.1 (Kessler et al., 2005) which was applied in this study (appendix 3). To provide a variable for statistical analysis we added MWQ and ASRS scores together (ASRS between 1 to 5 per question, MWQ between 1 to 6 per question) and divided participants into two groups; low and high (from now on MWQ+ASRS groups). The cut-off score was 40 points. Although the variation in the combined scores was moderately high (min. 20, max. 97) within the sample, sorting to active ($n$ = 8) and non-active ($n$ = 7) groups was possible to conduct. Repeated measures ANOVA was conducted using these two groups as between subjects factors.

In addition to attention and personality we also collected some demographic variables like musical training and the usage of music while studying. These questions were included in the preliminary information form (appendix 4). Usage of music was asked using a 5-point Likert scale (1 = never – 5 = almost always) and for statistical analysis this variable was divided into 3 groups (1 and 2 = seldom, $n$ = 6; 3 = occasionally, $n$ = 6; 4 and 5 = regularly, $n$ = 3). Musical training was defined according to the answers in the open-ended musical training question and the participants were divided in three group: no musical background (NM, $n$ = 4), some musical background (SM, 1-3 years of singing or playing an instrument, $n$ = 4) and plenty of musical background (PM, 3+ years of singing or playing an instrument, $n$ = 7).

TABLE 1. Descriptive statistics, ASRS and MWQ scores and d2-R scores in music, noise and silence (C = concentration, WS = working speed, WA = working accuracy)

| | Mean | Minimum | Maximum | Standard Deviation |
|---|---|---|---|---|
| Age | 23.93 | 21 | 28 | 2.314 |
| ASRS scores | 26.13 | 7 | 80 | 18.620 |
| MWQ scores | 15.33 | 12 | 19 | 2.024 |
| C music | 237.60 | 188 | 294 | 29.765 |
| C noise | 242.20 | 199 | 303 | 30.138 |
| C silence | 230.07 | 178 | 275 | 29.526 |
| WS music | 246.27 | 191 | 300 | 29.251 |
| WS noise | 250.20 | 209 | 303 | 29.972 |
| WS silence | 239.40 | 199 | 279 | 24.451 |
| WA music | 3.573 | 0.8 | 7.4 | 2.0869 |
| WA noise | 3.200 | 0.0 | 8.9 | 2.9425 |
| WA silence | 4.153 | 0.0 | 11.2 | 3.2439 |

### 2.3 Statistical analysis

Independent variables in this study were the three different auditory conditions: music, noise and silence. Dependent variables were the three different scores derived from the d2-R test: concentration (C), working speed (WS) and working accuracy (WA). In the second research question ASRS and MWQ scores were included as variables (see 2.2.2 Questionnaires). The third research question included musical training and usage of music as variables with attention test scores. All statistical analyses were conducted using SPSS Statistics 24.0 (IBM) software. All results are reported as significant at $p < .05$. Due to small number of participants ($n = 15$) the analysis was first conducted using a non-parametric Friedman’s test. This way we could compare the results of non-parametric and parametric analysis methods. When these approaches indicated similar results, the remaining analyses were conducted using parametric analysis methods.

The first research question compared the mean differences of the d2-R scores in the three different auditory conditions (music, noise and silence). A repeated measures analysis of variance (rm-ANOVA) was conducted with the three d2-R components (concentration, working speed, working accuracy) as separate measures. The second research question addressed the influence of MWQ and ADHD characteristics on the d2-R scores in the three listening situations. This was studied using rm-ANOVA. The two groups formed from the combined MWQ and ASRS scores (see 2.2.2 Questionnaires) were included to rm-ANOVA as between subjects factors.

Because the cut-off score of the combined ASRS and MWQ -groups considering the second hypothesis was decided arbitrarily by the authors, a correlational analysis was done using the original MWQ and ARSR scores. Correlational analysis, alongside ANOVA, was conducted for the possible and additional information about the connections between individual characteristics and attention test scores. In addition, the questionnaire scores were continuous variables which promoted the usage of correlational analysis. To be able to compare the influence of attentional processes (ARSR) and proneness to mind-wandering (MWQ) to the influence of background music, two more variables were created for correlational analysis. These variables indicated the difference in the d2-R scores in music and noise situations and music and silence situations. These variables were named music-noise (M-N) and music-silence (M-S) variables. M-N and M-S variables were created for all three components of the d2-R (concentration, working speed and working accuracy). After that, a correlational analysis was conducted using MWQ and ARSR scores as variables with M-N and M-S.

The third research question was studied by using rm-ANOVA where musical training and the usage of music groups (see 2.2.2 Questionnaires) were defined as between subjects factors. In addition, we examined the d2-R scores in the order of the trials ignoring the auditory situation. This was investigated using repeated measures ANOVA.

### 3. RESULTS

The overall variation in the d2-R test scores was moderate between subjects (min. 178, max. 303), but in general the test group performed above the European norm. The first research question addressed whether attention test scores vary between three auditory situations. Statistical analysis contrary to the hypothesis, resulted in no statistically significant differences in the three d2-R variables. The auditory situation did not affect overall d2-R test scores. ANOVA results can be found in table 2.

TABLE 2. ANOVA results for the differences in the d2-R (concentration, working speed and working accuracy) scores in three auditory situations (music, silence and noise)
($F$ = F-ratio, $df$ = degrees of freedom, $p$ = statistical significance, $\eta_p^2$ = partial eta squared)

| Variable | $F$ | $df$ | $p$ | $\eta_p^2$ |
|---|---|---|---|---|
| Concentration (C) | 0.731 | 2,28 | .490 | .050 |
| Working speed (WS) | 0.709 | 2,28 | .501 | .048 |
| Working accuracy (WA) | 0.528 | 2,28 | .595 | .036 |

The second research question addressed whether the combined MWQ and ASRS scores affect the connection between the d2-R scores and auditory situation. Statistical analysis, contrary to the second hypothesis, resulted in no statistically significant main effects or interaction effects. Interaction effects, being the most relevant for our research question, are reported in table 3. The MWQ and ASRS characteristics did not have an effect on the varying d2-R results in different auditory situations. Correlational analysis for the second research question did not reveal any significant correlations between the d2-R variables and ASRS and MWQ scores indicating no apparent dependence between the variables.

TABLE 3. Interaction effects of the d2-R variables (C = concentration, WS = working speed, WA = working accuracy) and MWQ+ASRS group
(*F* = F-ratio, *df* = degrees of freedom, *p* = statistical significance, $\eta_p^2$ = partial eta squared)

| Variable | *F* | *df* | *p* | $\eta_p^2$ |
|---|---|---|---|---|
| C * MWQ+ASRS group | .356 | 2,26 | .704 | .027 |
| WS * MWQ+ASRS group | .147 | 2,26 | .864 | .011 |
| WA * MWQ+ASRS group | 1.679 | 2,26 | .206 | .114 |

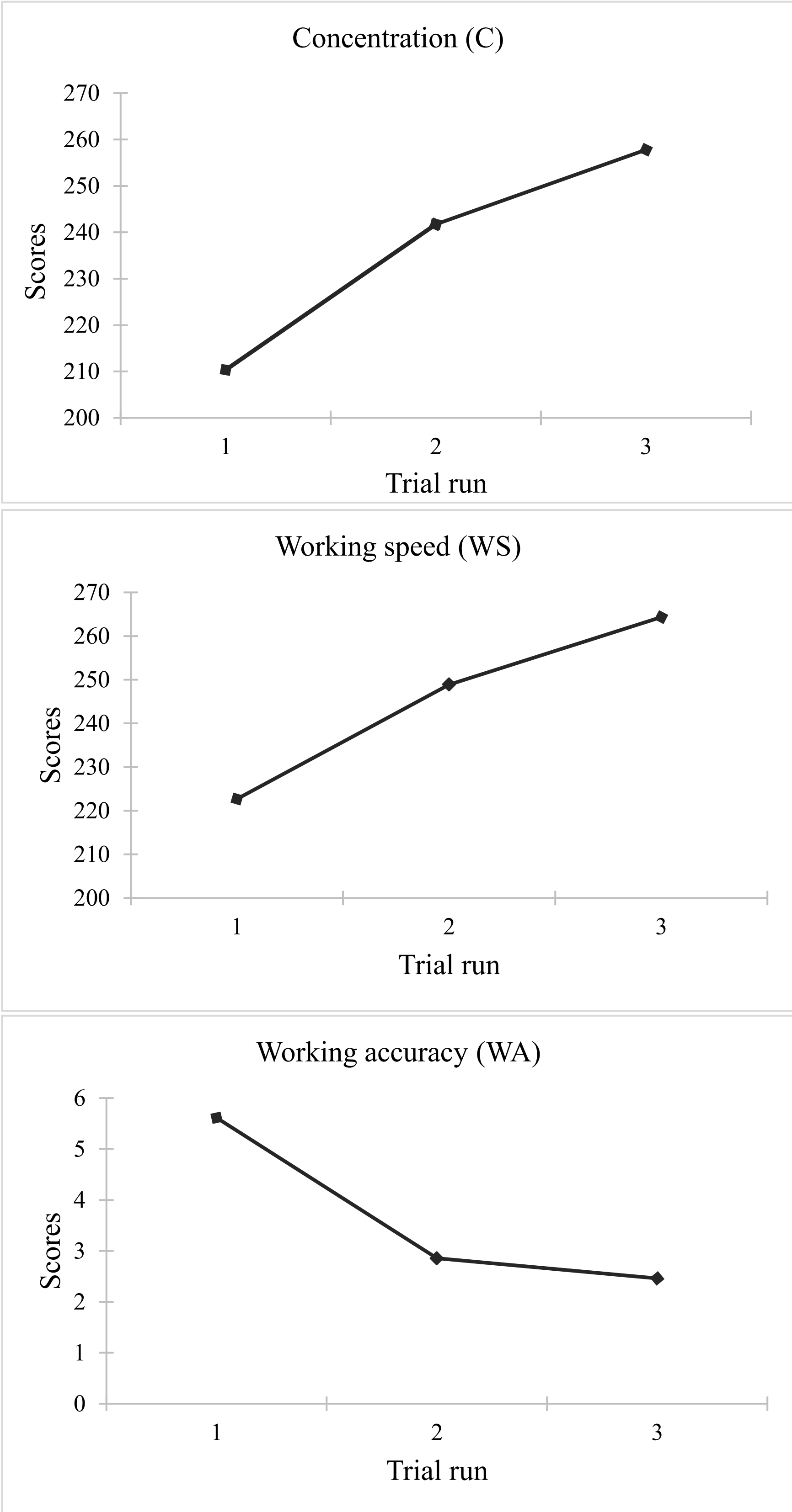
The third research question focused on the influence of demographic variables, musical training and the usage of music while studying, on the d2-R scores in auditory situations. Statistical analysis, contrary to the hypothesis, resulted in no statistically significant main effects or interaction effects. Interaction effects are reported in table 4. These demographic variables did not influence how the auditory situation affects the attention test scores.

TABLE 4. Interaction effects of the d2-R variables (C = concentration, WS = working speed, WA = working accuracy) and musical background and music usage
(*F* = F-ratio, *df* = degrees of freedom, *p* = statistical significance, $\eta_p^2$ = partial eta squared)

| Variable | *F* | *df* | *p* | $\eta_p^2$ |
|---|---|---|---|---|
| C * Musical background | .356 | 2,26 | .704 | .027 |
| WS * Musical background | .147 | 2,26 | .864 | .011 |
| WA * Musical background | 1.679 | 2,26 | .206 | .114 |
| C * Music usage | .937 | 4,24 | .460 | .135 |
| WS * Music usage | .809 | 4,24 | .531 | .119 |
| WA * Music usage | 1.812 | 4,24 | .159 | .232 |

The only statistically significant results were found from the consecutive d2-R test trial scores. The scores tended to improve as a function of trial order, indicating that learning effect was present. The learning effect was present in all d2-R variables; concentration ($F$ (2,28) = 47.204, $p$ = .00*, $\eta_p^2$ = .772), working speed ($F$ (2,28) = 35.290, $p$ = .00*, $\eta_p^2$ = .716) and working accuracy ($F$ (2,28) = 12.182, $p$ = .00*, $\eta_p^2$ = .465). This illustrates a clear gradual increase in test scores (see figure 1.), regardless of the auditory stimulus. Pairwise comparisons revealed the improvement as a function of trial order. Concentration scores were better for the first than the second ($p$ = .00*), the second than the third ($p$ = .007*) and the first than the third ($p$= .00*) trials. The same phenomena was found in working speed scores (1&2: $p$ = .002*, 2&3: $p$ = 0.12*, 1&3: $p$ = .00*). In working accuracy the scores were significantly better for the first than the second ($p$ = .004*) and the first than the third ($p$ = .004*) trials. There was no significant difference between the second and the third trial ($p$ = 1.00). The existing learning effect was an unexpected result, given the fact that the test is extensively researched.

FIGURE 1. Mean scores in Concentration, Working Speed and Working Accuracy for each trial run



## 4. DISCUSSION

The main purpose of this study was to find out whether background music improves attention performance. Acknowledging the individual differences in personality and musical background, this study aimed to consider the many aspects and relationships regarding music and attention. We aimed to clarify possible effects systematically because the research before is controversial and has not reached consensus.

The first research question considered whether attention test scores are different in three auditory conditions: music, noise and silence. Our hypothesis was that music enhances the attention test performance resulting in the highest test scores in music condition. However, we could not find any differences between the three situations indicating that music was not better for attention than silence or noise. Second research question concentrated on the individual differences in mind-wandering and attentional processes. We examined whether music improves the attention test performance of those people with high scores in MWQ and ASRS. However, there were no differences or correlations between the MWQ and ASRS scores and the d2-R scores in different auditory conditions. Hence our second hypothesis was not supported. Third, we studied whether musical training or the habit of listening to music while studying influence the results of the attention test in music, noise or silence. Contrary to our hypothesis, there were no differences in these groups either. Although there were no statistically significant differences considering hypotheses, qualitative variation between people was possible to observe. Especially time vs. accuracy trade-off was noticeable. Some participants followed a more accurate approach where wrong answers were minimised. However, this approach took more time and resulted in decrease in overall points. Other participants concentrated on performing more quickly which led to multiple wrong answers and an overall decrease in the test points.

The only statistically significant result in our study was that the participants improved their test scores in every consecutive trial, regardless of the auditory stimulus. This indicates a clear learning effect on the d2-R test in our sample. The result was surprising given the fact that the previous results about the validity of the test are optimistic (Hogrefe, 2020) and only recently multiple issues regarding the d2-R have been identified (Wühr, 2019). This study revealed that increase in the test scores happens also between the second and the third trial. Therefore to counterbalance the effect of trial order in within-subjects design there should be more than one trial for introduction or orientation. The usage of the d2-R in within-subjects paradigms should be questioned and more research about the validity of the d2-R is needed. When accounting practice benefits and situational stress factors in the first test trial, it becomes evident that in a repeated measures paradigm, the d2-R test scores illustrate also other cognitive processes in addition to attention.

Previous studies have found varying results on how listening to music affects attention and other cognitive processes. Therefore our results agreed with some previous studies but at the same time disagreed with others. Previous research has indicated that listening to music has the ability to affect short-term performance in multiple areas, such as spatial processing (Rauscher et al., 1993), reading comprehension (Kiger, 1989) and working memory (Mammarella et al., 2007) but there are also studies that have found no significant effect (Furnham & Allass, 1999; Newman et al., 1995). When it comes to attention, the results are also inconsistent. Some studies have found detrimental effects (Alikonis et al., 2002) and some studies suggest that listening to music is beneficial for attention (Gonzalez & Aiello, 2019; Jaušovec & Habe, 2003; Morton et al., 1990). However, in our study we found neither detrimental nor enhancing effects when background music was compared to silence and noise. Our study is somehow in line with the previous research in this area because it seems that unequivocal results are rare.

Previous studies have argued whether music affects through emotional valence or directly to one's cognitive abilities (see 1.1 Music listening and cognition). We hypothesised that an optimal level of (musical) arousal temporarily improves attentional resources. Because every individual has their own optimal arousal level and musical liking, we gave our participants a possibility to choose their volume level and musical pieces (see 2.2. Experimental design). The three different situations, a randomised trial order between test subjects and information from the participants allowed us to compare multiple different scenarios and factors and observe statistical and correlational linkages. In the end, we could not find an answer whether music affects cognition directly or through emotions.

We studied also the connection between music listening, mind-wandering and inattention, which only a few previous studies have concentrated on. Gonzalez and Aiello (2019) speculated that background music could help to maintain attention by preventing mind-wandering and boredom. This is something we hoped to see especially with participants that had high scores in MWQ. However, we could not find this connection in our study. To our knowledge, there are only a few studies that have linked MWQ with music. Recent study by Kuschpel and others (2015) investigated whether mind-wandering acts as a moderator in the connection between breaks and working memory. We could not find any studies that would have linked music, mind-wandering and attention.

There are a number of theories and hypotheses, in addition to the ones we have already mentioned, that have tried to clarify the relationship between music and cognition. Perham and Vizard (2011) for example highlight the irrelevant sound effect -paradigm and its impact on various mental tasks, whereas Baldwin and Lewis (2017) focus more on vigilance and alternative theories around it, including "attentional restoration theory". Still others have taken a more neuroscientific approach (see for example Jäncke, Kühnis, Rogenmoser & Elmer, 2015; Jaušovec et al., 2006) but the results have been inconsistent. Different ideas and viewpoints are successfully being presented in previous studies but their ecological validity has been difficult to verify. Music psychology field is still young and the lack of unity among theory and experimental design allowed us to approach the topic openly. Although the main idea of music as a powerful modulator is well studied and understood (Miller et al., 2017; Särkämö & Huotilainen, 2012), there are still some unresolved questions about the way people experience, perceive and utilise music. By choosing two opposing theories (see 1.1.1 Theoretical framework of background music and cognition), it was possible to build a research paradigm where results would support one of the major theories presented. The ambiguity of the field gave us an opportunity to take a critical but neutral perspective when searching for theories and methods. This is a crucial part of scientific research and a major advantage of this study.

The main advantage of this study compared to others before was the usage of "concentration" music and controlling familiarity and emotional connections to the music pieces (see 2.2 Experimental design). Focus and study playlists are a rather new phenomena but still adapted by many listeners. Previous research in the field of music psychology has not concentrated on whether these playlists really enhance studying or other aspects of human cognition. When looking into the amount of different news reports, articles and speeches (see for example Burnett, 2016; Gillett, 2015; TEDx Talks, 2016; Vaughn College, 2018), it seems that modern musical topics fascinate a wide audience. However, the scientific methodology and experimental design have not stabilised and therefore valid and scientifically proven results are lacking. Some studies have concentrated on low-arousal music (see for example Cockerton, Moore & Norman, 1997) but these studies have been conducted prior to the time of focus playlists. This study sought to update some of the methodological elements adopted in the field therefore bringing scientifically proven data closer to everyday life. By emphasising the ecological validity of the situation, we were able to provide an experimental design that was controlled and valid but also as authentic as possible.

The experimental nature of this study resulted in a few restrictions. The incoherent framework of the field, where there were no systematic conceptions or results, complicated the creation of our experimental setting. With complex concepts as music and cognition, straightforward answers are rare. First restriction was linked to the noise we used in this study. Some of our results may have been due to the Babble effect (Jones & Macken, 1995), meaning our selected noise was actually beneficial to the participants. We wanted the noise stimulus to be emotionally neutral and as authentic as possible but not too disruptive. This way we controlled mood and complexity between the listening situations. However, earlier studies have found for example white noise to be beneficial as well (Söderlund, Sikström & Smart, 2007; Angwin et al., 2017) and since its popularity, some of our participants could have been using it in their everyday life. In addition, we allowed the participants to self-adjust the volume level to their own preference within the previously settled volume range. The purpose was to create an ecologically valid situation but this might have caused the people to purposely decrease the volume to perform better in the test.

Another restriction was related to the musical components. Jones and Macken (1995) as well as Mehta, Zhu and Cheema (2012) emphasise the difference between "sound level" and "loudness", which we were not able to control in this study. Another problem was the arousal level of music which we were not able to measure or control in a valid way. Furthermore, since the researchers personally selected the musical pieces, there might be a bias in the playlist. Because of this, some participants may have reacted differently to the music and therefore beneficial effects might have been impaired (see for example Schellenberg & Hallam, 2005). Because the musical pieces were not identical between the participants, the controlled setting required in scientific circumstances was compromised. However, this allowed us to highlight individual preferences regarding music and therefore bring our research design closer to everyday situations.

There were also limitations concerning the selected attention test. Attention is a complicated phenomenon consisting of many sub-divisions and it is closely linked to many other cognitive processes. It is challenging to find a test that would measure purely attention. Even though the d2-R is presented as an attention test, performing it also requires other cognitive processes like working memory. In addition, the d2-R concentrates on visual attention while ignoring auditory and other sub-divisions of attention. Using other tests like Flanker, n-back, SART, Stroop or TMT-A & B could have resulted in different results. Another restriction concerning the d2-R test is the degree of difficulty. The d2-R is a complicated test that requires persistent concentration from the participants, but when done systematically, the ceiling effect is relatively easy to achieve. Therefore the possible benefits of music might not have been found in this study and more effortful and complex tests could have revealed the possible effects. However, Gonzalez and Aiello (2019) argued that if the task is too difficult and complex, it demands undivided attention from the participants and attention is disturbed by any distraction. This means that simply adding complexity to the task does not automatically elevate the possible benefits of music. Also contrary to Gonzalez and Aiello's (2019) theory, in our study silence was not significantly better for the task results either. Altogether task complexity, linked with confounding variables, is something that future studies should focus on. It is also possible that music does not affect learning or studying through attention but through some other cognitive process.

Another restriction in our study was linked to the COVID19-pandemic. By the time the situation in Finland worsened we had measured only half of the participants intended in the beginning. Because of the lockdown we could not measure more participants and we had to execute statistical analysis with only fifteen participants. Therefore the number of participants was small and some phenomena may have left unseen in the statistical analysis. Another limitation is the heterogeneity of the participants. All participants were university students and nearly the same age. This means that it is not meaningful to generalise these results to a larger population. The results may have altered with different participant group.

Present study resulted in only a few answers and perspectives, but more questions regarding background music and its possible effects on cognition. As seen, there is a limited number of studies that connect background music and attention, not to mention mind-wandering. Linking these three together would provide important knowledge on how to help people with attention problems or proneness to mind-wandering. This is something that future studies could target more. It would be useful to know more about the true impact of concentration music on learning since similar music is becoming more popular. It would also be desirable for the future studies to concentrate on the operationalisation of the variables so that specific questions are answered. Our study shows that with a simple experiment it is challenging to demonstrate connections between two big topics such as music and attention especially when underlying concepts are hard to define. It would also be advantageous to have more extensive research equipment so that musical and physiological variables would be as exact as possible. Using MEG or fMRI for example, it would be possible to determine some event-related phenomena and large-scale brain activation during music listening and various cognitive tasks.

When it comes to ecological validity, we were able to generate a relatively accurate and consistent situation without compromising scientific principles. This is something that future studies should really consider and develop in order to take some of the results into practice. Different real-life scenarios must be observed alongside with the scientific context and then transferred into experimental settings. This is especially true with field studies of music (Nilsson, 2008; Brotons & Koger, 2000; Silverman & Marcionetti, 2004; Cheek, Bradley, Parr & Lan, 2003) which suggest that music can help people in multiple situations. All this would create a more unifying field of research where musical knowledge eventually accumulates. And although music, like any kind of art, is hard to fit in a scientific environment, it is still worth exploring and investigating. Our study may not have found any significant results considering music and attention, but nevertheless it indicated new paths for the future studies in the field of music psychology.

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**APPENDIX**

**Appendix 1.** *Concentration music playlist*

| Title | Artist | Album | Length |
|---|---|---|---|
| Aware | Inkognitone | Aware | 2:55 |
| Bouncing Clouds | Sava Sol | Bouncing Clouds | 4:50 |
| Colors Of The Moon | Mandala Dreams | Winds Of Fuji | 3:50 |
| Curiosity | Beau Projet | Curiosity | 2:36 |
| Divine | Tejal Yann | Divine | 4:50 |
| A Fighting Chance | Trevor Kowalski | Degrees Of Separation | 3:11 |
| Flower | Steven Goldmund | Analogue Nature | 4:39 |
| Golden Chant | Joseph Beg | Gentle Arrival | 5:10 |
| Halving the Compass | Helios | Helios Remixed | 6:43 |
| Immersive Minds | Pim Miles | Ambient Fields | 3:29 |
| Interstatus | Steven Goldmund | Deep Below | 4:06 |
| Kyoto | Kumbhaka | Yoga Music | 2:43 |
| Looped | Kiasmos | Kiasmos | 6:01 |
| Magnolia | Fleurs de Son | Magnolia | 4:03 |
| Mind Drift | Steven Goldmund | Drift Off | 4:00 |
| Paranormal | Empty Space | Paranormal | 4:30 |
| Poekhali | 36 | Tomorrow's Explorers | 7:50 |
| Polar Drone | Binaural Landscapes | Drones | 3:55 |
| Proceed | Corre | Form | 4:15 |
| Roots | Jakob Ahlbom | Escaping Reality | 3:34 |
| Selah | They Bream By Day | Selah | 6:52 |
| Silent Letters | Hushed | A Faint Glow | 4:54 |
| Silent Memories | Calm Shores | Fall Of A Raindrop | 4:12 |
| Soft Upon Your Face | Ave Air | Paper Thin Reality | 3:15 |
| Solar Sailer | Daft Punk | TRON: Legacy | 2:42 |
| Supine | Clifford Solum | Supine | 3:50 |
| Tell Me And I'll Forget | Rand Aldo | Time Is But A Wellspring | 2:53 |
| To the corner of Your Soul | Primer Dia | Floating, Always | 2:43 |
| Wings of Glass | La Reve | Wings of Glass | 2:56 |
| Yoga Spirit | Spirit Of Our Dreams | Dream Helpers | 4:12 |

**Appendix 2.** *Mind-wandering questionnaire (MWQ)*

Mind Wandering Questionnaire (MWQ) Pvm:
(suomennettu versio)

Rastita jokaisen kysymyksen kohdalla sinulle sopivin vaihtoehto.

1 = ei lähes koskaan
2 = hyvin harvoin
3 = melko harvoin
4 = melko usein
5 = todella usein
6 = lähes aina

| Kh numero: | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Minulla on vaikeuksia ylläpitää keskittymistä yksinkertaisen tai itseään toistavan tehtävän aikana. | | | | | | |
| 2. Lukiessani huomaan, etten ole keskittynyt tekstiin ja joudun lukemaan sen uudestaan. | | | | | | |
| 3. Teen asioita kiinnittämättä niihin kunnolla huomiota. | | | | | | |
| 4. Huomaan ajattelevani muita asioita, kun minun pitäisi kuunnella toisia. | | | | | | |
| 5. Mieleni vaeltelee muissa asioissa luentojen ja esitelmien aikana. | | | | | | |

**Appendix 3.** *ASRS Questionnaire*

## ASRS — v1.1

| **Kh numero** | | **Päivämäärä** | | | | | |
|---|---|---|---|---|---|---|---|
| Olkaa hyvä ja vastatkaa alla oleviin kysymyksiin oikealla näkyviä vaihtoehtoja käyttäen. Kunkin kysymyksen kohdalla rastittakaa se ruutu, joka parhaiten kuvaa vointianne ja pärjäämistänne yleisesti. | | | Ei koskaan | Harvoin | Joskus | Usein | Hyvin usein |
| 1. Kuinka usein Teidän on vaikea tehdä tehtäviä loppuun saakka sen jälkeen, kun haastavat tai mielenkiintoiset osat on tehty? | | | | | | | |
| 2. Kuinka usein Teillä on vaikeuksia järjestelmällisyyttä vaativissa tehtävissä? | | | | | | | |
| 3. Kuinka usein Teidän on vaikea muistaa velvollisuuksianne tai sovittuja tapaamisianne? | | | | | | | |
| 4. Kun Teidän pitäisi tehdä tehtävä, joka vaatii paljon ajatustyötä, kuinka usein vältteletet sitä tai viivyttelette sen aloittamista? | | | | | | | |
| 5. Kuinka usein kiemurtelette tai liikuttelette levottomasti käsiänne tai jalkojanne kun joudutte istumaan paikoillanne pitkään? | | | | | | | |
| 6. Kuinka usein Teillä on yliaktiivinen olo ja tunnette pakonomaista tarvetta tehdä asioita, ikään kuin sisällänne olisi moottori? | | | | | | | |
| 7. Kuinka usein teette huolimattomuusvirheitä, kun Teidän täytyy tehdä jotain tylsää tai vaikeata? | | | | | | | |
| 8. Kuinka usein Teidän on vaikea keskittyä tekemäänne, kun teette tylsää tai samanlaisena toistuvaa työtä? | | | | | | | |
| 9. Kuinka usein Teidän vaikea keskittyä siihen, mitä muut sanovat, vaikka he puhuisivat suoraan Teille? | | | | | | | |
| 10. Kuinka usein hukkaatte tavaroitanne tai Teidän on vaikea löytää niitä kotona tai töissä? | | | | | | | |
| 11. Kuinka usein häiriinnytte ympäristönne tapahtumista tai äänistä? | | | | | | | |
| 12. Kuinka usein lähdette liikkeelle kokouksissa tai muissa tilanteissa joissa Teidän tulisi istua paikallanne? | | | | | | | |
| 13. Kuinka usein liikehditte hermostuneesti tai tunnette olonne levottomaksi? | | | | | | | |
| 14. Kuinka usein Teidän on vaikea rentoutua tai rauhoittua silloinkin kun Teillä on aikaa itsellenne? | | | | | | | |
| 15. Kuinka usein huomaatte puhuvanne aivan liikaa ollessanne ihmisten seurassa? | | | | | | | |
| 16. Kuinka usein jatkatte keskustelukumppaninne lauseen loppuun, ennen kuin hän itse ehtii tehdä sen? | | | | | | | |
| 17. Kuinka usein Teidän on vaikea odottaa vuoroanne tilanteissa, joissa niin pitäisi tehdä? | | | | | | | |
| 18. Kuinka usein keskeytätte toisten tekemiset, vaikka he olisivat kiireisiä? | | | | | | | |

**Appendix 4.** *Background information questionnaire*

Esitietolomake

*Music in Mind*

*Pro Gradu -tutkielma*

Päivämäärä: ____________

Nimi (etu- ja sukunimi): ____________________________________________

Ikä: ____________

Sukupuoli: ____________

Sähköpostiosoite: ____________________________________________

Musiikillinen tausta (oletko harrastanut soittamista/laulamista, kuinka monta vuotta ja missä):

________________________________________________________________________________

________________________________________________________________________________

Kuunteletko musiikkia opiskelu/keskittymistilanteessa?

- Hyvin usein ☐
- Usein ☐
- Joskus ☐
- Harvoin ☐
- Ei koskaan ☐

Millaista musiikkia?

________________________________________________________________________________

________________________________________________________________________________

Valitut musiikkikappaleet:
1.
2.
3.
4.
5.