The Effects of Balanced and Unbalanced Bilingualism on the Discrimination Between Musical Stimuli

MA-Thesis

Taal, Mens en Maatschappij

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Chapter 1: Introduction

Both music and language are distinct human phenomena and both phenomena are prominently present in the daily lives of mankind. Music and language require cognitive resources to be processed and it has been argued that musical training and bilingualism, due to intensive use of these resources, both enhance cognition. When one decides to start playing a musical instrument or starts taking music lessons, the reason is generally not to improve one's cognitive skills. This is, however, a secondary effect of learning to play a musical instrument. Musicians, for example, are sometimes found to be better at processing musical and linguistic stimuli. There are, thus, additional advantages to receiving musical training besides learning to play an instrument, which is the main goal of taking musical lessons. Bilingualism is similar to music in the sense that it has another effect besides the fact that will learn to speak more than one language. This effect is an enhancement of cognition, specifically it increases inhibitory control. Inhibition is the cognitive skill that represses irrelevant information and stimuli. Both music and language increase cognitive skills, and this enhancement of cognition may have an influence on other tasks that require cognitive resources.

There has been ample research on the effect of musical training on learning languages and linguistic processing and it has been suggested that musical training can positively affect language learning and processing. The effect of bilingualism or more linguistic experience on musical abilities, however, has not been sufficiently researched. The purpose of this thesis is to investigate whether linguistic experience can influence the perception of music and the discrimination between musical stimuli, to explore the relationship between music and language, and to see whether bilingualism, speaking more than one language, can influence musical abilities in a similar manner as musical abilities can influence linguistic processing (Slevc and Miyake, 2006). A musical discrimination experiment will be used to determine whether bilingualism enhances the ability to discern between musical stimuli. Specifically, two types of bilinguals will be compared to determine the effect of additional linguistic experience: unbalanced and balanced bilinguals.

This thesis will start with a review of the literature in chapter 2. This review contains information on what bilingualism is and what specific cognitive advantages are found in bilingual people as opposed to monolingual speakers. The effects of musical training on cognition and cognitive skills will be explored and the effect of musical training on linguistic processing will also be discussed. Furthermore, a comparison between language and music will be made, focusing on different aspects of language and music such as semantics and harmony, and syntax and musical structures. It will explore the differences and similarities that exist between music and language. After the literature review, the hypotheses and predictions will be stated in chapter 3 and the method of the discrimination experiment called the Musical Ear Test that was conducted will be given in chapter 4. Chapter 4 includes information on the participants and the experimental procedure. Subsequently, the results will be given and analysed chapter 5 and 6. This analysis will be followed by a discussion chapter 7 in which the theories discussed in the literature review will be considered in the light of the results of the experiment. Chapter 8 will be the conclusion in which it will be determined whether the hypotheses posed in this study can be confirmed or rejected.

Chapter 2: Literature Review

2.1 Bilingualism

Defining bilingualism is fairly difficult, according to Beardsmore (1986), since there are many types of bilingualism and there is not always consensus on what constitutes a bilingual person. This section will, however, attempt to define the different types of bilingualism nonetheless. In general, Beardsmore states, a bilingual person is someone who is somewhat proficient in two languages and alternates between using these languages.

A *simultaneous bilingual* is someone who acquires two languages very early in her or his life. He or she acquires two languages at once, some say before three years of age. Early bilingualism is similar, and both simultaneous and early bilinguals acquire two languages during their "pre-adolescent" phase of life (Beardsmore, 1986). It has been suggested that these types of bilinguals enjoy most cognitive advantages (Baker, 2001).

A *late bilingual* is a second language learner that starts learning a second language after the critical period has passed, generally after the first eleven years of life (Beardsmore, 1986). The critical period will be discussed in detail in the next section. A late bilingual starts acquiring a second language when one has already fully acquired their first language (Beardsmore, 1986).

A *balanced bilingual* is someone who speaks two languages and is roughly equally proficient in both languages. De Groot (2011) argues that the dispersion 40%-60% and 60%-40% can be considered balanced bilingualism. In this thesis, there will be slightly more leniency, namely the percentages will be 33%-67% and 67%-37%. Balanced bilinguals may not have the same proficiency as two monolingual speakers of the languages they have acquired (Beardsmore, 1986). *Unbalanced bilingual* speakers are not equally proficient in both languages, but have one language that is dominant. For this study, one must speak their second language at least 5 percent overall. It is also possible that people are balanced bilinguals in certain vernaculars and unbalanced in other vernaculars. This may mean that one only uses their second language in very limited situations and thus may not receive the cognitive advantages one enjoys when using two languages in more or all situations in life.

2.2 The Critical Period Hypothesis

It has been generally accepted that acquiring a language is easiest at a young age. First language acquisition generally happens automatically, and learning a second language at a young age is also relatively easy. Learning a second language later in life, however, can be very difficult. The Critical Period Hypothesis (CPH), first devised by Lenneberg (1967), states that there is a period in which full language acquisition is possible, but once this period has passed, language cannot be acquired fully or normally anymore (Schouten, 2009). This critical period was said to be up to adolescence. After this period brain plasticity decreases and people may have less access to a language acquisition device, if such a device exists (Beardsmore, 1986).

There is evidence supporting the CPH and evidence against the CPH. Evidence for the CPH is generally found in the fact that it is very difficult to acquire a language fully when one starts learning a language after adolescence. Becoming a near-native speaker is often said to be nearly impossible (McDonald, 2000). A famous example in support of the CPH is Genie's case. Genie was a child that was deprived of linguistic input in her youth. When she was found, many efforts were put into teaching her English, but she never fully acquired the language (Schouten, 2009). This suggests that there is a timeframe in which one must start learning a language, however, this cannot be interpreted as fool proof evidence since it cannot be determined whether Genie would have acquired language normally if she was exposed to language from birth or whether she suffers from other deficiencies. Other such examples do not exist. Evidence against the CPH is found in the fact that occasionally, there are people who fully acquire a second language at a later age (McDonald, 2000). According to McDonald (2000), level of acquisition and difficulty of acquisition may be dependent on how similar someone's L1 is to the L2 he or she is learning. She tested this claim by subjecting different second language learners to a Grammaticality Judgement Task. The bilinguals, or second language learners, in question were early Spanish and Vietnamese learners of English and late Spanish and Vietnamese learners of English. Spanish is more similar to English than Vietnamese is to English and the results from MacDonald's study show that Spanish early and late acquirers of English perform better than the Vietnamese acquirers of English. Similarity of one's L2 to the L1 seems to have an effect on the extent of acquisition.

McDonald is not the only one who reports that similarity of L2 to L1 has an influence on the acquisition of a second language. Van Wuijtswinkel (1994) investigated Dutch late learners of English and the possibility of ultimate attainment. It was found that the late learners were not significantly different from native speakers of English. Kellerman (1995), who mentions Van Wuijtswinkel's (1994) study in a paper, suggests that the similarity of the L1 to the L2 influences whether or not one can achieve a native-like ability in a second language.

The critical period for the acquisition of phonology is sometimes said to be shorter than for other aspects of language. It seems to be very difficult for second language learners to acquire a foreign accent, even with ample amounts of training and lessons (Oyama, 1976). In a study by Oyama, it was investigated whether it was possible for late learners of English to acquire phonological aspects of this second language. The participants in this study were immigrants from Italy to the US. Their age of arrival was between 6 and 20 years of age. The participants were recorded when casually speaking and they had to perform a reading task. Their foreign accents were judged by two judges who agreed on most of their judgements. It was found that there was a strong effect of age of arrival, in both tasks, while numbers of years in the US had virtually no effect on the results. The youngest arriving participants scored in the 'normal' range, and participants that arrived after the age of 12 were generally considered outside the 'normal' range and. Additionally, according to Oyama (1976), heavy non-native accents appear well before this particular age of arrival (an earlier age of arrival may still influence acquisition of accent severely). It seems, thus, very difficult to learn a second-language accent and only the very early arrivals were considered to sound native.

Munro, Flege, and Mackay (1996) studied the effect of age of arrival of Italian speakers to Canada on the acquisition of a foreign accent. The age range of arrival was between 2 and 23 years of age. The participants were recorded speaking words in a sentential context and these recordings were edited and foreign accentedness was subsequently judged by native speakers of English. The judgements by native speakers show that the positivity of ratings decreased when age of arrival increased. Learners of English that had a late age of arrival were judged to have a heavier accent than speakers who arrived at an early age, according to Munro et al.. A foreign accent was detected for participants who arrived as early as 7,5 years of age, which may suggest that the critical period for acquisition of phonology ends before this age. However, degree of foreign accent differed per vowel. Not all vowels were simply unintelligible. To test whether native speakers were able to discern what vowel a non-native speaker was using, a vowel identification task was designed. The recordings gathered in the first experiment were also used in this experiment. Most vowels were correctly identified above chance level, one vowel, however was not. The [ʌ] vowel was only correctly identified only 25% of the time. These results suggest that Italian learners of English do not simply substitute English vowels with Italian vowels but that they can learn, to some extent, that these vowels are different from Italian vowels. Errors were oftentimes found to within category errors. Instead of wrong vowel use the Italian speakers used the correct vowel but did not pronounce it in a native-like manner. In general, early arrivals were judged to have unaccented speech while late arrivals were judged to only be able to pronounce a few vowels without a foreign accent, but these accented vowels are still identifiable, according to Munro et al. (1996). Non-native speakers may be able to learn new vowel categories beyond the critical period, but pronouncing them in a native-like manner is difficult when one starts learning language at a later age.

The consequence of the concept of a critical period for the current study is that it might be the case that a late bilingual (a late learner of a second language) may not develop in the same way early, simultaneous bilinguals develop. It may be possible that late bilinguals, due to a critical period, do not attain the same cognitive advantages as simultaneous and early bilinguals. Another question that must be addressed is whether any learner of a second language can be considered to be bilingual, or whether there is a threshold one must surpass to be considered a bilingual. In this thesis, a person is bilingual even when one is a late learner of a second language. However, this person must use their second language at least somewhat in their daily life. A questionnaire will determine level of bilingualism, and the participants will be divided in groups, one group being unbalanced bilinguals and the other balanced bilinguals. The exact specifications of balanced bilingual participants and unbalanced bilingual participants and other biographical information can be found in the chapter four of this thesis.

2.3 Bilingualism and Cognition

In the past, it has been said that bilingualism disadvantages and confuses children. Some doctors have even argued that raising a child bilingual causes mental disorders. It was once believed that bilingualism would cause cognitive disadvantages instead of advantages and that one would not be able to use the brain to its full advantage as two languages are already taking up space in the brain (Baker 2001). These claims are now generally regarded as untrue;

however, there may actually be actual disadvantages for children due to their acquisition of two languages, such as the fact that they receive less input per language than monolingual receives for their single language. Both languages take up (roughly) half the input (Baker, 2001). This causes bilingual children to have a smaller lexicon per language which makes it seem like bilingual children know less than monolingual children. However, more recent studies suggest that bilingualism actually causes several advantages for the speaker and a smaller lexicon per language does not necessarily mean a smaller lexicon in total (Baker, 2001).

2.3.1 Inhibition

It is often argued that one of the advantages of being bilingual is an increase in inhibitory skills. Inhibition is the cognitive skill that one uses to repress and ignore irrelevant information and stimuli. According to Bialystok, Craik, Green, and Gollan (2009), the generally assumed easy act of using language is not as simple for bilingual speakers as it is for monolingual speakers, as two languages, or more in the case of multilingual people, need to be activated and deactivated and the speaker must suppress one of these languages. Choosing what language to speak, "language selection" (Bialystok et al., 2009, p. 93), is inherently bilingual and this causes bilinguals to use more cognitive resources when using language which enhances cognitive abilities such as inhibition and selective attention (which entails choosing what information to focus on and ignoring irrelevant information).

Colzato, Bajo, van den Wildenberg, Paolieri, Nieuwenhuis, and La Heij (2008) also investigated this suggested advantage in inhibition skills. Colzato et al. argue that bilingual advantages mostly come down to inhibition and cognitive control, but that previous studies have not explained how and what mechanisms exactly drive inhibition. In their study, they wanted to explore two ways that "inhibitory control" (Colzato et al., 2008, p. 303) might be wielded. The first possibility is that inhibition suppresses noise from the irrelevant language. This is called active inhibition. The second possibility is that the target language is more activated while the non-target language is deactivated by inhibitory control. This second possibility, called reactive inhibition, does not imply inhibition of words from the non-target language, but simply a type of focusing on the target language. What type of inhibition bilingual participants use was tested in three experiments, two of which tested active inhibition while the last tested reactive inhibition. The participants were Spanish monolinguals and Dutch-English bilinguals. The first two tasks showed that there is no advantage for bilinguals when active inhibition is tested, as there were no significant differences found between monolinguals and bilinguals. The last experiment tested reactive inhibition. In this last task, significant differences between monolinguals and bilinguals were found. Bilinguals are better at ignoring irrelevant elements and noise, however, it seems that bilinguals have an advantage in only specific situations and that not active inhibition is enhanced but that reactive inhibition is enhanced.

Marian and Shook (2012) give an overview of the consequences of being bilingual for cognition. They argue that there is evidence suggesting that whenever a bilingual is in a speech situation, not one but two (or all) their languages are activated. When a German-English bilingual hears the word ‘tree’, the German translation of this word is also activated. There is linguistic competition between the languages and this competition causes an enhancement in executive functioning. Bilinguals, for example, perform better than monolinguals on a “Stroop” task, which is a task in which a participant is presented with contradicting stimuli and the participant must repress the irrelevant information. Even aging related deficiencies such as Alzheimer’s can be slowed down by being bilingual. Marian and Shook, however, do not define what types of bilinguals have these advantages or whether there is a threshold of linguistic experience one must surpass.

It seems that the cognitive skills that are enhanced due to bilingualism are mainly inhibition and inhibitory control, as a bilingual must repress one language and activate the other in any linguistic task. Evidence from studies by Colzato et al. (2008), Bialystok et al. (2009), and Marian and Shook (2012) all suggest that bilinguals are better at repressing irrelevant information and are thus more skilled in their inhibition. The next section explores whether there is a threshold for how bilingual someone must be to enjoy this enhanced inhibition.

2.3.2 Threshold Theory

In Baker's (2001) work on bilingualism and cognition numerous cognitive advantages for bilinguals are suggested, such as metalinguistic awareness, more knowledge of concepts and being less dependent on a single word for a single concept. It was even found that bilinguals have a different cognitive learning style, they are more field independent than monolinguals. Baker, however, proposes that these advantages are mainly found in people who are relatively balanced bilinguals and that there is a boundary one must cross before having access to advantages of bilingualism.

The Threshold Theory suggests that not every bilingual enjoys cognitive advantages, but that there is, as the name suggests, a threshold of bilingualism one must surpass to be able to enjoy these advantages. Bilinguals who are equally proficient in both languages will perform better cognitively than unbalanced bilinguals. Ricciardelli (1992) designed a study to test the claims of the Threshold Theory and investigated whether balanced bilinguals have more advantages over very unbalanced bilinguals and monolinguals in a battery of tests that tested metalinguistic awareness, creativity and cognition. Significant differences between very proficient, balanced bilinguals and unbalanced bilinguals were found. Overall, the balanced, proficient bilinguals performed better on the battery of tasks. The comparison between monolinguals and unbalanced bilinguals showed no significant differences. According to these results, the Threshold Theory seems to be confirmed. The advantages to bilingualism affected those bilinguals that were proficient in both languages and unbalanced bilinguals were comparable to monolinguals.

To summarise, bilinguals seem to have some cognitive advantages over monolinguals. It is however unclear when these advantages present themselves exactly, as not all studies are clear on what type of bilinguals were tested. It is sometimes argued that only relatively balanced bilinguals experience these advantages.

To ascertain whether musical ability gives one cognitive advantages, the next section will explore musical training and abilities and its effect on cognition.

2.4 Musical Ability and Cognition

Playing a musical instrument uses the brain's resources intensively. It requires many skills to play an instrument, such as reading musical notations and translating these into sounds, and the use of memory to remember passages of music (Miendlarzewska and Trost, 2014). It has been suggested that the intensive use of these resources can enhance cognitive skills.

2.4.1 Processing and Memory

Exposure to music and to musical training causes changes in the brain to occur. In a study on the effect of musical training by Paquette and Goulet (2014), it was found that after only fourteen months of musical lessons, children that received musical lessons differed strongly from children that did not receive musical training. The children that received musical training were found to have advantages in pitch processing and showed more efficient auditory processing. All these children were also tested before the onset of the fourteen months of musical lessons and at that point, there were no significant differences between these children. Cognitive advantages were also found in adults who received musical training.

Apparently, musical training has some effects on processing skills. There are two types of processing, global and local processing, according to Stoesz, Jakobson, Kilgour, and Lewycky (2007). Global processing refers to a type of processing in which people look at patterns and coherence in the stimuli they are presented with, one focusses on the entire stimulus as whole. On the other hand, local processing is a more detailed type of processing; one zooms in, so to speak, on a certain aspect of a stimulus and inspects this in detail. In general, it has been shown that people that have not received musical training, process music on a global level. Musicians do not have the same tendency as non-musicians to use only global processing skills when listening to music, but musicians process music also on a local level. The goal of the study by Stoesz et al. was to determine whether this local processing advantage could be translated to other tasks. To test this, two experiments were designed. The experiments were an embedded figures task and a task on testing constructional abilities (Stoesz et al., 2007). Attaining high scores in these types of task is associated with well-developed local processing skills (Stoesz et al., 2007). It was predicted that non-musicians would perform less well than musicians who started musical training at an early age. The results from both tasks showed that musicians significantly outperform the non-musicians. The local processing advantage that musicians enjoy when processing musical stimuli seems to be translatable to other tasks that require local processing skills.

Even though it seems that, according to Stoesz et al., there are processing advantages for musicians, there is conflicting evidence concerning the improvement of mental abilities through musical training, according to Brandler and Rammsayer (2003). Some studies have shown that musical training has no influence on intelligence, while other studies have shown that musicians are often highly intelligent but highly intelligent people are not always musically inclined. In several studies, it has been found that music is processed in the right hemisphere of the brain, and musicians may experience an advantage in cognitive tasks that require processing in this hemisphere. These studies, however, were investigations of non-musicians. It may be that musicians, as suggested in Stoesz et al., process music differently than non-musicians. The goal of Brandler and Rammsayer's study was to ascertain the effect of musical training on several aspects, such as "verbal comprehension, word fluency, reasoning space, and perceptual speed and memory" (Brandler and Rammsayer, 2003). Musicians and non-musicians, who were comparable in level of education, were subjected to the intelligence tests (Brandler and Rammsayer, 2003). Brandler and Rammsayer did not find statistical differences between non-musicians and musicians overall, but the groups did differ significantly from each other in some of the subtests. For example, non-musicians performed better on the topology subtest (topological reasoning is dealing with and processing spatial information according to Muller, 2012), while musicians scored significantly better on the verbal memory subtest. Musicians do not have a general advantage due to musical training on all cognitive aspects, but it may be that only very specific aspects are enhanced (Brandler and Rammsayer, 2003).

In general, the previously discussed studies show that there are some advantages to receiving musical training. It increases local processing abilities and verbal memory. It is, however, still impossible to definitively say that there are general cognitive advantages to being a musician, as the study by Brandler and Rammsayer (2003) shows that, overall, there are no significant differences between musicians and non-musicians. Generally, participants in studies such as those mentioned previously are highly educated and very intelligent and it would be interesting to see whether musical training has the same effect or maybe a greater effect on cognition on less educated people. This thesis does not test this idea, but it may be interesting to investigate this in future research.

2.5 The Auditory Cortex: the effect of Musical Training and Bilingualism

Bilingualism increases linguistic experience and this linguistic experience may change parts of the brain. Ressel et al. (2012) have shown that being bilingual has an effect on the auditory cortex. An experiment was conducted to compare monolingual participants with bilingual participants. MRI data were gathered and specifically, "anatomical images of Heschl's gyri" (Ressel et al., 2012) were acquired. Heschl's gyrus (HG) is one of the parts of the brain that process auditory stimuli and information. Ressel et al. found a difference in volume of HG between monolinguals and bilinguals. Bilinguals had significantly bigger HG's than monolinguals. There is, apparently, a difference between monolinguals and bilinguals and their auditory cortex.

It was found that musical training and musical expertise enlarges the same parts of the brain as bilingualism does, namely Heschl's gyri (Groussard et al., 2010). In addition to the enlargement, partly, of the same area in the brain, musicians have cognitive advantages over non-musicians just as bilinguals can have cognitive advantages over monolinguals (Groussard et al., 2010).

Musical training and bilingualism seemingly have a similar effect on the auditory cortex, which may suggest that other effects of music and bilingualism such as cognitive advantages may be similar.

2.6 Language and Music

Language and music share similarities but are also different in many ways and language and music are often used in combination with each other, such as in songs. Jackendoff (2009) says that the similarities between music and language can among other things be found in the cognitive processes they both require. Both music and language require memory capacity, the ability to structure these things in the brain, and the formation of expectations of what kind of utterance or musical melody is coming next and more. One of the aspects of language that is not the same in music is translatability, according to Jackendoff. Linguistic utterances can be translated into any other language, but this cannot be done with music. The difficulty of translating music may possibly lie in the fact that music is more culturally determined than language and often very emotional. Experiences are not always universal, and the expressions of experiences through music may not be translatable.

2.6.1 Music Abilities and Phonology

Music and language are both phenomena that deal with the perception and processing of sounds. It may be that musical abilities and phonological abilities are connected or can facilitate each other. In a study by Wong, Skoe, Russo, Dees, and Kraus (2007) the idea that musicians are better at encoding pitch information and linguistic information has been confirmed. Wong et al. measured the frequency following responses (FFR), a measure of brain responses, of different participants listening to stimuli. The participants were non-professional musicians, professional musicians and non-musicians. These participants listened to Mandarin speech stimuli that differed only in F0 frequency. According to the results, musicians are better at encoding pitch than non-musicians and musical abilities can somewhat predict an enhanced ability of acquisition of phonological aspects of a second language. Additionally, these results suggest that there may be an interaction between music and speech in one's brain, as musical abilities can enhance discrimination between speech sounds.

Musical abilities seem to influence the perception of certain speech stimuli. In Delugo, Lampis, and Olivetti Belardinelli (2010), it was investigated to what extent musical abilities influence linguistic processing, specifically whether tonal and phonological processing is affected. They tested three different participant groups on the perception of Mandarin Chinese stimuli (monosyllabic words, in six tonal trials and six phonological trials): naïve participants (no musical and Mandarin Chinese experience), participants with some experience with Mandarin Chinese, and professional musicians, on their ability to determine on what level two stimuli differed from each other in a discrimination task. The group that had Mandarin language experience outperformed the other participant groups in the phonological condition. The naïve group of participants was outperformed by all groups in the tonal condition. In the tonal condition, the musicians and Mandarin language experience participants did not differ from each other. Musical ability influences processing of lexical tone, not of phonological discrimination, according to these results.

In a nutshell, musical experience and linguistic experience both have an influence on the perception and encoding of speech stimuli. Especially musicians seem to have an advantage in the perception of these stimuli and it may well be that linguistic processing and perception can be facilitated by musical experience. This may be due to additional auditory experience, but it may also be due to cognitive advantages that one attains through musical training.

2.6.2 Processing Harmony and Semantics

Several studies have investigated the processing of language and music when listening to songs. One of these studies was by Schön, Leigh-Gordon, and Besson (2005), who have found that music and language share cognitive resources in an experiment on the "neurocognition of singing" (Schön et al. 2005). The processing of language and music occur in regions of the brain that overlap. It was shown that when participants are instructed to focus on only the harmony or only the words in songs, they experienced difficulties in trying to suppress one of the domains. Instead of focussing on a single domain, music or language, the participants processed both.

Another study that investigated the similarities and differences between languages and music and the processing of language and music was designed by Besson and Schön (2001). Previously, it was thought by, for example, Darwin and Rousseau that language and music have evolved from a common ancestor. The validity of this idea is currently still the subject of much debate. Music and language are sometimes described in similar terms, as they both may contain a form of syntax and musical and linguistic rules are both easily learned by children. However, even though music may also, similar to language, have a type of syntax, these rules are much less universal than linguistic syntax, and also more flexible. Music is a distinct cultural phenomenon and adheres less to specific rules than language (Jackendoff 2009).

Many areas of the brain that are active in processing of language are also active in processing of music. The ERP (event related potential) component N400 is elicited when a linguistic utterance is semantically incongruent. The brain imaging, specifically ERP experiments designed by Besson and Schön (2001) were designed to see whether it is possible to elicit such a component with incongruent musical stimuli. The incongruous musical stimuli were pieces of music that defied expectations. The results of these experiments have shown that, just as with language, incongruity elicits a reaction, in the case of music a P600 component. Degree of incongruity also determined the amplitude of the P600 response. Both language and music raise expectancies, and when expectancies are not met, a reaction (N400 or P600) is elicited. However, N400 and P600 are different, qualitatively. Additional experiments were designed using opera fragments as stimuli to see whether sung words that are incongruous (semantically) also elicit an N400 response, whether out of tune sung words will elicit a P600 component and whether when these two are combined, incongruous words and out of tune singing, both components will be elicited. All of these questions have been confirmed positively. Incongruously sung words elicit an N400 response, sung words that were out of tune a P600 response and the stimulus in which incongruities were combined elicited both N400 and P600. However, N400 reaction occurred earlier, thus it seems that the linguistic part of the stimuli was processed first. Semantic aspects of language and harmonic aspects of music seem to be processed separately (Besson and Schön, 2001).

In short, both language and music, when stimuli are incongruent, elicit a reaction in the brain of the listener. This may make music and language seem similar, but the reactions that are elicited are qualitatively different. Music and language are thus similar in the fact that the both raise expectations in the listener but different in the type of reaction that is elicited when these expectations are violated.

The previous studies were specifically focused on harmony and semantics. The next section looks at the connection between music and syntax.

2.6.3 Structures of Music and Language in the Brain

In a study by Patel, Gibson, Ratner, Besson, and Holcomb (1998), a P600 component was elicited when participants were presented with syntactically incongruent stimuli, specifically when a violation of phrase-structure occurred, instead of the N400 component that is associated with semantically incongruent stimuli (Patel et al.,1998 / Besson and Schön, 2001). This same P600 component is also elicited by harmonically incongruous pieces of music. It may be that a general cognitive ability is used by people when processing “structural aspects of sequences of sounds” (Besson and Schön, 2001, p250). Musical structures and syntactic structures may overlap in the areas of the brain in which they are processed.

Neuropsychology, associated with experimental tasks and behaviour, and neuroimaging, associated with ERP studies and brain imaging, draw two different pictures when it comes to the connection between language and music, according to Patel (2012). There is data that suggests that people with the disorder amusia can still detect changes between pitches but that they are not sensitive to musical key. Based on the fact that people with amusia can still distinguish between linguistic stimuli and not between musical stimuli, neuropsychologists suggest that music and language are two specific, separate domains. However, neuroimaging shows an overlap between the domains. Patel introduces the idea that some parts of language and music share cognitive resources, that processing occurs in similar ways and in similar areas of the brain, but that the actual representations of music and language do not overlap. Specifically, there is evidence for both overlap and domain-specificity (Patel, 2012) when it comes to syntactic and structural aspects of language and music. Language and music are represented separately in the brain, just processing of both phenomena occur in shared areas.

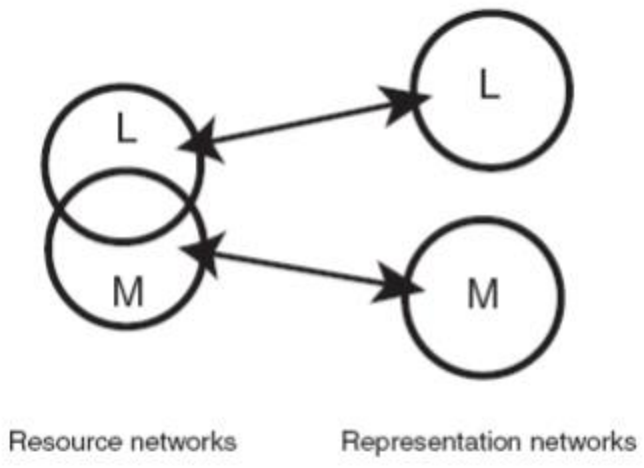

Figure 5. Schematic diagram of the functional relationship between linguistic and musical syntactic processing. L = language, M = music.

This figure (Patel, 2012, p. 14) shows in what way language and music overlap and their separate representations. Patel calls this idea the "shared syntactic integration resource hypothesis" (Patel, 2012, p. 13). Slevc and Okada (2014) studied to what extent the SSIRH holds and have found that not only the processing of the structural aspects of language and music occur in overlapping areas, but that a more general skill, namely cognitive control (executive functioning) is active in both domains. Both language and music involve the processing of complicated structures and relationships which demand much of cognition, and not only cognitive control plays a part in processing of these structures. Working memory and implicit learning both also play a role in processing of music and language.

In Jackendoff's (2009) exploration of the similarities and differences between music and language, he argues that though both music and language consist of sequences of sounds, they are not structurally identical. They do overlap in their metrical structure, but language, for example, can be analysed and structured into syntactic categories while there is no similar system for the structure of music.

In sum, the structural aspects of language and music may be partly domain-specific, but evidence from ERP studies has shown that syntactically incongruous stimuli elicit the same response in the brain as incongruous pieces of music, namely a P600 component. This suggests that the structural aspects of language and music may be processed in the same areas of the brain.

2.7 Bilingualism and Musical Ability

Not many studies have been conducted on the relationship between bilingualism and musical training or on the similar effects of bilingualism and musical training. The following sections serve to illustrate how musical abilities can facilitate second language acquisition and how similar the effects of bilingualism and musical training are.

2.7.1 Musical Training and Second Language Acquisition

The connection between musical abilities and bilingualism has often been thought of as myth, but has not often been studied thoroughly (Slevc and Miyake, 2006). It has been shown in a study by Slevc and Miyake (2006) that musical ability has an effect on L2 language proficiency. Fifty Japanese participants took part in several experiments to test this connection between language and music. The experiments were tasks on different linguistics levels, such as “receptive phonology, productive phonology, syntax, lexical knowledge, language history, non-verbal intelligence and musical ability” (Slevc and Miyake, 2006, p676). It was shown that a better musical ability may be correlated with a better phonological ability while syntactic ability was not influenced by musical ability to the same degree as phonological ability. Slevc and Miyake’s experiments show that musical ability mostly has an influence on phonological abilities which would cause a better L2 phonological performance. Even late learners of a second language may use musical abilities to facilitate the learning of new phonological structures.

2.7.2 Bilingualism, Musical Training and Executive Control

In Bialystok and DePape’s (2009) paper on the effect of bilingualism and musical expertise on executive functioning, it is proposed that just as bilingualism, musical expertise enhances certain cognitive aspects. The connection between language and music and the fact that they are processed partly in the same area of the brain suggest that musical expertise may have the same advantages as bilingualism, according to Bialystok and DePape. Monolinguals, bilinguals and musicians were tested on a battery of experiments, among which a memory task and an ‘Auditory Stroop’ task and several other experiments to compare their executive functioning skills. The results of this study have shown that bilinguals and musicians perform in similar ways and that both of these groups outperform monolingual participants. Both bilinguals and musicians have better executive control than monolinguals. Enhanced cognitive skills are apparently translatable to other tasks besides speaking two languages or playing a musical instrument.

2.8 Summary

The previously discussed studies have shown that both linguistic experience due to bilingualism and musical experience due to musical training both enhance cognition and cognitive skills, specifically inhibition (for bilingualism) and processing (for musical training). For bilingualism, it is important to note that it may be the case that there is a threshold (Threshold Theory) of how bilingual one is that must be crossed before being able to enjoy these cognitive advantages. Besides the fact that both music and language enhance cognition, it has also been shown that language and music both change the brain, namely Heschl's gyri (which is a part of the auditory cortex) is enlarged by both of the phenomena. Additionally, music and language are both different and similar on different levels. To be precise, structural aspects of language and music are processed in similar areas in the brain, while semantics and harmony are processed in different areas. The effect of musical experience on linguistic processing seems to be positive. It has been shown by Slevc and Miyake (2006) and by Delugo et al. (2010) that musical experience can facilitate linguistic processing and may even aid one in learning a second language. Considering this facilitation effect and that it has been shown that bilingualism and musical training have similar effects on the brain, this thesis will investigate whether bilingualism can aid one distinguishing between musical stimuli.

Chapter 3: Hypotheses and Predictions

Many studies have addressed musical ability as an influence on linguistic processing and perception (Delugo et al., 2010/Slevc and Miyake, 2006) but not many studies have investigated the opposite effect, namely whether linguistic processing abilities can enhance musical perception abilities. It has been shown that musical training has an effect on one's cognitive skills; it can enhance processing skills and executive functioning. Bilingualism also causes an enhanced cognition, specifically, it can enhance inhibition and in more general terms, it enhances executive functioning. These two phenomena seem to have similar effects on cognition. Additionally, it has been shown that musical training can enhance linguistic processing, which may be due to the previously mentioned cognitive advantages, and it has also been shown that both music and language are partly processed in the same area of the brain. Both incongruous music and incongruous syntactic structures elicit a P600 reaction. The question that can now be asked is whether bilingualism may aid one in the perception and processing musical stimuli, so whether the facilitating effect of musical training on processing linguistic stimuli can be turned around. To find an answer to this question, this study will investigate whether bilingualism can enhance the discrimination between musical stimuli, and specifically whether unbalanced and balanced bilingualism have the same effect on distinguishing between musical stimuli. The focus of this study lies on comparing unbalanced and balanced bilinguals (in language use) to each other, because it has been hypothesised in other studies that there is a threshold one must surpass to enjoy cognitive advantages (Baker 2001, Ricciardelli 1992). The main question addressed in this study is: are balanced bilinguals better at distinguishing between musical stimuli than unbalanced bilinguals due to cognitive advantages caused by balanced bilingualism?

The first hypothesis and predictions are as follows:

H1: Balanced bilinguals are better at distinguishing between musical stimuli than unbalanced bilinguals.

The cognitive advantages of being bilingual are expected to be most prominent when one is a balanced bilingual (Baker 2001, Ricciardelli 1992), thus when a bilingual uses both of the acquired languages in roughly equal amounts. It is predicted that these balanced bilinguals will experience more advantages when discerning between musical stimuli than unbalanced bilinguals and will attain a higher score than the unbalanced bilinguals on the experimental task.

Another question that will be addressed is whether balanced bilinguals are similar in their ability to discern musical stimuli to musicians. The literature suggests that musical training and bilingualism have similar positive effects on cognition, and that linguistic processing is enhanced in musicians. Does this mean that bilingualism can also facilitate musical processing so that balanced bilinguals are similarly proficient or more similar to musicians than unbalanced bilinguals in distinguishing musical stimuli? The second hypothesis is as follows:

H2: Balanced bilinguals are more similar to musicians than unbalanced bilinguals when it comes to distinguishing between musical stimuli.

To test this hypothesis, the scores of the balanced bilinguals on the experimental task will be compared to scores of musicians on the same task gathered by Wallentin, Nielsen, Friis-Olivarius, Vuust, Vuust (2010). It is expected that balanced bilinguals will score somewhere in between the scores of the non-musicians and the musicians in the study by Wallentin et al. (2010). It is also predicted that the balanced bilinguals scores will fall somewhere between the unbalanced bilinguals and the musicians.

Chapter 4: Method

4.1 Participants

In this study, balanced and unbalanced bilinguals will be investigated. To determine the input levels the participants received in their native language(s), their age of learning, language dominance and their current use of language, the participants were subjected to an extensive questionnaire. Based on this questionnaire, participants will be divided into two groups, balanced and unbalanced bilinguals, to be able to ascertain differences between these groups in the analysis of the results. The bilinguals investigated in this study have the language combination Dutch-English to make sure there is no effect of language interfering with the results.

All participants were either still BA students or had recently graduated and already had a BA degree. All participants were between 18 and 36 years old. Some of the participants, mainly the balanced bilingual participants, were still students of English or had been students of English and thus received specific language instruction.

The participants were excluded from the groups of balanced and unbalanced bilingual participants if they could be considered to be amateur musicians, as musical experience can influence the discrimination between musical stimuli. The participants were asked about their musical experiences in the aforementioned questionnaire. According to Wallentin et al., participants are amateur musicians when a person "played an instrument for at least two years <u>and</u> who for the last year had spent on average at least one hour per week practicing/playing" (p. 5), if these criteria were not met by their participants, the participants were considered to be non-musicians. If these criteria were met by one of the participants in this study, he or she was excluded because he or she can be considered to be an amateur musician. If participants indicated that they did play a musical instrument, but only once a month for example, he or she was not excluded from the results.

4.1.1 Unbalanced Bilingual Participants

Unbalanced bilinguals are bilinguals who use one language significantly more over the other language. In the case of unbalanced bilinguals, there is a clear dominant language. When the percentage of use for one language is below 33%, this person will be considered to be an unbalanced bilingual. De Groot (2011) suggests that any bilingual that uses one of the languages less than 40% is an unbalanced bilingual. It was decided to be somewhat more lenient in this thesis. These participants may not use their second language less than 5% overall, otherwise they could have been considered to be monolingual participants. A questionnaire determined the language dispersion of the participants. Age of acquisition has been documented, but will not be a determining factor in whether a participant is unbalanced or balanced bilingual.

4.1.2 Balanced Bilingual Participants

Balanced bilinguals are people who use both languages evenly (50%-50%) or almost evenly and do not have a very dominant language. There aren't many studies who clearly define balanced and unbalanced bilinguals in terms of percentages. Again, de Groot (2011) suggests balanced bilinguals to be bilinguals with a language dispersion of 50%-50%, 60%-40% and 40%-60%. In this thesis, it was chosen to be slightly more lenient and consider bilinguals with a language dispersion of 33%-67% and 67%-33% also to be balanced bilinguals (one language is spoken at least 1/3 of the time and the other maximally 2/3 of the time). Again, a questionnaire has determined this language dispersion and language use is what the group division is based on, not age of acquisition.

It was chosen to focus mostly on language use when determining balanced or unbalanced bilingualism because when using two languages equally, inhibition is practised most as there is active competition between languages. If the results are confounding, the age of acquisition will be taken into account.

4.2 The Musical Ear Test

The current study makes use of the discrimination task called the Musical Ear Test (or MET) that was designed by Wallentin et al. (2010), in which participants are presented with two musical stimuli and must determine whether the stimuli are the same or whether they are different. The Musical Ear Test contains 104 trials, consisting of sets of two types of stimuli. Namely, a section of rhythmic stimuli and a set of melodic stimuli. The melodic stimuli consist of piano samples and consisted of 3-8 tones. In a set of stimuli that differed from each other, the second stimulus contained a single pitch violation (one aspect was different from the previously played stimulus). The rhythmic stimuli consist of "wood block sounds" (Wallentin et al, 2010, p189) and contained 4-11 of these "wood block beats" (Wallentin et al, 2010, p189). If a set of stimuli was different from each other, the difference consisted of a single rhythmic variation. Both subsets consist of 52 trials. The experiment has a duration of 20 minutes approximately. The musical ear test was designed to determine musical abilities of any type of participant.

Several discrimination experiments were carried out by Wallentin et al. (2010) to validate the Musical Ear Test. All experiments have showed that it is possible to use the Musical Ear Test to differentiate between musicians and non-musicians. The experiments showed that musicians were better at determining whether stimuli were the same or different. In their second experiment, of which it is possible to extract the raw data, musicians were found to score on average 88.7% correct, while non-musicians scored 69.8% correct. This is a significant difference between groups. Additionally, it is interesting to see that even musicians do not attain a perfect score. No professional musician attained a score of 100%. This suggests that the MET is relatively difficult. It is assumed that this test can also be used to determine differences between unbalanced bilingual non-musicians and balanced bilingual non-musicians. The results of the experiment 2 by Wallentin et al. (2010) will be used to test the second hypothesis of this thesis. It isn't entirely clear from the study by Wallentin et al. whether they used monolingual or bilingual participants, so even though a comparison may be made, it will be impossible to definitively give conclusions based on these comparisons.

There are multiple types of discrimination experiments that can test to what degree participants can distinguish between two different stimuli and it has been the subject of much consideration what experiments are most suitable in specific situations. Gerrits and Schouten (2004) investigated many types of different discrimination tasks, and about AX experiments, Gerrits and Schouten (2004) say that participants are conservative in using the label 'different'. Assuming that all participants are conservative in their judgements, for this experiment, this issue should not be considered problematic, as the goal of this experiment is mainly to determine whether there is a difference in the judgements of unbalanced and balanced bilingual participants of musical and tonal stimuli. The MET, which is an AX task, is thus a suitable task to test the hypotheses posed in this thesis.

4.3 The Questionnaire

As mentioned previously, to determine to what degree the participants use a foreign or second language, what the age of learning was, to establish language dominance, and to determine how much musical experience they have, the participants were asked to fill in a questionnaire. The unbalanced and balanced bilinguals filled in the same language/music background questionnaire.

The questionnaire contained questions on musical ability, such as whether they play an instrument and how often they listen to music. It is important to document musical experience to distinguish musicians from non-musical people (ideal would be to test no musicians at all) as musicians would have better musical perception abilities than non-musicians and possibly skew the results. The questionnaire was anonymous and no name had to be given. The questionnaire did contain a question on the age of the participant, to determine how much cognitive experience they have (cognitive experience increases with age) and to ensure the participants fell within the age range set in this study.

The specific questionnaire used in this study was the Bilingual Language Profile questionnaire, which was devised by Birdsong, Gertken, and Amengual (2012). This is a standard questionnaire to, among other things, determine language dominance. The questions on musical experience were added to this questionnaire and some questions on motivation were excluded from the BLP since they were not important for this study and to keep the questionnaire length manageable. The BLP is a useful tool for determining whether a participant is a balanced or unbalanced bilingual as it asks the participant to report on their language use. The questionnaire was translated from English to Dutch. The questionnaire was administered digitally, through Google Forms. The instruction for filling out the questionnaire was as follows:

"In deze vragenlijst staan vragen over u talige ervaring en uw muzikale ervaring. Het is belangrijk om volledig te zijn in uw antwoorden en wanneer er naar uw ervaring gevraagd wordt, alle ervaring in te vullen. De vragenlijst bevat eenentwintig vragen. U hoeft uw naam niet op te schrijven, de vragenlijst is geheel anoniem."

This translates to: 'This questionnaire contains questions on your linguistic and musical experience. It is important to be complete in your answers when you are asked about your experience. The questionnaire contains twenty-one questions. You do not have to give your name, as the questionnaire is entirely anonymous.'

Filling in the questionnaire took approximately ten minutes per participant.

4.4 Procedure

All participants were sent an e-mail confirming the test appointment and were asked, in this e-mail to fill in the questionnaire before participating in the actual experiment. The Musical Ear Test was administered in a quiet room and the participants listened to the stimuli over sound-blocking headphones. The stimuli were either presented on a laptop computer or on a computer in a phonetics lab in Utrecht. They were instructed to listen to the stimuli and to determine whether the stimuli they heard were 'same' or 'different' and to indicate their answer on an answer sheet by filling or checking a box in the yes or no column on the answer sheet. In addition to the instruction from the experimenter, the MET itself contained an explanation of the procedure as well, so the participants were given the same instructions twice. The participants were told the experiment would take approximately 20 minutes and they were instructed to always give an answer even if they were unsure of their answer.

Chapter 5: Results

In total, 22 participants were tested on the MET, 8 of whom were unbalanced bilinguals, 10 balanced bilinguals, 4 amateur musicians (3 balanced bilinguals, 1 unbalanced bilingual). One of the balanced bilinguals participants was excluded since the age of the participant fell outside of the decided range of 18-36 years. There were 19 female participants and 3 male participants. It would have been ideal to test an equal amount of male and female participants, however, due to time constraints and the fact that the all participants were volunteers did not make this possible. Wallentin et al. (2010) tested whether gender had a significant effect on how well or poorly one performed on the MET and found no effect of gender. The next sections provide an overview of the raw data that was gathered.

5.1 Unbalanced Bilinguals

The following table shows the raw scores attained by the unbalanced bilinguals on the MET.

	Raw Scores Melody	Percentage Scores Melody	Raw Scores Rhythm	Percentage Scores Rhythm	Total MET Score	Total MET Percentage
P1	**32**	**61,54**	**30**	**57,69**	**62**	**59,62**
P2	**29**	**55,77**	**35**	**67,31**	**64**	**61,54**
P3	**31**	**59,62**	**39**	**75,00**	**70**	**67,31**
P4	**28**	**53,85**	**35**	**67,31**	**63**	**60,58**
P5	**38**	**73,08**	**41**	**78,85**	**79**	**75,96**
P6	**42**	**80,77**	**32**	**61,54**	**74**	**71,15**
P7	**33**	**63,46**	**39**	**75,00**	**72**	**69,23**
P8	**32**	**61,54**	**41**	**78,85**	**73**	**70,19**
Mean	**33,13**	**63,70**	**36,50**	**70,19**	**69,63**	**66,95**
SD	**4,67**		**4,14**		**6,07**	

Table 1: The scores of the unbalanced bilinguals on the MET.

Wallentin et al. (2010) say that a score of at least 60 points, 57,69%, must be attained to score above chance. The lowest scoring unbalanced bilingual participant in this study attained a score of 59,62% correct. This score is just above chance. The highest scoring unbalanced bilingual attained a score of 75,96%.

The following table shows the language dispersion scores of the unbalanced bilingual participants. It also includes age of acquisition (AOA) for their second language and their age.

	English %	Dutch %	Other %	Age	AOA
P1	**10**	**90**	**0**	**25**	**10**
P2	**22**	**60**	**18**	**25**	**12**
P3	**22**	**78**	**0**	**23**	**4**
P4	**6**	**94**	**0**	**25**	**10**
P5	**32**	**68**	**0**	**19**	**10**
P6	**8**	**92**	**0**	**35**	**10**
P7	**18**	**82**	**0**	**33**	**10**
P8	**26**	**74**	**0**	**25**	**7**
Mean	**18**	**79,75**	**2,25**	**26,25**	**9,13**

Table 2: Language dispersions, age and age of acquisition of the unbalanced bilingual participants.

The unbalanced bilingual participants used English, on average, 18% of the time. There was one participant who was trilingual. The mean age of acquisition was 9,13 and the average age of the unbalanced participants was 26,25 years old.

5.2 Balanced Bilinguals

The following table shows the raw scores attained by the balanced bilinguals on the MET.

	Raw Scores Melody	Percentage Scores Melody	Raw Scores Rhythm	Percentage Scores Rhythm	Total MET Score	Total MET Percentage
P1	**28**	**53,85**	**39**	**75,00**	**67**	**64,42**
P2	**31**	**59,62**	**41**	**78,85**	**72**	**69,23**
P3	**40**	**76,92**	**35**	**67,31**	**75**	**72,11**
P4	**41**	**78,85**	**27**	**51,92**	**68**	**68,38**
P5	**36**	**69,23**	**30**	**57,69**	**66**	**63,46**
P6	**38**	**73,08**	**38**	**73,08**	**76**	**73,08**
P7	**44**	**84,62**	**40**	**76,92**	**84**	**80,77**
P8	**29**	**55,77**	**35**	**67,31**	**64**	**61,54**
P9	**32**	**61.54**	**38**	**73,08**	**70**	**67,31**
Mean	**35,44**	**68,16**	**35,88**	**69,02**	**71,33**	**68,59**
SD	**5,94**		**4,96**		**6,63**	

Table 3: The scores of the balanced bilinguals on the MET.

The lowest scoring balanced bilingual participant attained a score of 61,54 percent correct. The highest scoring balanced bilingual scored 80,77 percent correct. The next table shows the language dispersions of the balanced bilinguals based on the BLP questionnaire on language use. It also includes age of acquisition for their second language and their age.

	English %	Dutch %	Other %	Age	AOA
P1	**38**	**60**	**2**	**26**	**7**
P2	**52**	**46**	**2**	**24**	**9**
P3	**44**	**56**	**0**	**25**	**11**
P4	**54**	**46**	**0**	**36**	**9**
P5	**44**	**56**	**0**	**21**	**12**
P6	**52**	**48**	**0**	**19**	**11**
P7	**44**	**56**	**0**	**24**	**7**
P8	**38**	**62**	**0**	**33**	**9**
P9	**34**	**66**	**0**	**26**	**11**
Mean	**44,44**	**55,11**	**0,44**	**26**	**9,56**

Table 4: Language dispersions, age and age of acquisition of the balanced bilingual participants.

The average age of the balanced participants was 26 years old and the average age of acquisition was 9,56 years. The overall mean language dispersion is 44,44% English versus 55,11% Dutch and 0,44% other languages.

5.3 Amateur Musicians

After testing and after scoring the questionnaires, it was discovered that four participants had to be excluded from the unbalanced and balanced participant groups because, according to Wallentin et al.'s (2010) criteria, they could be considered to be amateur musicians. The average score of the amateur musicians tested by Wallentin et al. (2010) was 78%. In the next table, the scores of the amateur musicians gathered in this experiment are shown.

	Raw Scores Melody	Percentage Scores Melody	Raw Scores Rhythm	Percentage Scores Rhythm	Total MET Score	Total MET Percentage	Type of Bilingual
M1	**38**	**73,08**	**43**	**82,69**	**81**	**77,88**	BAL
M2	**37**	**71,15**	**43**	**82,69**	**80**	**76,92**	BAL
M3	**42**	**80,77**	**35**	**67,31**	**77**	**74,04**	BAL
M4	**46**	**88,46**	**42**	**80,77**	**88**	**84,62**	UNBAL
Mean	**40,75**	**78,37**	**40,75**	**78,37**	**81,5**	**78,37**	
SD	**4,11**		**3,86**		**4,65**		

Table 5: The scores of the amateur musicians on the MET.

It is impossible to use these data to run a statistical analysis since there were only four participants tested (accidentally) in this category. It is, however, interesting to note that the mean percentage lies close to the mean percentage score of the amateur musicians tested by Wallentin et al. (2010), namely, the average percentage score of the amateur musicians tested in this study is 78,37%.

5.4 Professional Musicians

In Table 6, the raw results of Wallentin et al.'s (2010) second experiment are shown. These are the scores of the 16 musicians that were tested on the MET. These raw scores were extracted from Fig.3 from the article on the MET by Wallentin et al. (2010, p. 4). The participants tested by Wallentin et al. (2010) had a mean age of 22,9 years old and consisted of 16 males and 2 females. It was shown by Wallentin et al. (2010) that gender and age both had no effect on performance on the MET.

	Raw Scores MET	Percentage Correct MET
P1	**102**	**98,07**
P2	**100**	**96,15**
P3	**96**	**92,31**
P4	**95**	**91,35**
P5	**95**	**91,35**
P6	**94**	**89,42**
P7	**94**	**89,42**
P8	**93**	**88,46**
P9	**93**	**88,46**
P10	**93**	**88,46**
P11	**93**	**88,46**
P12	**92**	**86,54**
P13	**89**	**85,58**
P14	**87**	**83,65**
P15	**84**	**80,77**
P16	**83**	**79,81**
Mean	**92,69**	**89,12**
SD	**5,04**	**4,85**

Table 6: The scores and percentage scores of the professional musicians on the MET (data taken from Wallentin et al. 2010, P191, fig. 3).

As is visible from Table 6, no musician received a perfect score. This suggests that there is no ceiling effect in this experiment. The mean percentage score is slightly different than the mean score given by Wallentin et al. (2010) in their paper. A probable explanation for this is that they may have taken the mean of the rounded off percentages (when one does this with the numbers presented in Table 6, the mean is 88.90%), just as the figure these numbers were taken from contained only rounded off percentages. The raw scores of the musician group tested by Wallentin et al. (2010) will be compared to the scores of the unbalanced and balanced bilingual participants that were subjected to the MET in this study. The lowest scoring participant scored 89,12% correct while the highest scoring participant scored 98,07% correct.

The raw results from all participant groups will be used to perform one-way ANOVA's to discern whether there are differences between groups.

Chapter 6: Analysis of the Results

6.1 Unbalanced VS Balanced Bilinguals: Melody

The first ANOVA that was performed was to compare the scores of the unbalanced and balanced bilingual on the melody subtest of the MET. The mean score of the unbalanced bilinguals on this subtest was 33,13 out of 52 correct (SD: 4,67). The mean score of the balanced bilinguals on the melody subtest was 35,44 (SD: 5,94). The difference between groups on the melody subtest was not found to be significant at P= 0.38.

6.2 Unbalanced VS Balanced Bilinguals: Rhythm

The following ANOVA was performed to determine whether the unbalanced and balanced bilingual participants differed on the rhythm subtest of the MET. The mean score of the unbalanced bilinguals on this subtest was 36,5 (SD: 4,14) and the mean score of the balanced bilinguals on this subtest was somewhat lower at 35,89 (SD:4,96). There was no significant difference found between groups on this subtest (P= 0.78).

6.3 Unbalanced VS Balanced Bilinguals: Total MET

To determine whether there were differences between groups of bilinguals on the overall score on the MET, an ANOVA was performed. The mean score of the unbalanced bilingual participants was 69,63 (SD: 6,07) and the mean score of the balanced bilinguals was 71,33 (SD: 6,63). The difference between groups was found not to be statistically significant (P= 0.57).

6.4 Unbalanced Participants VS Professional Musicians

Another ANOVA was performed to determine whether there were significant differences between the unbalanced bilinguals and the professional musicians tested by Wallentin et al.. The mean score of the unbalanced bilinguals was 69,63, while the mean score of the professional musicians was much higher at 92,69 (SD: 5,04). The results from the ANOVA have shown that there is a significant difference between musician and unbalanced bilingual at P= <.0001.

6.5 Balanced Participants VS Professional Musicians

The mean score of the balanced bilingual participants on the MET was 71,33. The mean score of the professional musicians was 92,69. An ANOVA was performed and has shown that the differences between these two groups are significant at P=<.0001.

6.6 Unbalanced Participants: Melody compared to Rhythm

To see whether there was a significant difference between the scores of the subtests within the unbalanced participant group, an ANOVA was performed. The scores of the melody subtest were compared to the scores on the subtest rhythm. The average score of the unbalanced bilinguals on the melody subtest was 33,13. The average score on the rhythm subtest was 36,50. There was no significant difference found between the scores of the subtests (P=0.15), suggesting that the unbalanced bilingual participants score in a similar manner both on the melody and rhythm subtest.

6.7 Balanced Participants: Melody compared to Rhythm

For the balanced participant group, a comparison between subtests was also made to see whether there was an effect of test condition. The average score on the melody subtest by the balanced bilinguals was 35,44. The average score on the rhythm subtest was 35,89. Similar to the results of the comparison between subtest scores of the unbalanced bilingual group, no significant differences were found between the subtest scores of the balanced bilingual participants (P=0.86).

To summarise, no significant differences were found between unbalanced bilingual participants and balanced bilingual participants at all. Musicians did differ greatly in their scores on the Musical Ear test compared to both groups of bilinguals, scoring much higher than the bilingual participants. There were also no significant differences between the scores on the subtests by the bilingual participants, both unbalanced and balanced participants attained similar scores on both subtests.

Chapter 7: Discussion of the Results

As has been shown in the analysis of the results, the differences between the scores of the unbalanced and balanced bilinguals was so marginal that the ANOVA's performed showed that there is no significant differences between the two groups while it was hypothesised that there would be a difference between the groups of bilinguals. Additionally, the balanced bilingual participants differed significantly from the musicians tested by Wallentin et al. (2010), as did the unbalanced bilingual participant group. The balanced bilinguals did not score somewhere in between the unbalanced bilinguals and the musicians. In this section, these results will be explained in light of the theories discussed in the literature review.

The insignificance of the results of this study may be due to the fact that these participants were too similar to each other. It is possible that the balanced bilinguals, even though they could be considered to be balanced bilinguals in accordance with the criteria set in this study, were not balanced enough and age of acquisition must be taken into account when determining level of bilingualism. Age of acquisition may have played a role in the degree of cognitive enhancements and it is possible that not only language use is important. It can be that one must be an early acquirer to pass the threshold of cognitive advantages, and the participants in this study started learning their second language (English) on average before the end of the CPH, but after the first four years of life. The Threshold Theory states that balanced bilingualism, EG balanced use of the two languages one speaks, enhances cognition. This is, however, not apparent from the results in this study. In this case, either cognition is not enhanced or enhanced equally in both groups, which makes it impossible to say whether the Threshold Theory is in line with the results of this study or holds in general.

Some amateur musicians were tested in this study as well. Due to a low amount of participants in this group, no statistical analysis was performed, but when comparing the raw results to the results of the amateur musicians we can see that the ones tested in this study score in a similar manner to the ones tested by Wallentin et al. (2010) in their study. This suggests that the results of the bilingual groups are probably not due to testing circumstances, but have a different cause.

Additionally, it is also possible that bilingualism does enhance cognition in the balanced bilingual participants tested here but that the cognitive skills that are needed for the MET and the enhanced cognitive skills are not exactly the same. In general, studies have shown that both musical training and bilingualism enhance cognition. Both phenomena enhance cognitive control and specifically, for bilingualism, inhibition is most enhanced while local processing seems to be specifically enhanced in musicians. It may be that local processing skills need to be enhanced for the balanced bilinguals to have an advantage over unbalanced bilinguals when discerning between the stimuli presented in the MET and that an enhancement of cognitive control and inhibition is not enough.

This study tested whether an increase in linguistic experience enhanced processing musical stimuli or gave one advantages during a discrimination task such as the MET, but it may be that the linguistic experience between unbalanced and balanced bilingual participants did not differ enough to show differences in the results of both groups of bilinguals. It may be that additional linguistic experience does influence performance on the MET and that there could be a difference between monolinguals and bilinguals, but since no (pure) monolinguals were tested as they are almost impossible to find in the Netherlands, it is impossible to discern whether the bilinguals in general have an advantage over monolinguals in the MET. For further research, it would be useful to test pure monolinguals and to compare these to bilinguals in general to see if additional linguistic experience influences performance on the MET.

This study investigated bilingual participants that speak the language combination Dutch and English. These are two languages that are not very different from each other. It has been shown that the similarity of the second language one wants to learn or is learning influences how well one can eventually acquire the language (McDonald 2000, Kellerman 1995). The acquisition of English by the native speakers of Dutch should thus have been relatively easy. It may be that the similarity of one's L1 to one's L2 must also be considered when one investigates the cognitive advantages of bilingualism. Cognition may be more enhanced when one learns a second language that is not at all similar to one's first language. Additionally, if one learns a language that is significantly different from one's first language, one may attain more auditory experience than when one learns a language that is similar to one's L1. If this is true, it may well explain the results of the current study.

There may also be limitations to the MET. All people that participated in this study found the Musical Ear Test relatively difficult and encountered difficulties keeping focus during the twenty minutes the MET takes. The MET demands much of one's memory because the presented stimuli follow each other very rapidly and there is hardly any decision time in which to indicate an answer on the answer sheet. When one is still deciding whether the previous stimuli were different from each other, the new set of stimuli is already being presented. This fact, however, may have influenced the results but does not change their comparative power, as all groups of participants were confronted with this issue. It does beg the question what is actually being tested by the MET, musical experience or the memory capacity of the participants. Wallentin et al. (2010) say that the MET is a good tool in discerning between non-musicians and musicians. This may be, but it could be that the main advantages musicians have over non-musicians are cognitive in nature and not necessarily due to more auditory experience. If it did test auditory experience, there probably would have been a bigger difference between unbalanced bilinguals and balanced bilinguals. It may be also be possible that musicians have mainly an advantage over non-musician bilinguals tested in this study because they have a greater musical memory. Both bilingualism and musical training enhance working memory, but the advantages may be greater for musicians as playing a musical instrument requires on to remember musical passages (Brandler and Rammsayer 2003), which bilingualism does not require. It may be that this memory advantage aids one in remembering and dealing with the presented stimuli during the MET.

Chapter 8: Conclusions

The first hypothesis in this study was that balanced bilinguals would be better at distinguishing between musical stimuli than unbalanced bilinguals due to certain cognitive advantages that, according to the Threshold Theory, present themselves when one is a balanced bilingual. At first look, this hypothesis can be rejected. The balanced bilinguals did not perform better than unbalanced bilingual participants on the MET. However, it may be that the criteria of balanced bilingualism should be set differently than the criteria in this study. Namely, that balanced bilinguals are only balanced when a person is an early learner of their second language. It may be that there is a critical period, not only for general language learning, but also for an enhanced cognition due to bilingualism. It may also be that unbalanced and balanced bilinguals enjoy the same advantages due to bilingualism and that amount of language use does not play a role here. Another possibility can be that the advantages that one attains due to bilingualism do not play a role when discriminating between musical stimuli, but that other skills are at work during these types of tasks. Further research is needed to confirm or reject these ideas.

The second hypothesis was that balanced bilinguals would be more similar to the musicians tested by Wallentin et al. (2010) than the unbalanced bilinguals. This hypothesis can also be rejected, as no differences were found between the two bilingual participant groups. Balanced and unbalanced bilingual participants both differed significantly from the musicians. The musicians scored much better on the MET. Whether this is due to more auditory experience or due to cognitive advantages, such as local processing abilities, is still unclear. Both these aspects may influence the scores attained by the musicians.

In conclusion, both hypotheses are rejected. Even though it is sometimes argued that both musical experience and bilingualism ‘s cognitive advantages can be translatable to other tasks (Bialystok and DePape 2009) and may increase linguistic processing skills, this does not seem to be true for this current study. Increased linguistic experience and enhanced cognitive skills, according to the results from this study, do not translate to the specific task that is the MET. It might be useful for future research to test whether balanced bilinguals have an advantage over unbalanced bilingual speakers and monolinguals on a battery of musical experimental tasks, to see if such a facilitative effect on musical tasks due to increased linguistic experience is even possible in the same way as it seems to be the other way around.

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