MUSICIANS’ SENSORY PATTERNS IN RELATION TO THEIR PRIMARY MUSICAL INSTRUMENT

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Musicians’ sensory patterns in relation to their primary musical instrument.

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Professor Emerita Caroline van Niekerk

DECLARATION

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ABSTRACT

This study examined the relation between 1327 musicians' sensory patterns and their primary musical instrument. Musicians' sensory patterns were further compared with reference to different instrument groups, within instrument groups, and gender within these groups. To achieve this, a quantitative criterion group design was implemented using the *Adult/Adolescent Sensory History* (ASH). This 163-item self-report questionnaire is principally used in occupational therapy to evaluate individuals' sensory integration and its influence on their daily functioning.

Employing the ASH, musicians' sensory patterns were examined from three perspectives: sensory modulation and discrimination, functional problems, and motor/social components. It was established that, in comparison to the standard population, musicians demonstrate increased sensitivity for all the components contained in the ASH. Overall, musicians achieved higher auditory modulation, visual modulation, and proprioceptive discrimination scores than the average person. Instead of viewing these as sensory obstacles, they rather point toward musicians' increased sensitivity/awareness or superior sensory abilities.

It was found that in terms of auditory modulation, percussion, trombone, trumpet and tuba players were the only instrumentalists who score within the typical range of the ASH. Of the instruments which were within the mild difficulties range, violin players obtained the highest score. It emerged that the majority of musicians from all 19 instruments' visual modulation scores were within the ASH's mild difficulties range, indicating greater sensitivity to visual stimuli than the average person. Similarly, all groups except percussion scored at the low end of mild difficulties range. This is in accordance with previous research which determined that musicians have superior multisensory processing and integration of tactile and visual information which allow them to react significantly more quickly to such stimuli than non-musicians. It was further found that, although within the norm, musicians demonstrate greater discrimination sensitivity, especially in terms of proprioception, than the standard population.

As far as functional problems are concerned, musicians' scores were overall slightly higher than the norm. Sensory over-responsivity, often coinciding with modulation challenges/sensitivity, was established among all musician groups. With the exception of pianists and violinists, all instrument groups were at the low end of the mild difficulties range for the various sensory seeking behaviours. These behaviours are typically associated with higher modulation or discrimination scores – evident from the results of this study.

Several gender differences emerged in terms of vestibular, visual and tactile modulation, vestibular discrimination, as well as sensory seeking behaviours. Another noteworthy finding involves musicians' social/emotional patterns. Similar to previous research, it was established that higher levels of anxiety, depression, impulsivity and introversion exist among musicians. For the first time, as a result of my research, these traits have now been shown to be connected to sensory processing difficulties/sensitivity. By conducting this research, pioneering work was done concerning musicians' sensory patterns, providing multiple possibilities for further research.

KEY CONCEPTS

Adult/Adolescent Sensory History; gender differences; instrument group; musical instrument; musicians' sensory patterns; occupational therapy; sensory discrimination; sensory integration; sensory modulation.

OPSOMMING

Hierdie studie het die verband tussen 1327 musikante se sensoriese patrone en hulle primêre musiekinstrument ondersoek. Musikante se sensoriese patrone is verder vergelyk ten opsigte van verskillende instrumentegroepe, instrumente binne hierdie groepe, asook geslag binne die groepe. Om hierdie doel te bereik, is 'n kwantitatiewe kriteriumgroepontwerp met behulp van die *Adult/Adolescent Sensory History* (ASH) geïmplementeer. Hierdie 163-item vraelys word hoofsaaklik in arbeidsterapie gebruik om mense se sensoriese integrasie asook die invloed hiervan op hulle daaglikse funksionering te evalueer.

Deur van die ASH gebruik te maak, is musikante se sensoriese patrone vanuit drie perspektiewe ondersoek: sensoriese modulasie en diskriminasie, funksionele probleme en motoriese/sosiale funksionering. Daar is vasgestel dat, in vergelyking met die standaardbevolking, musikante vir al die komponente van die ASH sensitiwiteit toon. Oor die algemeen het musikante hoër ouditiewe modulasie, visuele modulasie en proprioseptiewe diskriminasietellings as die gemiddelde persoon behaal. In plaas daarvan om dit as sensoriese uitdagings te beskou, dui dit eerder op musikante se hoër sensitiwiteit/bewustheid of uitsonderlike sensoriese vermoëns.

Daar is bevind dat in terme van ouditiewe modulasie, perkussie-, tromboon-, trompet- en tubaspelers die enigste instrumentaliste binne die tipiese verspreiding van die ASH was. Van die instrumente wat aan die lae kant van die matige uitdagingsverspreiding was, het vioolspelers die hoogste telling behaal. Die meerderheid van spelers van al 19 instrumente se visuele modulasietellings was aan die ASH se lae kant van die matige uitdagingsverspreiding. Dit beteken dat musikante meer sensitief is in terme van visuele stimuli as die gemiddelde persoon. Soortgelyk hieraan, was al die instrumentgroepe, behalwe perkussie, aan die lae kant van die ASH se matige uitdagingsverspreiding. Hierdie is in ooreenstemming met vorige navorsing wat bepaal het dat musikante oor gevorderde multisensoriese prosessering en integrasie van taktiele en visuele inligting beskik wat hulle in staat stel om aansienlik vinniger te reageer op hierdie tipe stimuli as nie-musikante. Daar is verder gevind dat musikante, hoewel binne die norm, groter diskriminasie-sensitiwiteit as die standaardbevolking toon, veral in terme van propriosepsie.

Wat funksionele probleme betref, was musikante se tellings oor die algemeen effens hoër as die norm. Sensoriese oorresponsiwiteit is in al die musikantgroepe gevind. Hierdie aspek gaan dikwels met uitdagings/sensitiwiteit op modulasievlak gepaard. Met die uitsondering van pianiste en vioolspelers was alle instrumentgroepe aan die lae kant van die matige uitdagingsverspreiding vir die verskillende sensoriese gedragte. Hierdie gedrag word tipies geassosieer met hoër modulasie- of diskriminasietellings wat duidelik vorendag gekom het in die uitslae van hierdie studie.

Verskeie geslagsverskille het vorendag gekom met betrekking tot vestibulêre, visuele en tasmodulasie, vestibulêre diskriminasie, sowel as sensoriessoekende gedrag. 'n Verdere noemenswaardige bevinding behels musikante se sosiale/ emosionele patrone. Soortgelyk aan vorige navorsing, is vasgestel dat musikante aan hoër vlakke van angs, depressie, impulsiwiteit en introversie gekenmerk word. As gevolg van my navorsing word hierdie eienskappe vir die eerste keer aan sensoriese prosesseringsprobleme/sensitiwiteit gekoppel. Deur hierdie navorsing, is pionierswerk gedoen met betrekking tot musikante se sensoriese patrone. Gevolglik is verskeie moontlikhede vir verdere navorsing oopgevlek.

SLEUTELBEGRIPPE

Adult/Adolescent Sensory History; arbeidsterapie; geslagsverskille; instrumentgroep; musiekinstrument; musikante se sensoriese patrone; sensoriese diskriminasie; sensoriese integrasie; sensoriese modulasie.

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CHAPTER 1

INTRODUCTION

1.1 Background and rationale

My interest in musicians'[1] sensory patterns in relation to their primary musical instrument was sparked when I was introduced to the book *The right instrument for your child* (2012) by Atarah Ben-Tovim and Douglas Boyd. The aim of this book is to assist parents in choosing the most suitable musical instrument for their child. The book includes a basic musicality test, as well as a description of the mental ability, personality traits and physique associated with a person playing a particular musical instrument. The choice of instruments is systematically narrowed down. The last step involves visiting a music shop where the child can "play" on the instruments after which the final choice is made. This approach is known as the *Ben-Tovim/Boyd Instrument Matching System* and is based on the authors' personal experience and research.

Apart from the *Ben-Tovim/Boyd Instrument Matching System*, choice of instrument has been investigated from the perspective of age, intelligence, instrument availability, level of difficulty, timbre, pitch, loudness, size, weight and cost (Dangler, 2014; Payne, 2014; Mihajlovski, 2013; Eitan & Rothschild, 2010). In addition, it has been established that gender stereotyping and/or association and exposure to the instrument/s (Payne, 2014; Bayley, 2004); genetics and motivation (Mosing & Ullén, 2018; Cantero & Jauset-Berrocal, 2017); as well as the influence of family, friends, peers and teachers (Dangler, 2014) play an important role in choosing an instrument.

Somewhat different to factors influencing choice of instrument, scholars like MacLellan (2011) and Langendörfer (2008) have contrasted musicians in terms of

[1] In the context of this study, "musicians" refer to people who have studied musical performance and are professional musicians or are final year tertiary music students specialising in musical performance.

the instrument they play, while others have focused on differences between instrument groups (Cameron, Duffy & Glenwright, 2015; Ziv, Ayash & Omstein, 2013). In addition, musicians' personality traits have been investigated from within the fields of music as well as psychology (Rose, Jones Bartoli & Heaton, 2018; Mihajlovski, 2013). While overall characteristics have been the focus of most of these music studies, anxiety and depression among musicians have been studied specifically by psychologists (Kenny & Halls, 2018; Nicholson, Cody & Beck, 2015).

A further aspect still requiring consideration is the effect of aspects such as the ones mentioned above in combination with different events during which the musician profile[2] develops and matures, for example changing from one instrument to another or starting to learn another instrument in addition to the primary instrument. Figure 1-1 provides an overview of aspects which may influence the musician profile. Adding to this list of aspects is the musician's personal background, amount of exposure to the instrument, work conditions and socio-economic factors. Considering these variables the complexity of the development of the musician profile becomes clear.

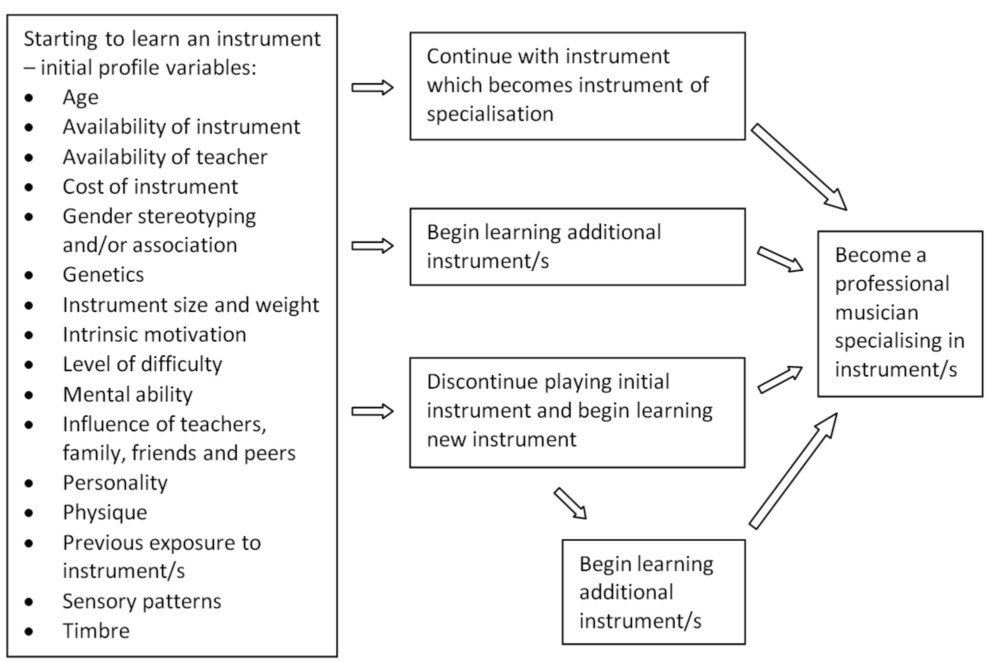


Figure 1-1: Aspects influencing the development of the musician profile

[2] In the context of this study, "musician profile" refers to the elements which, together with his/her instrument, make up "the musician": character traits/personality, as well as mental, physical, emotional and sensory characteristics.

During my preliminary literature review, I discovered that, although fundamental to music performance, limited research has been done regarding sensory patterns of musicians, especially in the field of music. Occupational therapists typically view sensory patterns (also known as sensory processing patterns) in the context of sensory processing dysfunction. Dunn (2007:85) explains these patterns in light of four neurological thresholds: low registration of sensory stimuli, seeking of sensory stimuli, sensory sensitivity and sensation avoiding. Each of these patterns is described in more detail in Chapter 2. Despite the traditional context in which sensory patterns are considered, the aim of this study was to establish possible sensory pattern trends among musicians without the intention to diagnose dysfunction. Consequently and in the context of this study, sensory patterns refer to a person's registration, processing and behavioural response/s to sensory input.

Noticing the gap in research stemming from the preliminary literature review, my original aim was to determine the influence of sensory patterns on the choice of instrument and, secondly, to construct musician-instrument profiles in order to create a tool for choosing a musical instrument. To achieve this, I intended to integrate sensory pattern data with existing information concerning the link between musicians and their primary musical instrument. However, during the course of my study, I realised that too little research has been done regarding the mental, physical, emotional and sensory development (not to mention other aspects which have been pointed out) of musicians since the start of their training to becoming professionals. Consequently, drawing up accurate musician-instrument profiles at this stage would not be possible. My focus therefore shifted towards the connection between musicians' overall sensory patterns and their primary musical instrument. Although realigning the focus of a study is not uncommon, it is necessary to mention it here since the "Letter of informed consent" (Appendix 7) makes mention of two questionnaires.

While overall sensory patterns is an unexplored area of research, some aspects like auditory processing, tactile processing, and the influence of pitch, dynamics, timbre and vibrato on a person's audio-tactile metaphorical mapping have been investigated by scholars like Payne (2014), Ziv et al. (2013), Eitan and Rothschild (2010) and

Hudson (2004). Additionally, a number of neurological and neuroscience studies have compared musicians' brain plasticity to that of non-musicians and other artistic individuals (Intartaglia, White-Schwoch, Kraus & Schön 2017; Slater, Azem, Nicol, Swedenborg & Kraus, 2017; Draganova, Wollbrink, Schulz, Okamoto & Pantev, 2009). The reason for including musicians in this type of research is that it has been proven that long-term musical training influences the brain's anatomy and functions (Kuchenbuch, Paraskevopoulos, Herholz & Pantev, 2014:1).

However, as far as I could establish, no research has been done concerning musicians' sensory patterns in relation to their primary musical instrument by employing a sensory profile test like the *Adolescent/Adult Sensory Profile* and *Adult/Adolescent Sensory History* (ASH). This is particularly interesting considering musicians' extensive use of their senses.

Sensory profile tests are used primarily by occupational therapists as a baseline assessment to evaluate a person's sensory processing patterns for diagnostic purposes and to determine the effect of these patterns (especially in terms of dysfunction) at a functional performance level (Pearson, 2015). One of these tests, a widely recognised and validated sensory processing tool, is the *Adolescent/Adult Sensory Profile* which was designed by Catana Brown and Winnie Dunn and published in 2002. It outlines a person's sensory profile according to the four quadrants which were mentioned earlier (low registration, sensation seeking, sensory sensitivity and sensation avoiding). Lombard (2007:3) points out that these quadrants do not provide details regarding specific senses or sensory processing and can therefore not be used "to address sensory systems for intervention purposes".

In order to provide a more comprehensive understanding of the link between musicians' sensory patterns and their primary instrument, I decided to use the ASH as sensory tests in my research. The ASH was published by the Spiral[3] Foundation in 2015. It was developed by Teresa May-Benson, the Executive Director of the Spiral Foundation. As far as I could determine, the ASH is the only reliable sensory

[3] Acronym for Sensory Processing Institute for Research And Learning.

processing assessment which is sense-specific and measures what I intended to measure. Once I established this, I was able to formulate the research problem, research questions and hypotheses.

1.2 Statement of the problem

The connection between musicians playing a particular instrument and their sensory patterns has not been investigated by means of a sensory profile test which is mainly used by occupation therapists to determine sensory patterns.

1.3 Research questions

The following main research question emanates from the stated research problem:

What is the relation between musicians' sensory patterns and their primary musical instrument?

Stemming from the main research question, the following sub-questions were posed for this study:

1. What are the similarities/dissimilarities between different instrument groups' musicians in terms of their sensory patterns?
2. What are the similarities/dissimilarities regarding musicians' sensory patterns within each particular instrument group?
3. What is the correlation between gender and sensory patterns of musicians within each particular instrument group?

1.4 Hypotheses

Linked to the current study, previous research paralleled playing a particular musical instrument to personality, gender, as well as auditory and tactile processing. It is therefore reasonable to hypothesise that there is a correlation between musicians who specialise in a particular musical instrument, their sensory patterns and their gender. Considering the research questions, I derived three hypotheses.

Research hypothesis 1

There are significant differences concerning the average **modulation and discrimination** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

Research hypothesis 2

There are significant differences concerning the average **functional problem** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

Research hypothesis 3

There are significant differences concerning the average **motor/social components** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

1.5 Research aims

In answering the research questions through testing the hypotheses, the aim of this study was to determine whether there is a relation between musicians' sensory patterns and their primary musical instrument, as well as the sensory patterns of musicians from different instrument groups. Supporting these primary aims, the study also intends to determine the correlation between gender and musicians' sensory patterns. Considering previous research, an additional aim is to include a larger number of musical instruments than previous research so that wider trends can be established. Following the outcome of this study, knowledge concerning musicians' sensory patterns can be integrated with what is already known about the association between musicians and their instrument.

1.6 Research design and methodology[4]

In order to answer the research question, a quantitative research design was implemented. Data was collected by means of the ASH which is a validated and standardised self-report questionnaire. The purpose of this tool is to measure a person's sensory integration[5] (May-Benson, 2015:12). Using the ASH makes it possible to establish the relation between musicians, their sensory patterns and their primary instrument.

The ASH is divided into nine sections comprising 163 Likert-scale questions in total. Six of the nine sections involve the senses, while the remaining three assess postural control, motor coordination, and social/emotional functioning. These sections and questions are discussed in detail in Chapters 2 and 4. For each of the nine categories, a total is calculated in order to determine a person's level of sensory processing which can either be typical according to the standard population[6], or indicate mild or definite difficulty in a particular processing area (May-Benson (2015:19). These criteria are explained in Chapter 4.

[4] The research design and research methodology are discussed in detail in Chapter 4.
[5] Sensory integration as a term was coined by Dr A. Jean Ayres in the 1960s and refers to a person with a typical sensory profile. This means that the neurological process where information is received through the senses, processed by the brain and used to carry out a suitable response, is functioning properly (Alternatives for Children, 2018).
[6] The term "standard population" refers to a large sample that represents the majority of people within a specific context which serves as a standard against which other people can be compared. In this study, "standard population" is interchangeably used with the terms "average person", "general population", "norm" and "normative sample".

Considering the fact that this study is the first of its kind, my aim was to include 19 instruments from five different instrument groups. These instruments include standard orchestral instruments, as well as instruments which are occasionally, especially currently, used in orchestral performances (refer to Table 1-1). Instruments like the piccolo, cor anglais, bass clarinet and contrabassoon have been omitted since they are seldom played as primary instrument (Ben-Tovim & Boyd, 2012:27).

Table 1-1: List of instruments

Instrument group	Instruments
Woodwinds	Flute, oboe, clarinet, bassoon and saxophone
Brass	French horn, trumpet, trombone and tuba
Percussion	Orchestral percussion and drum kit
Keyboards	Piano and pipe organ
Strings	Violin, viola, cello, double bass, harp, classical/nylon string guitar and electric/steel string guitar

Since the ASH comprises nine sections, the statistician advised me to recruit 70 participants per instrument for statistical significance. In the end, 1416 musicians participated. In order to proceed with the study and collect data, ethical clearance was sought and granted by the University of the Free State (ethical clearance number: UFS-HSD2015/0500).

Participants were recruited by means of random sampling. The sample consisted of both national and international professional musicians, music lecturers, music teachers, as well as final year and postgraduate music students specialising in performance. As long as the participants met one or more of these criteria, and were 18 years of age or older, they were allowed to participate. No pre-existing medical, neurological or sensory conditions were taken into account. Invitations containing the criteria for participation (type of musician and instrument of specialisation) were personally distributed, sent via email or posted on several Facebook musician groups. The recruitment process is explained more comprehensively in Chapter 4 which describes the methodology and presentation of data.

In exchange for data which was collected during the period of my study, the Spiral Foundation offered to set up the online questionnaire and provide monthly updates of new data entries. After concluding data collection, the results from the ASH were formally processed and analysed by a professional statistician from the University of the Free State by means of the One-way MANOVA.

1.7 Delimitations

The focus of the study is the relation between musicians, their primary instrument and their sensory patterns. Although non-musicians are not included in this research, findings are viewed in terms of the Spiral Foundation's standardised sample. Furthermore, aspects like personality, intelligence, personal background, work conditions and socio-economic factors of musicians, which have been investigated previously, were not included in this inquiry.

The ASH is an occupational therapy clinical assessment tool and not a psychological, neurological or neuroscience test. Furthermore, in terms of literature that was reviewed, it is important to be aware of the fact that the fields of occupational therapy, psychology and neurology/neuroscience have somewhat different views regarding the nervous system, sensory systems, the brain's processing of sensory information, as well as approaches to, assessment and diagnosis of dysfunction. Since this study employed the ASH, these aspects have been considered mainly from an occupational therapy stance.

Although the purpose of the ASH is to measure persons' sensory processing patterns for diagnostic purposes, this study was exclusively concerned with musicians' sensory patterns and not with pathology. I made it clear to participants who requested further interpretation of their results that I am not an occupational therapist and am therefore not qualified to interpret results in depth. In these cases, I recommended seeing an occupational therapist. In most cases, these particular participants' results pointed towards mild or definite sensory processing problems.

Since the sample involved any person who met the study's criteria for participation, aspects like respondents' intelligence, musicality, medical history or conditions, and physical or mental disabilities were not taken into consideration. The influence of these aspects thus requires further research. Furthermore, although the *Adult/Adolescent Sensory History* provides the opportunity for comments by participants, these comments were not included or considered in terms of data analysis. Besides, only a few comments were made. Apart from not serving the purpose and scope of this study, these comments need to be interpreted in the context of the *Adult/Adolescent Sensory History* results which can only be done by an occupational therapist.

Lastly, this was a quantitative investigation. The ASH is a quantitative data collection tool and therefore all data was statistically analysed.

1.8 Value of the study

No research has been done with reference to musicians' overall sensory patterns in relation to their primary musical instrument, particularly in South Africa. This provided me with a unique opportunity to contribute new knowledge in both music and occupational therapy disciplines, paving the way for further research. In addition, two further aspects were investigated: firstly, whether different instrument groups have divergent sensory patterns, and secondly, if gender has an influence on musicians' sensory patterns within the various instrument groups. By exploring these aspects, new light is shed on variables that influence choice of instrument. Although a vast amount of research is still required before a tool can be developed to aid individuals who are faced with the choice of choosing the most suitable musical instrument, this study brings researchers a step closer towards achieving it.

Apart from music, this research also focused on a new population of participants in the field of occupational therapy. Until now, musicians have not been sampled with the aim of determining their sensory patterns by using a sensory profile test. This can be particularly beneficial in order to determine differences between musicians versus a normative sensory profile sample. For this reason, as well as for obtaining a

South African normative sample, the Spiral Foundation is interested in the data of the study.

The fact that the ASH has been used as data collection tool significantly increases the value of this study since it is a validated and standardised self-report questionnaire which is used worldwide. Furthermore, the Spiral Foundation (publisher of the ASH) and their statistician were consulted throughout the research process and provided invaluable input in terms of interpretation of the data, thus ensuring the trustworthiness of my findings.

1.9 Thesis outline

This chapter provides the background to the study at hand. Its main purpose was to provide the reader with an overall understanding of the background that led to this inquiry. The research problem became clear, giving rise to the research questions and hypotheses. The research aims were formulated. Following careful consideration of these questions and hypotheses, a brief delineation of the research design and methodology was provided.

Using this chapter as the point of departure, the thesis unfolds in five further chapters. Chapter 2 explains the theoretical foundation, and key concepts related to the nervous system, senses and sensory processing by discussing associated literature. In the chapter that follows, Chapter 3, an account is given pertaining to the link between musicians, their personality traits and their senses. After concluding the review of literature, Chapter 4 provides an in-depth explanation relating to the research design and methodology which were implemented. It also includes a systematic presentation of the data that was collected during the course of the study. This is followed by Chapter 5 which presents a detailed analysis of this data. Chapter 6 concludes the study by means of a discussion of the findings in light of the hypotheses that were tested in order to answer the research questions. Recommendations for further research are then made.

CHAPTER 2

THE NERVOUS SYSTEM, SENSES AND SENSORY PROCESSING

2.1 Introduction

The foremost purpose of a literature review is to determine what has been investigated and written concerning research in a specific field (Maree & Van der Westhuizen, 2007:26; Hofstee, 2006:91; Mouton, 2001:87). This provides information on previously explored methodologies scholars have used, "how they have theorised and conceptualised on issues" (Mouton, 2001:87), what data collection instruments they used, and what their findings were (Maree & Van der Westhuizen, 2007:26; Hofstee, 2006:91; Mouton, 2001:87). This both allows the researcher to be familiar with what has been investigated previously (Maree & Van der Westhuizen, 2007:26) and illumines gaps in existing literature (Bryman, 2012:101; Maree & Van der Westhuizen, 2007:26). As a result, it ensures that the researcher's work is distinctive, authentic and contributes to new knowledge in the field (Hofstee, 2006:91).

Mouton (2001:87) further points out that a "review of existing scholarship", as he prefers calling it, highlights "different theories, models and hypotheses; … existing data and empirical findings; … [and] measuring instruments" (Mouton, 2001:87). This includes critically analysing similarities, dissimilarities, weaknesses, controversies and inconsistencies in existing scholarly contributions (Bryman, 2012:98,100; Maree & Van der Westhuizen, 2007:26; Hofstee, 2006:93; Mouton, 2001:87).

Furthermore, by reviewing literature, the authority of the researcher is established (Maree & Van der Westhuizen, 2007:26; Hofstee, 2006:91; Mouton, 2001:87). It ensures the researcher does not duplicate another study's methodology (unless it is the intention); is aware of existing instruments which are validated and standardised; and is up to date with the latest scholarly contributions and points of view in the field.

Lastly, Hofstee (2006:88) and Mouton (2001:87) stress that the researcher should demonstrate that he/she is acquainted with recognised definitions and should clarify concepts to provide a solid understanding of the research among its readers.

Considering the aims of a literature review, I intend to highlight the "most widely accepted empirical findings" (Mouton, 2001:87) while providing a "critical, factual overview" of existing literature (Hofstee, 2006:91). This provides a contextual understanding of how the current study links with existing literature while strengthening its theoretical base (Hofstee, 2006:93; Mouton, 2001:87). In order to achieve this, the literature review is divided into the following sections: theoretical foundation, the human nervous system, sensory processing, sensory processing disorder, assessment of sensory processing in adolescents and adults, and the Adult/Adolescent Sensory History after which the chapter concludes.

2.2 Theoretical foundation

Hofstee (2006:92) explains that a theory is an "explanation for why something is as it is or does as it does" while the "principles that cause it to work" are known as the theoretical foundation. The research question corresponds with empiricism which suggests that knowledge is constructed through experience (Bryman, 2012:23). To achieve this, deductive reasoning is used to link previous research with this study to answer the research questions (Bryman, 2012:24; Creswell, 2009:55).

In order to establish the theoretical foundation of the research questions, the bigger picture should first be considered. My study falls under social sciences and therefore draws its "conceptual and theoretical inspiration" (Bryman, 2012:5) from the social sciences. Social research is considered through the lens of three paradigms: ontology, methodology and epistemology (Guba & Lincoln, 2011:165; Corbetta, 2003:14). Ontology concerns the question "what is truth/reality?" (Maree, 2007:52), while methodology determines "how … social reality [can] be studied" (Corbetta, 2003:13), and epistemology looks at "how one knows [or comes to know] reality" (Maree, 2007:55). The latter paradigm reflects the aim of the research question which involves "the relationship between the 'who' and the 'what' (and the outcome of this relationship)" as referred to by Corbetta (2003:12) in his explanation of epistemology.

Having established epistemology as the paradigm of this study, the next question is through which theoretical lens the research question/s should be viewed (Saunders, Lewis & Thornhill, 2009:109). As pointed out by Guba and Lincoln (2011:166), Saunders, Lewis and Thornhill (2009:109) as well as Crotty (1998:5), the choice of theoretical base depends on the nature of the research question/s and what the researcher aims to achieve.

The methodology for my study is informed by the research questions. This approach is known as methodological pluralism which is often associated with a post-positivist research philosophy (Jupp, 2006:174). By considering the main research question, the intention is to gain an understanding of the trends and causal relationship between musicians' sensory patterns and their primary musical instrument through deductive reasoning. Considering the aim as well as the method of data collection and its analysis, this study calls for a post-positivist philosophy (Creswell, 2009:7; Trochim & Donnelly, 2006:52; Miller, 2005:39).

Post-positivism, an epistemological philosophy, is often associated with qualitative methods (Guba & Lincoln, 2011:165; Creswell, 2009:6; Corbetta, 2003:14) since it views reality as something which is "multiple, subjective and mentally constructed by individuals" (Maree, 2007:65). This philosophy is therefore not immutable. Post-positivism is often criticised by positivists who argue that reality is concrete, can be observed and measured, and that "knowledge can be 'revealed' or 'discovered' through the use of the scientific method" (Maree, 2007:65). However, if the research problem is ontologically approached from the point of view of critical realism, a form of post-positivism, the problem can be studied scientifically as a reality which is independent from a particular perspective or way of thought (Trochim & Donnelly, 2006:52). Consequently, positivists claim that research results can be relied upon as true and absolute (Saunders, Lewis & Thornhill, 2009:119; Corbetta, 2003:14). However, by using quantitative methods, post-positivists are able to produce "probabilistically true" results without claiming them to be absolute (Corbetta, 2003:14).

As mentioned earlier, deductive reasoning is used throughout this work to grasp the topic and to ultimately draw a coherent conclusion. This is achieved through reviewing existing literary contributions and systematic data analysis. The sections that follow are devoted to gaining a cumulative understanding of the topic through existing literature. Firstly, the human nervous system is discussed.

2.3 The human nervous system

The human nervous system shares many similarities with other vertebrates (Purves, Augustine, Katz, LaMantia, McNamara & Williams, 2004:1). However, the purpose of this study is to examine the sensory characteristics of musicians and therefore only literature related to the human nervous system (hereafter referred to as the "nervous system") is discussed. The nervous system refers to the brain, spinal cord, nerves, ganglia, and parts of the receptor organs that receive and interpret stimuli which then generate impulses that are sent to the effector organs (muscles or glands) (VanPutte, Regan & Russo, 2016:193; Betts, DeSaix, Johnson & Korol, 2013:474).

The nervous system consists of the central nervous system (CNS) and the peripheral nervous system (PNS) (Peilan, Wang & Chen, 2016:11). The CNS comprises the brain and spinal cord, while the PNS contains sensory neurons which transfer impulses from the sensory receptors to the CNS (VanPutte et al., 2016:194; Purves et al., 2004:14; Morris & Fillenz, 2003:2). Although experts in the field of neuroscience agree on the existence of two nervous systems, they have not reached consensus regarding the exact point of divergence between them (Betts et al., 2013:470).

The nervous system can be thought of as a chain or cycle made up of five components: sensory receptors, sensory pathways (sensory divisions), integration centre (CNS), motor pathways (motor divisions) and effectors (muscles or glands)

(Martini & Bartholomew, 2016:277; Queen Margaret University, 2016:1). This cycle is demonstrated in Figure 2-1.

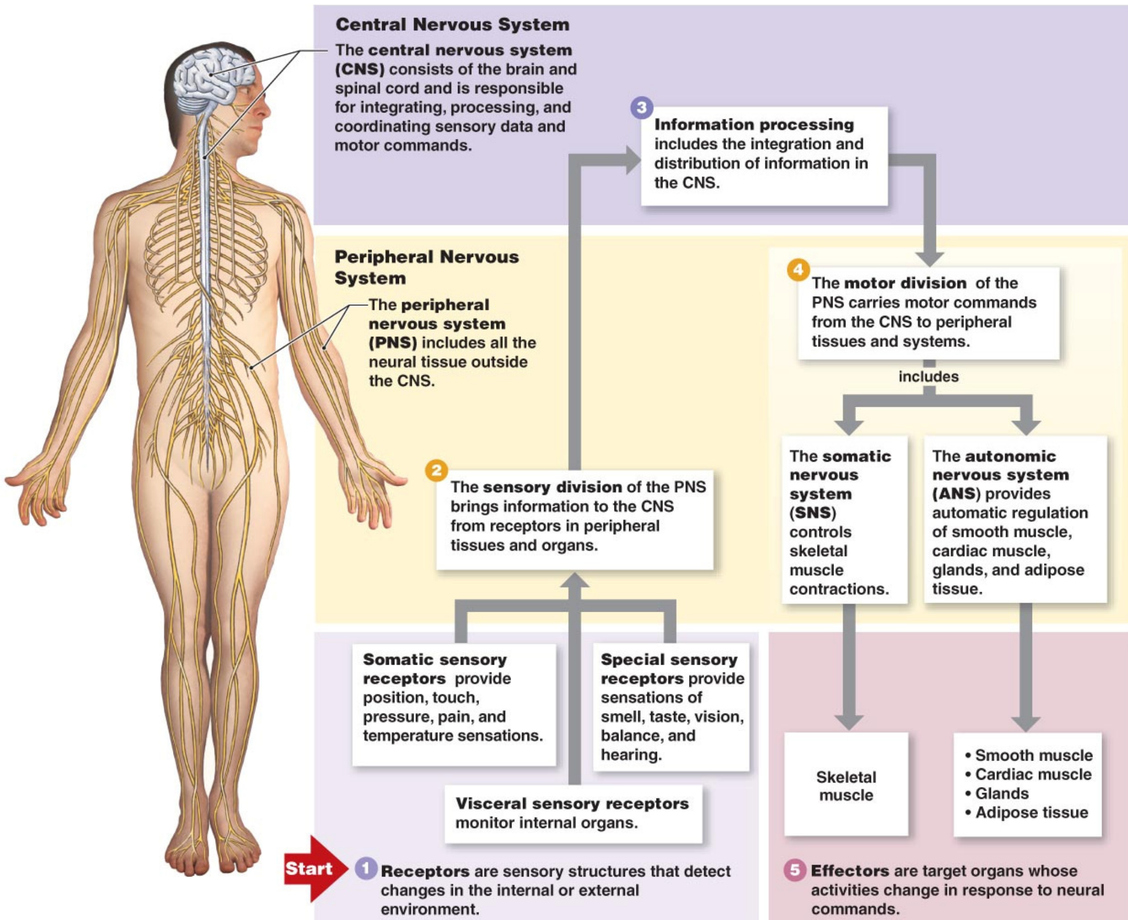


Figure 2-1: The nervous system (Martini & Bartholomew, 2016:277)

Each component of the nervous system is central to its effective functioning and fulfils a specific role (VanPutte et al., 2016:194; Betts et al., 2013:474; Scanlon & Sanders, 2007:198). The first component in this chain is the sensory receptors which are specific nerve endings located throughout the body. These nerve endings receive and respond to information from stimuli inside and outside the body by generating nerve impulses. From here, neurons functioning as sensory pathways in the PNS transmit nerve impulses from the sensory receptors to the CNS. After receiving impulses from the PNS, the CNS processes the information and sends out instructions to effectors via motor pathways located in the PNS. Effectors complete the cycle, effecting instructions by means of a reflex (VanPutte et al., 2016:194; Betts et al., 2013:474; Scanlon & Sanders, 2007:198).

As discussed previously, the nervous system has five components, one of these being sensory receptors which are located in the senses (VanPutte et al., 2016:239). Since one of the main goals of this particular study is to determine if musicians playing the same instrument share similar sensory and motor behavioural patterns, the senses and the processing of sensory information are discussed in more detail.

2.4 Overview of the different parts of the brain

The main parts of the human brain are the brainstem, diencephalon, cerebellum and cerebrum (VanPutte et al., 2016:212; Betts et al., 2013:515; Purves et al., 2004:14). Figure 2-2 illustrates the medial view of these parts.

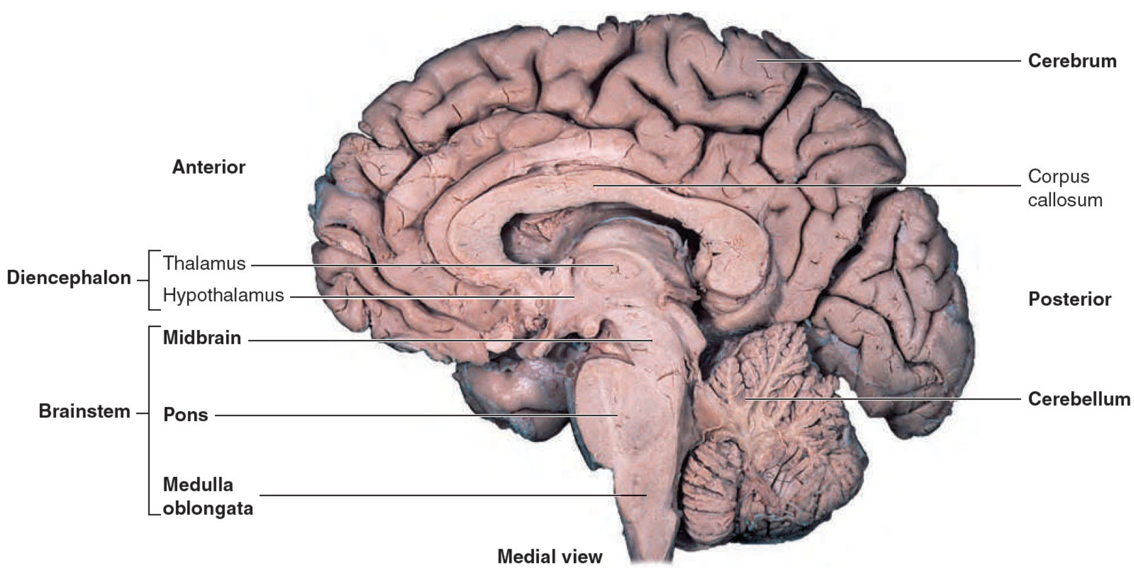


Figure 2-2: Medial view of the human brain (VanPutte et al., 2016:212)

The brainstem, consisting of the medulla oblongata, pons and midbrain, connects the rest of the brain with the spinal cord (VanPutte et al., 2016:212; Betts et al., 2013:515; Purves et al., 2004:18). The medulla oblongata controls body functions like balance, breathing, coordination, coughing, heart rate, sneezing, swallowing and vomiting (VanPutte et al., 2016:212; Scanlon & Sanders, 2007:176). The pons on the other hand is responsible for functions like chewing and production of saliva (VanPutte et al., 2016:212; Purves et al., 2004:356) as well as conducting impulses to and from the cerebellum and cerebrum by means of ascending and descending neural pathways. The pons and medulla oblongata are collectively responsible for core functions like balance, breathing and swallowing.

The third and smallest part of the brainstem, is known as the midbrain (VanPutte et al., 2016:212; Betts et al., 2013:528). It contains four bulges known as colliculi. Two of these, referred to as the inferior colliculi, serve as “centers for the auditory nerve pathways in the CNS”, while the two superior colliculi control “visual reflexes and receive touch and auditory input” (VanPutte et al., 2016:212). It further contains nuclei involved with eye movement, as well as regulating a variety of body movements, breathing, walking, chewing and pupil size.

The diencephalon has three components: the epithalamus, hypothalamus and thalamus (VanPutte et al., 2016:213; Betts et al., 2013:526). The epithalamus comprises the pineal gland and nuclei which have to do with emotional and internal responses to smell. The pineal gland is believed to be responsible for regulating sleep patterns which are subject to seasonal day-night changes (VanPutte et al., 2016:214; Betts et al., 2013:716). The hypothalamus plays a vital role in homeostasis – maintaining a steady balance between internal elements like “temperature, volume, and chemical content” despite exterior environmental changes (VanPutte et al., 2016:4). It also regulates hormone secretion, as well as sensations such as hunger, thirst and event-dependant emotions. The thalamus influences mood and records most sensory stimuli, including discomfort or pain, from where the information is conveyed to the cerebral cortex.

The cerebellum, which is responsible balance and coordination (Peilan et al., 2016:44), integrates sensory responses with information from the cerebrum in order to execute “suitable” voluntary and involuntary reflexes (VanPutte et al., 2016:213; Betts et al., 2013:528-529). To achieve this, there are fibres which are connected to the inferior olive which is located in the medulla. The inferior olive conveys “sensory information from the muscles and joints, proprioceptive information about the movements of walking, and sensations of balance” (Betts et al., 2013:528-529). The cerebellum then compares the information with previously obtained information from where adaptive information is sent to the midbrain which further conveys it via the spinal cord to the effecting muscles. The cerebellum is also connected with other parts of the CNS by means of motor pathways (VanPutte et al., 2016:213; Betts et al., 2013:529).

The cerebrum is divided into the left and right hemispheres which are separated by the longitudinal fissure (Peilan et al., 2016:44; Betts et al., 2013:552). Each of these hemispheres is divided into four lobes (frontal, parietal, occipital and temporal). The frontal and parietal lobes are separated by means of the central sulcus. The frontal lobe is involved with “voluntary motor functions, motivation, aggression, mood, and olfactory (smell) reception” (VanPutte et al., 2016:214). The parietal lobe receives and discriminates between sensory information pertaining to balance, pain, temperature and touch. The occipital lobe, on the other hand, “receives and perceives visual input” (2016:214). The temporal lobe processes olfactory and auditory input, and plays a vital part in language and memory processing (Peilan et al., 2016:45). The lateral fissure isolates most of the temporal lobe from the other lobes. Figure 2-3 illustrates the superior view of the lobes, while Figure 2-4 represents the lateral view.

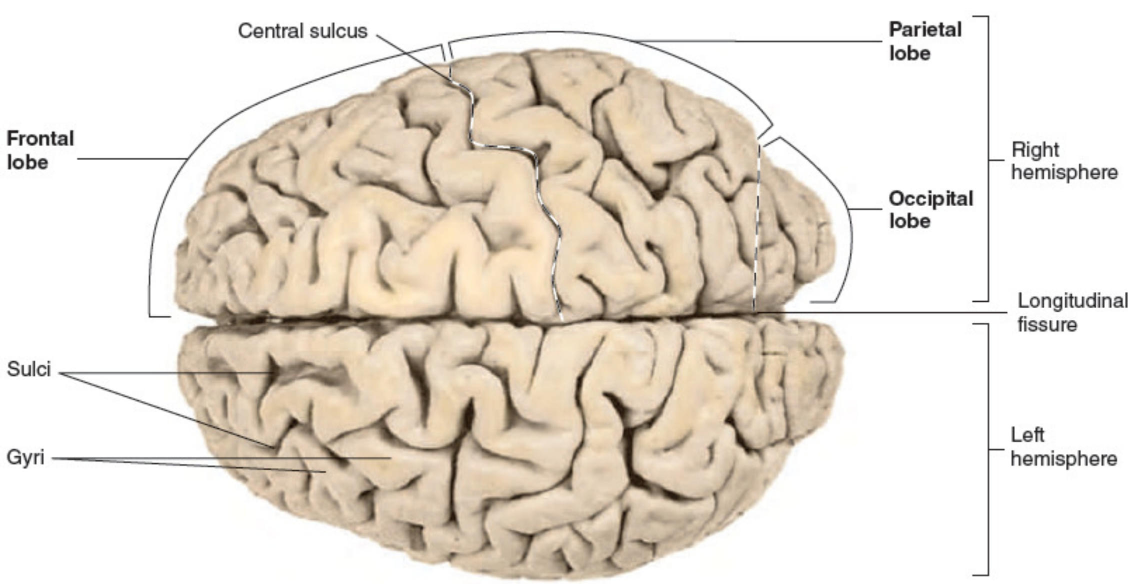


Figure 2-3: Superior view of the human brain (VanPutte et al., 2016:215)

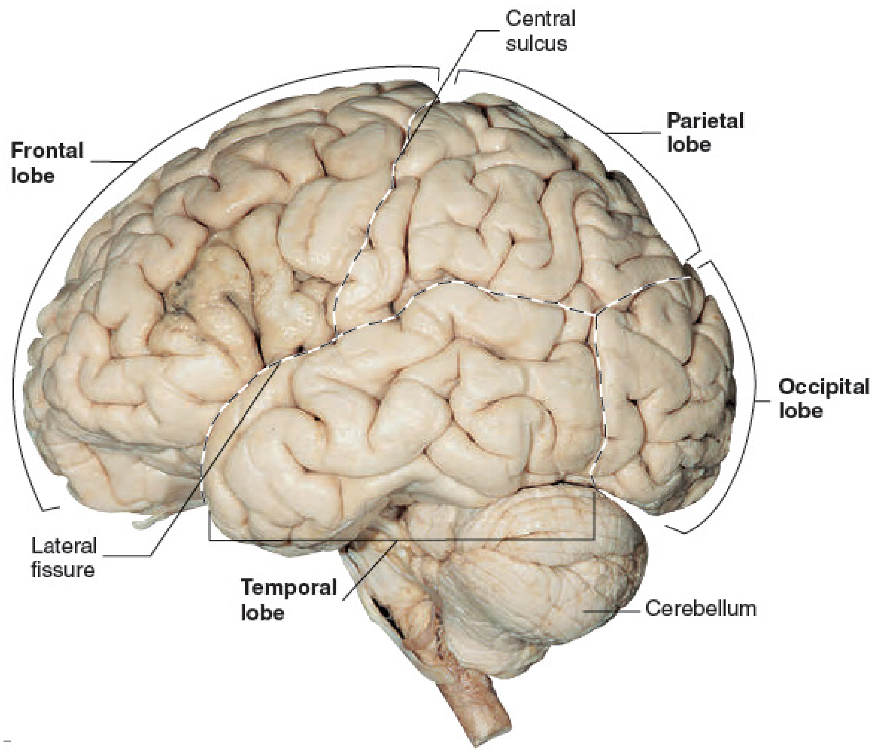


Figure 2-4: Lateral view of the human brain (VanPutte et al., 2016:215)

2.5 Senses

The concept of having five senses (hearing, sight, smell, taste and touch) dates back to Aristotle who first introduced it (Finger, 2001:134; Postgate, 1995:165). Apart from the traditional senses, other senses like balance, pain, pressure, proprioception and temperature have since been included (VanPutte et al., 2016:239-240; Betts et al., 2013:474; Scanlon & Sanders, 2007:198). Senses are furthermore divided into general senses and special senses (Figure 2-5). General senses are found throughout the body and have receptors in more than one organ, while receptors in special senses are dedicated to that specific organ (VanPutte et al., 2016:239; Betts et al., 2013:563-564). In addition, general senses are classified as somatic senses (senses that receive information from outside the body and are located in the joints, muscles and skin), and interoceptive or visceral senses (senses situated in the internal organs that convey information from within the body) (Peilan et al., 2016:216; Scanlon & Sanders, 2007:198).

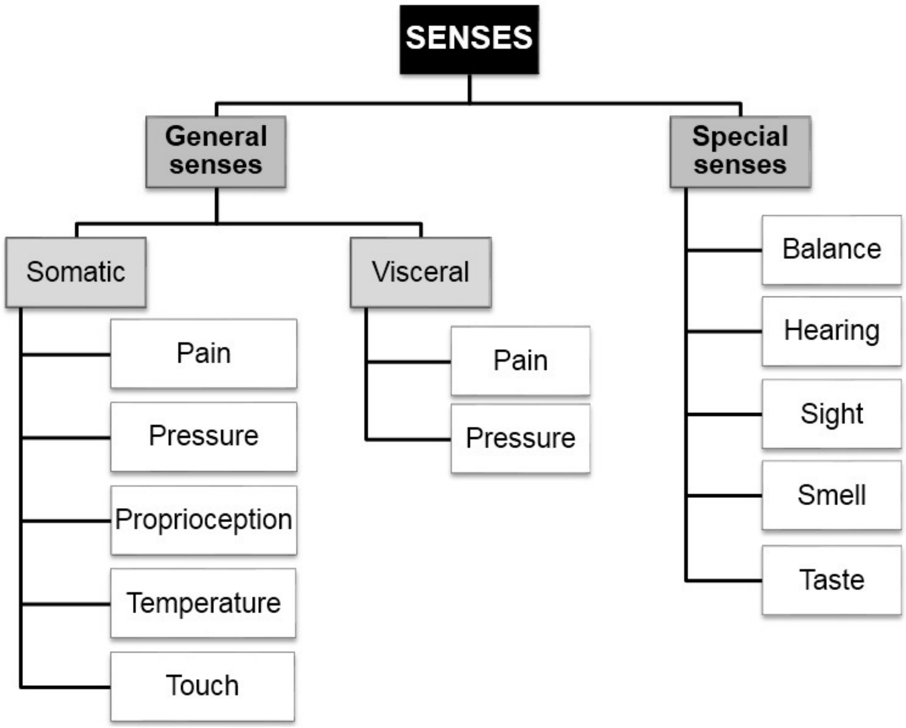


Figure 2-5: Classification of the senses (VanPutte et al., 2016:240)

The exteroceptive senses (which include the five traditional senses) involve "the exteroceptors; denoting the surface of the body containing the end organs adapted to receive impressions or stimuli from without" (Stedman, 2006:686). On the other hand, interoceptive senses convey stimuli which are produced within the body to the CNS (Stedman, 2006:686). Interoceptive senses include senses beyond the five traditional senses located in the organs. These senses detect sensations such as pain, hunger, temperature, proprioception (awareness of the position/location of body parts without visual support) and vestibular processing (movement) (Betts et al., 2013:623). After receiving sensory information via the PNS, the CNS processes the data at both a brainstem level and a cerebrum level (VanPutte et al., 2016:212, 214; Purves et al., 2004:1).

Another classification of senses is found in the field of occupational therapy. Winnie Dunn[7] defines two groups of senses. The one group records "sensations that tell us

[7] Winnie Dunn is an American occupational therapist with a PhD in neuroscience. She is particularly known for her research on sensory modulation and its influence on people's daily life (Pearson, 2017:1). In 2009, she published the book *Living sensationally* which is based on her research.

about the world around us”, while the other group registers “sensations that tell us about our bodies” (Dunn, 2009:21, 25). She categorises the visual sense, auditory sense and sense of smell (olfactory sense) under sensations that inform individuals about the world around them (Dunn, 2009:25-27). According to Dunn (2009:1-4), sensations that tell people about their bodies include the tactile sense (touch), proprioceptive sense (position), vestibular sense (movement) and the oral sense. Since one of the main aims of this study is to determine if sensory patterns can be established among musicians, each of these senses is briefly explained below.

2.5.1 Visual sense

Of all the senses, the visual sense involves the most complex process (Lombard, 2014:12). During this intricate process, of which only an overview is provided, light enters the eye through the cornea, is focused by the lens and projected onto the retina where visual receptors are located (Lombard, 2014:12; Scanlon & Sanders, 2007:202). From here, the visual information is converted into action potentials and sent to the brain via special nerves (VanPutte et al., 2016:244; Lombard, 2014:12). The final visual input stage involves the brain converting the information into a picture (Lombard, 2014:12) that portrays location, size, shape, colour, intensity, texture of objects, as well as direction and speed if movement is involved (Lombard, 2014:12; Purves et al., 2004:229).

2.5.2 Auditory sense

Sound waves are received by the outer ear, transmitted by the middle ear and converted into an action potential[8] in the inner ear (Purves et al., 2004:283; Bundy, Lane & Murray, 2002:59). This is achieved through auditory receptors known as “hair cells” which are located in the cochlea, a membranous structure in the inner ear. These receptors are components of the organ of Corti. From here, information is sent to the brain via five different auditory pathways (Gutman, 2008:94; Purves et al., 2004:303-309). Firstly, there is the cochlear nucleus pathway that is responsible for

[8] "The electrical signal conducted along axons (or muscle fibers) by which information is conveyed from one place to another in the nervous system" (Purves et al., 2004:G-1).

analysing the quality of sound and identifying frequency differences. Next is the superior olivary pathway which is responsible for the localisation of sound. It also responds to differences in intensity and timing between sounds. Then there is the inferior colliculus pathway which integrates spatial information from the superior olive with pitch information from the cochlear nucleus. The fourth pathway is known as the medial geniculate nucleus which is the auditory nucleus of the thalamus. The final pathway is the primary auditory cortex which is located in the upper part of the temporal lobe where a person perceives what he/she hears (VanPutte et al., 2016:221; Purves et al., 2004:309-310).

2.5.3 Olfactory sense

The olfactory sense or olfaction (sense of smell) responds to molecules in the air known as odorants (VanPutte et al., 2016:242; Betts et al., 2013:566). When these airborne molecules enter the nose, they are absorbed and dissolved by mucus which keeps the olfactory epithelium lining of the nasal cavity moist (VanPutte et al., 2016:242). The dissolved molecules attach to dendrites from the olfactory neurons, register the smell and relay this information to the limbic system in the brain (VanPutte et al., 2016:242; Lombard, 2014:20). In contrast to other sensory information that first passes through the thalamus, olfactory information is directly transferred to the limbic system of the brain (Lombard, 2014:20). The limbic system is the part of the brain that processes emotions and memories and therefore reaction to smell is direct, strong and profound – "when something stinks, it really STINKS with a capital S" (Lombard, 2014:20).

2.5.4 Tactile sense

The tactile sense refers to sensations of touch, pressure, vibration, temperature, itch and pain, all of which are detected by different receptors (VanPutte et al., 2016:240-242; Kranowitz, 2005:82-83). These include free nerve endings that register pain, temperature, itch and movement; Merkel disks which register light touch and surface pressure; Meissner corpuscle receptors responsible for localising touch; hair follicle receptors detecting light touch and lastly Ruffini corpuscles which detect continuous pressure (VanPutte et al., 2016:240). Figure 2-6 provides a visual representation of the tactile receptors (as well as pacinian corpuscles which are discussed under the next sub-heading). Considering the wide-ranging tactile input, Lombard (2014:17) points out that each of these particular receptors follows “a specialized pathway to the brain”.

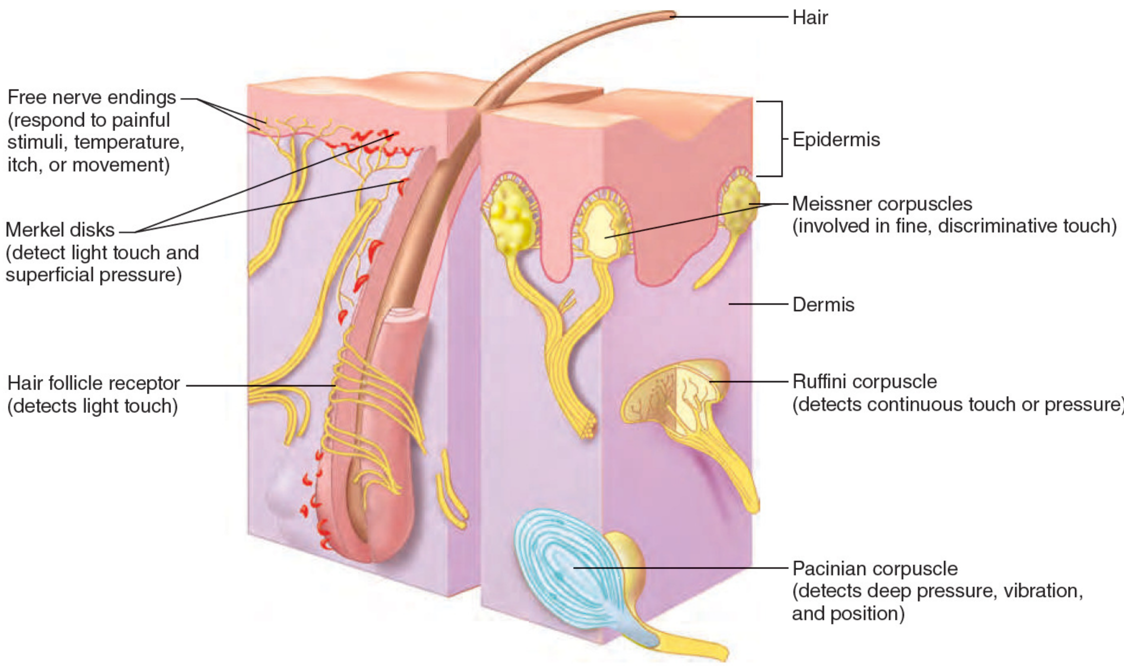


Figure 2-6: Sensory receptors in the skin (VanPutte et al., 2016:241)

2.5.5 Proprioceptive sense (proprioception)

The word proprioception stems from two Latin words, *proprius* meaning “one’s own” and *ceptus* denoting “sense of” or “receiving” (Lowery, 2016:73; Ayres, 2005:41). Literally meaning “sensations from one's own body” (Ayres, 2005:41), proprioception provides an internal picture of where the “body parts are in space” (Wilson & May-Benson, 2014:16; Dunn, 2009:23). This is achieved through registering sensations of deep pressure, vibration and position through pacinian corpuscle receptors that are located in the joints and muscles (VanPutte et al., 2016:240; Wilson & May-Benson, 2014:16). Pacinian corpuscle receptors which are situated in the joints distinguish “bending, straightening, pulling, and compression”, while pacinian corpuscle receptors in the muscles detect “contraction and stretching” (Ayres, 2005:41). This, for example, enables a person to walk down a flight of stairs without looking at his/her feet (Lombard, 2014:23). Conversely, a lack of proprioceptive discrimination is typically seen in a tendency to bump into things, break objects, drop things easily, spill liquids, and grasp objects tightly; as well as over/underestimate the amount of force that is required for a task, and seem shaky when doing fine motor tasks (Porter, 2017:1; May-Benson, 2015:74-75).

2.5.6 Vestibular sense

Located in the inner ear, the vestibular sense allows a person to know where he/she is "in space" and detects acceleration in movement of the head and body's orientation with regard to gravity (Cullen & Sadeghi, 2008:1; Wilson & May-Benson, 2014:4). Information which is gathered from the vestibular organs is conveyed to the neural structures that control eye movements, posture and balance. "[D]aily activities such as stabilising the visual axis (gaze) and maintaining hand and body posture" rely on effective vestibular function (Cullen & Sadeghi, 2008:1). In addition, the vestibular system provides one with one's sense of movement through space and a sense of mastery over one's body when moving (Cullen & Sadeghi, 2008:3). Together with the visual system, the vestibular system manages a person's posture and fight or flight responses. In addition, it "has a strong influence on emotions and self-regulation" (Wilson & May-Benson, 2014:17).

2.5.7 Oral sense

The oral sense registers taste (sweet, salty, sour, bitter and spicy) by means of sensory receptors known as taste buds that are located on the tongue and other fleshy areas of the mouth and pharynx (VanPutte et al., 2016:243). VanPutte et al. explain that taste enters the taste bud through a taste pore (small opening in the taste hair) which is located on the surface of the taste bud (Figure 2-7). Molecules then dissolve and bind to receptors on the taste hair causing an action potential after which it is carried to the cerebral cortex via sensory neurons (VanPutte et al., 2016:243). Apart from taste, the oral sense also responds to information concerning texture and temperature of sustenance or objects in the mouth (Dunn, 2009:24).

Lastly, the oral sense (taste) is closely linked to olfaction: for example, when you block your nose with your fingers when consuming something with an unpleasant taste, you often do not taste it until you remove the block (Lombard, 2014:20).

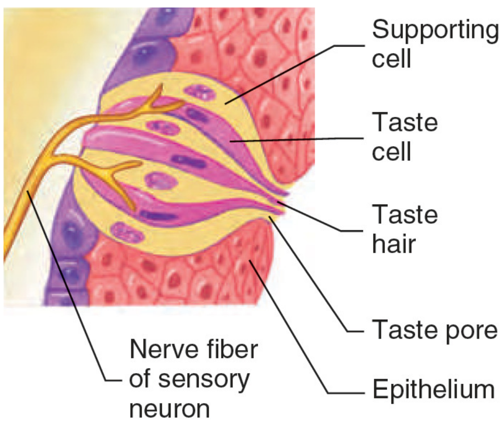


Figure 2-7: Structure of a taste bud (VanPutte et al., 2016:243)

This section dealt with the different senses through which sensory information is received from the body and its environment, and how this information is passed on to the brain through specialised pathways. The next process involves the manner in which the brain organises and interprets information. This is known as sensory integration, a division of sensory processing (Wilson & May-Benson, 2014:4).

2.6 Sensory processing

According to Jorquera-Cabrera, Romero-Ayuso, Rodriguez-Gil and Triviño-Juárez (2017:1), sensory processing "generally refers to the handling of sensory information by neural systems, including the functions of receptor organs and the peripheral and central nervous systems". Apart from receiving information from the seven sensory systems, sensory processing is also responsible for modulation, integration, organisation of sensory input, as well as responding to sensory input (Jorquera-Cabrera et al., 2017:1; Miller & Lane, 2000:2).

2.6.1 Sensory integration

Sensory integration was first introduced by Jean Ayres, an American occupational therapist (Pollock, 2009:6). She defined it as “the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment” (Ayres, 1972:11)[9]. To achieve this, sensory integration is divided into intrasensory integration and intersensory integration. Intrasensory integration processes “sensory input from a single sensory system [which] converges on a cluster/s of neurons, and together they affect the activity of the neuron/s on which they synapse” (Miller & Lane, 2000:3). On the other hand, intersensory integration involves “the central process in which multisensory neurons, or clusters of neurons, receive input from more than one sensory system” (Miller & Lane, 2000:3). Wilson and May-Benson (2014:4) explain that the degree of success with which we perform daily activities such as “work, dressing, eating and self-regulation” relies on effective sensory integration.

2.6.2 Sensory modulation

Ayres (1979:44-45) states that “the combination of facilitatory and inhibitory messages produces modulation which is the nervous system’s process of self organization”. This means that sensory information is integrated with previous information, memories and knowledge (Lujan, n.d.:2), allowing the brain to adjust the amount of stimulation in order to carry out a meaningful response (May-Benson, 2015:12; North Shore Pediatric Therapy[10], 2017c:1). Therefore, based on the sensory input the brain receives and its capacity to integrate it with previous exposure to the specific stimuli, occupational therapists Roley, Mailloux, Miller-Kuhaneck and Glennon (2007:315) add that modulation “regulate[s] and organize[s] the degree, intensity and nature of responses to sensory input in a graded and adaptive manner”. In other words, at behavioural level, modulation involves

[9] Despite the fact that this reference is more than 40 years old, it is still regarded as a seminal source.
[10] North Shore Pediatric Therapy is based in Chicagoland and the Milwaukee area and consists of nine branches. They focus on maximising children’s potential using “neuropsychology, occupational therapy, physical therapy, speech therapy, applied behavior analysis (ABA), social work, school advocacy services, dieticians, and academic specialists” (North Shore Pediatric Therapy, 2017:1).

responses that match demands and expectations of the environment. It is observed in sensory seeking and sensory avoiding behaviours (Bundy et al., 2002:103).

Dunn (2007:85; 2006:6) explains sensory modulation in terms of neurological thresholds. A neurological threshold refers to the amount of sensory stimulation needed for a nerve or sensory system to notice change and to generate a response (Dunn, 2007:85). If a person has a low sensory threshold, a small amount of sensory stimulation is needed to trigger response and reaction is quicker to stimulus than it is with the average person. Conversely, someone with a high sensory threshold requires stronger sensory stimulus to respond to sensory input and consequently fails to notice stimuli other people may recognise automatically (Dunn, 2007:85).

In addition to Dunn's explanation, May-Benson (2015:12) points out that sensory modulation refers to "the ability to determine the relevance of sensory stimuli and adapt one's nervous system responses to make an appropriate response". Examples of effective modulation include "jumping when you hear a loud bang, but not when the air conditioner cycles on […] or jumping at every bang when your office is next to a large construction job" (Dodge, n.d.:1). To achieve this, the brain organises sensory information through filtering out irrelevant stimuli and "filing" important information for ongoing use (May-Benson, 2015:12; North Shore Pediatric Therapy, 2018a:1). May-Benson (2015:12) states that both hyper- and hypo-responsivity to sensations frequently indicates dysfunction in modulation and that sensory modulation dysfunction[11] often involves "multiple sensory systems including visual, auditory, vestibular and tactile sensations".

2.6.3 Sensory discrimination

Sensory discrimination, also known as sensory organisation, is a central (brain) process which identifies "the salient qualities of sensory stimuli and process[es] the information effectively for use, especially for postural-ocular and praxis skills"[12] (May-

[11] The term "dysfunction" refers to a functional problem which a person experiences in a specific occupational area; it is caused by a number of "contributing factors that are interfering with the client's engagement" (Gateley & Borcherding, 2017:45).
[12] Postural-ocular and praxis skills are discussed under the next two headings.

Benson, 2015:12). It therefore allows a person to interpret features such as “size, shape and texture, direction of noise and body position and movement in space” (Wilson and May-Benson, 2014:16) from the information that was generated by sensory modulation.

2.6.4 Praxis (motor coordination)

With reference to sensory integration, praxis (also known as motor coordination or motor-based function) refers to a person’s capacity to conceptualise, plan and execute the steps of a motor action (Jorquera-Cabrera et al., 2017:2; May-Benson & Cermak, 2007:148). Additionally, Whitney (2016:1) explains that praxis allows an individual:

> to interact successfully with the physical environment; to plan, organize, and carry out a sequence of unfamiliar actions; and to do what one intends, wants, and needs to do in an efficient, satisfying manner. It is a broad term which actually includes:
>
> - Ideation: the thought, planning an idea in the mind, ability to visualize the activity
> - Motor Planning: making a plan for the action
> - Execution: actually doing the activity or “executing” the action.

Discrimination difficulties often coincide with postural and praxis difficulties (May-Benson, 2015:37). Praxis difficulties may present themselves in fine motor planning, motor planning, oral motor planning and sequencing (May-Benson, 2015:37; Le Roux, 2014:7). May-Benson (2015:37) explains that challenges in these areas are often related to other processing abilities. These are shown in Table 2-1. The term “dyspraxia” is used to refer to praxis problems (Wilson & May-Benson, 2014:16). Dyspraxia and its effect on daily activities are described under the heading “Sensory processing disorder”.

Table 2-1: Praxis difficulties and related processing challenges (May-Benson, 2015:37)

Praxis difficulty	Related processing challenge/s
Fine motor planning	Fine motor-specific tactile and/or proprioceptive processing
Motor planning	Decreased tactile and/or proprioceptive processing
Oral motor planning	Tactile, proprioceptive or taste and smell processing
Sequencing	Vestibular processing

2.6.5 Postural-ocular skills

May-Benson (2015:12) describes postural-ocular skills as "the ability to demonstrate adequate and functional postural control, and to coordinate that control with the oculo-motor system"[13]. This impacts non-gravitational activities such as reaching, pushing and pulling which require resistance against force, or to maintain good posture when being stationary, for example standing or sitting (STAR Institute for Sensory Processing Disorder, 2017:1). Postural-ocular skills are essential for activities like reading and participating in sport which require balance, depth perception and eye-hand coordination (North Shore Pediatric Therapy, 2017c:1).

May-Benson (2015:37) asserts that postural control difficulties often go together with motor coordination, proprioceptive processing and/or vestibular processing. Postural-ocular dysfunction is often noticeable when a person has difficulty maintaining postural stability, muscle tone, muscle strength and endurance (May-Benson, 2015:12). Postural stability refers to balance, while muscle tone involves the body's ability to sustain a steady amount of tension in most muscles in order to stabilise the joints. Stabilising the joints makes it possible to maintain body posture (VanPutte et al., 2016:165; Betts et al., 2013:396). Muscle strength on the other hand involves the size and number of muscle fibres. A decrease in muscle tissue and endurance often occurs as a result of injury, movement disorders or reduced physical activity which is commonly found among elderly people (VanPutte et al., 2016:578; Betts et al., 2013:406, 670).

2.6.6 Visual spatial processing

Visual spatial processing refers to people's ability to tell where objects, including their body parts, are in space (Kelly, 2018:1). It allows them to tell the distance between objects, as well as between objects and themselves. To achieve this, the brain processes what the eyes see whether it is symbols, pictures or distances (Nielsen Vision Development Center, 2018:1). Kelly (2018:1) explains that a person

[13] The oculo-motor (oculomotor) system refers to the six muscles around the eye ball which control the movement of the eye (North Shore Pediatric Therapy, 2017c:1).

relies on visual-spatial processing to complete daily activities such as finding your way home and merging in traffic. Kelly (2018:1) and May-Benson (2015:20) emphasise the fact that visual spatial processing cannot be isolated from other functional processing skills such as oculo-motor control and visual hypersensitivity (oversensitivity to visual input). Table 2-2 shows examples which typically indicate visual spatial discrimination difficulty.

Table 2-2: Possible indicators of poor visual spatial processing (Porter, 2017:1; May-Benson, 2015:70; Miller & Collins, 2012:2)

Potential indicators of poor visual spatial processing
Avoid or have difficulty with eye contact
Become easily distracted by visual stimulation
Difficulty distinguishing similar letters like b and d
Difficulty in telling left from right
Dislike bright coloured clothing
Dislike bright lights or seem irritated by them
Draw some numbers or letters backwards
Have difficulty finding your way from a map?
Have difficulty looking for items on a grocery shelf
Have difficulty with depth perception
Judging distance between oneself and an object/person
Like to stare at lights or oncoming traffic's headlights
Lining up numbers in a math problem
Overly attend to small visual details
Prefer wall and/or ceilings painted dark colours
Scanning a page for keywords

2.6.7 Auditory and language processing

As discussed earlier under the heading "Senses", the auditory sense is responsible for recording auditory input and transmitting it via various pathways to the brain for further interpretation. Auditory and language processing are "functional skills related to auditory processing, auditory discrimination, auditory hypersensitivity and following verbal instruction" (May-Benson, 2015:20). Auditory processing, the first part of this process, refers to the processes which occur along these pathways and what the brain does with the auditory signal it receives from the ears (Goldstein, 2010:280). Following auditory processing, language processing takes place and meaning is given to verbal input. Auditory discrimination, a person's ability to interpret what is being heard as well as to follow verbal instructions, is among the important elements of language processing (May-Benson, 2015:20; Kranowitz, 2005:177). Signs of possible auditory and language processing difficulty are shown in Table 2-3.

Table 2-3: Potential indicators of auditory and language processing difficulty (North Shore Pediatric Therapy, 2017a:1; Porter, 2017:1; May-Benson, 2015:71)

Potential indicators of poor auditory and language discrimination processing
Avoid going places that may be too loud
Become anxious/angry when there is too much noise
Difficulty understanding speech in noisy environments
Distracted by lots of noise
Distracted/bothered by background noises
Frequently asking for repetition or clarification of verbally presented information
Have difficulty attending to a conversation when there is background noise
Have difficulty following verbal instructions
Have trouble finding the language to express what you want
Have trouble remembering or understanding what is said
Overly sensitive to sound
Talking too loud or too softly
Unable to determine who is speaking

2.6.8 Movement (vestibular) processing

May-Benson (2015:20) explains that movement or vestibular processing is reflected in "functional skills related to hypersensitivity to movement, vestibular discrimination, gravitational insecurity, and seeking movement inputs". Unlike other sensory systems, it is a multisensory system which also relies on information from the tactile, auditory and visual senses (Goldstein, 2010:158; Cullen & Sadeghi, 2008:11). It provides a perception of space, movement of oneself and others, as well as one's spatial orientation and as a result influences functions such as a person's "posture, balance, movement, coordination, attention, arousal level, impulsivity and behaviour" (North Shore Pediatric Therapy, 2018b:1). Typical examples of vestibular discrimination difficulty are shown in Table 2-4.

Table 2-4: Possible indicators of vestibular discrimination difficulty (North Shore Pediatric Therapy, 2018b:1; May-Benson, 2015:71-72)

Potential indicators of poor vestibular discrimination processing
Afraid of heights
Avoid elevators/escalators
Avoid walking on uneven surfaces
Avoid/crave excessive movement, e.g. carnival rides and roller coasters
Clumsiness
Difficulty retaining attention
Dislike travelling through a tunnel
Dislike/fearful of catching balls
Enjoy roughhousing/head banging/jumping a lot/shaking
Fall when on a bus, car or subway that stops quickly
Get disorientated easily
Have difficulty distinguishing between fast and slow movement
Have difficulty finding a seat in a dark movie theatre
Hesitate going up or down stairs/climbing ladders
Inability to sustain listening without moving or rocking
Motion sickness
Poor posture

2.6.9 Touch (tactile) processing

Tactile processing has to do with tactile information which is processed in order to guide a person's experiences and interactions with his/her environment (Bundy et al., 2002:83). Efficient tactile processing and discrimination allow a person to identify sensations which are perceived by the skin. These sensations include the ability to identify and distinguish between details, vibration, texture and objects, temperature, intensity, duration and speed of input, and sensitivity to sustained input which is then conveyed to the CNS (Goldstein, 2010:334; Bundy et al., 2002:44). According to North Shore Pediatric Therapy (2018a:1), dysfunction in the areas of tactile processing and discrimination can cause a person to be over or under responsive to touch, often drop objects when distracted, and have difficulty learning new skills that require different aspects of touch (for example holding a pen). Furthermore, people who are oversensitive to physical pain or have an aversion to imposed touch, being splashed with water and tasks that involve clothes and hygiene are often indicators of tactile defensiveness (over responsiveness) (May-Benson, 2011:13). Signs which are evident in everyday life which might point towards tactile discrimination difficulty can be viewed in Table 2-5.

Table 2-5: Potential indicators of tactile discrimination difficulty (North Shore Pediatric Therapy, 2018a:1; Porter, 2017:1; May-Benson, 2015:73-74)

Potential indicators of poor tactile processing
Avoid getting your hands into messy things
Avoid/overreact to touch by other people
Become angry when bumped or pushed unexpectedly
Become irritated by tags in the back of your shirts
Dislike fingernail or toenail cutting
Dislike haircutting or shampooing
Have difficulty finding objects in your pockets or purse without looking
Have difficulty petting animals due to the feeling of fur
Not noticing a messy face or messy hands
Over or under dress for the temperature
Over or under reactive to pain
Prefer deep pressure rather than light touch
Prefer tight clothing
Seem overly sensitive to food or water temperature
Unable to describe a texture via touching
Unable to identify objects through touch

2.6.10 Social-emotional functioning

May-Benson (2015:12) points out that there is a correlation between social-emotional functioning and sensory processing. For example, higher anxiety score often indicates sensory modulation, sensory defensiveness and/or over-responsivity to sensory stimuli (May-Benson, 2015:12; Levit-Binnun, Szepsenwol, Stern-Ellran & Engel-Yeger, 2014:1). Being withdrawn/depressed or aggressive/impulsive frequently coincides with discrimination difficulties. At the same time, there is often a link between social-emotional functioning and Sensory Processing Disorder (SPD)[14] which is often observed in adults with mental health conditions like anxiety, depression and Post-Traumatic Stress Disorder (PTSD) (May-Benson, 2015:39). However, May-Benson adds that SPD can also be found in adults without mental

[14] Discussed under section 2.7, "Sensory Processing Disorder".

illnesses. This also applies to aggression which may or may not be connected with sensory seeking behaviours (May-Benson, 2015:37).

2.6.11 Functional problems

Functional problems refer to areas which reflect sensory seeking and sensory over-responsivity (May-Benson, 2015:36; Lane, 2002:104). The purpose of these functional problem areas is "to determine if there are any discrete problems in functioning" in cases where "sensory modulation problems are identified, especially mild difficulties in the areas of tactile and movement processing" (May-Benson, 2015:36). In the ASH, sensory seeking includes sub scores for the following sensory seeking behaviours: visual seeking/oculo-motor, seeks movement and seeks touch. Sensory seeking behaviour can point either to discrimination or modulation problems.

May-Benson (2015:36) explains that people with modulation problems "sometimes seek sensory inputs as a way of providing organizing inputs to counteract other uncomfortable stimuli". Correspondingly, individuals with discrimination problems show similar behaviour "in order to perceive the input or make the input meaningful" (May-Benson, 2015:36). On the other hand, sensory over-responsivity is divided into five categories: discomfort with imposed touch; tactile related hygiene; discomfort with water; atypical pain response; and gravitational insecurity (May-Benson, 2015:31). While gravitational insecurity is linked to vestibular difficulty, the other sensory over-responsivity areas are linked to modulation problems. Visual seeking can occur with either greater visual discrimination or modulation sensitivity (May-Benson, 2015:36; Hanft, Miller & Lane, 2000:3; Lane, Miller & Hanft, 2000:1).

2.6.12 Sensory processing sensitivity

Sensory processing sensitivity (SPS) is usually discussed under personality psychology. Although SPS is not tested in the ASH (*Adult/Adolescent Sensory History*) per se, it overlaps to some degree with the current study. It is possible that it can have an influence on the results and it is therefore briefly discussed.

SPS is a fairly recent field of study in psychology which was officially introduced by Elaine and Arthur Aron who developed the Highly Sensitive Person Scale (HSPS) questionnaire in 1997 (Booth, Standage & Fox, 2015:24). SPS is described as a personality trait which refers to a particularly high level of sensitivity to external stimuli. It results in profound cognitive sensory processing and a stronger than usual emotional response (Aron, Aron & Jagiellowicz, 2012:262). The HSPS comprises 27 questions of which eight are similar to questions in the ASH which is used in this study. Unfortunately no research could be found in which the HSPS was used to test SPS among musicians. The next section provides an overall understanding of SPD, as well as its effect on social-emotional functioning.

Similar to SPS, occupational therapists refer to "sensory sensitivity" which has to do with to a person's level of awareness as far as their sight, sound, taste, smell, touch, and pain are concerned (The Center for Parenting Education, 2019:1). Despite the fact that people "have varying degrees of sensitivity" and different ways of responding to and expressing awareness of their sensory sensitivities (Dunn, 2007:85), the ASH (which is discussed under the next heading) makes it possible to assess an individual's sensory sensitivity in relation to the typical person's functioning.

2.7 Sensory processing disorder

The STAR Institute for Sensory Processing Disorder (2017:1) and Miller, Anzalone, Lane, Cermak and Osten (2007:136) explain that sensory processing disorder (SPD), previously known as sensory integration dysfunction (Miller et al., 2007:136), refers to dysfunction at integration, modulation or discrimination level. Consequently, such an individual is unable to compensate for sensory difficulty. SPD has a negative impact on learning and it is therefore important to identify dysfunction during a child's sensorimotor development stage (Ayres, 1977:291). SPD can be diagnosed if sensory processing problems manifest in daily activities and routines (May-Benson, 2015:39). In other words, a person's daily functioning is impacted by an "inability to modulate, discriminate, coordinate, or organize sensation adaptively" (Lane et al., 2000:2).

It is important to note that although researchers are "getting closer to agreeing on cut-off scores" (Gourley, Wind, Henninger & Chinitz, 2013:913) for diagnosing SPD, there are no standardised cut-off scores for individuals with a high level of sensory processing difficulty and SPD. However, there is a strong correlation between sensory processing difficulties and behavioural difficulties as a result of a lesser control over self-regulation (May-Benson, 2015:19,34; Gourley et al., 2013:913).

Miller et al. (2007:136-138) state that SPD is characterised by three main patterns: sensory modulation disorder (SMD), sensory-based motor disorder (SBMD) and sensory discrimination disorder (SDD). Each of these disorders influences specific aspects of sensory processing as shown in Figure 2-8.

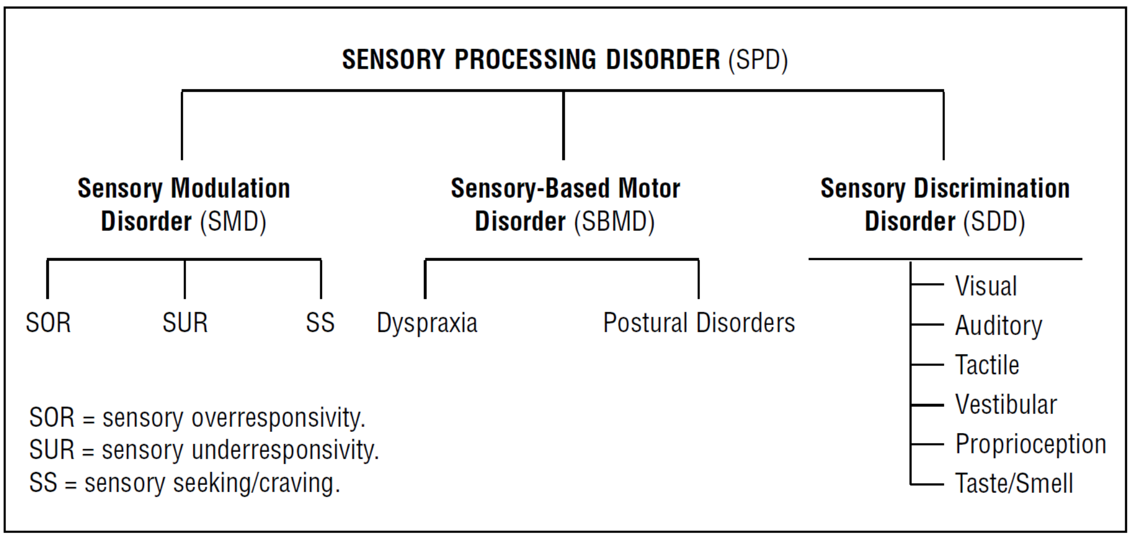


Figure 2-8: Sensory Processing Disorder (Miller et al., 2007:137)

Depending on the type of SPD, dysfunction is often displayed in a specific area (STAR Institute for Sensory Processing Disorder, 2017:1). A person with SMD has difficulty regulating his/her response to sensory stimuli and as a result is often sensory over-responsive, sensory under-responsive or sensory seeking (STAR Institute for Sensory Processing Disorder, 2017:1). Evidence of over-responsivity is often found when a person is exposed to unfamiliar situations and transitions (Miller et al., 2007:137). May-Benson (2015:12) adds that while dysfunction is often associated with a specific sensory system, sensitivities are also found in other senses like the visual, auditory, vestibular and tactile. As a result, individuals with SMD find daily activities like dressing and grooming challenging and limit their social interaction (including intimacy) with other people (May-Benson, 2015:39).

Wilson and May-Benson (2014:16) and May-Benson (2015:12) point out that most people with SMD display either hyper-responsivity or hypo-responsivity which results in fine motor or oral motor skills dysfunction. While hyper-responsivity triggers a strong emotional or behavioural response in the form of being defensive, overwhelmed or withdrawn, hypo-responsivity is often synonymous with sensation seeking (Wilson & May-Benson, 2014:16). Abernethy (2010:210) found that tactile defensiveness is particularly common in the adult category and is linked to increased anxiety. Engel-Yeger and Dunn (2011:214-215) further established that people between 18-50 years of age with sensory hypersensitivity and/or a high sensory threshold (in other words, a low registration of sensory input) have elevated trait anxiety and state anxiety[15]. In addition, their findings suggest that sensory avoidance is a “significant predictor for state anxiety” (2011:213). As for gender differences, Engel-Yeger and Dunn (2011:214) concluded that males with lower sensory registration have increased levels of trait anxiety.

It has further been established that there is a strong correlation between adults with SMD (particularly over responsiveness) and those with “mental health issues such as anxiety, depression, social-emotional issues, autonomic nervous system reactivity, and coping strategies" (Kinnealey, Koenig & Smith, 2011:320). At the same time, Kinnealey et al. (2011:324) found the level of anxiety and the amount of social support to be significantly related among adults with SMD between the ages 18-60.

In contrast to the previous views, Dunn (1997:24) explains SMD in terms of neurological thresholds (high or low) which are characterised by specific behavioural responses. Dunn (1997:32) explains that behavioural responses are divided into passive and active self-regulation. Passive self-regulation refers to people who are reactive to sensory input, “let[ting] sensory input happen, and then react[ing] to that

[15] State anxiety refers to how a person’s levels of anxiety are affected by specific situations, while trait anxiety has to do with a person’s predisposition to experience anxiety (Kemp, 1996:85).

input" (Dunn, 1997:32). Active self-regulation on the other hand refers to being proactive in terms of controlling "the amount and type of sensory input" (Dunn, 1997:32) a person is comfortable with. A person with a high threshold and a passive self-regulation response fails to notice sensory information, while someone with high threshold and an active self-regulation seeks more sensory input. In contrast to people with a high sensory threshold, people who have a low threshold with passive self-regulation allow a large amount of sensory information without regulating it while those with active self-regulation avoid sensory input (Dunn, 1997:31-32). The following figure from Dunn (2009:32) provides a good visual understanding of her interpretation of sensory processing.

Neurological Thresholds	*Self-regulation*	
	Passive	**Active**
High threshold	Bystander	Seeker
Low threshold	Sensor	Avoider

Figure 2-9: Dunn's model of sensory processing (Dunn, 2009:32)

Apart from SMD's influence on a person's reaction to sensory stimuli, it also influences a person's social-emotional functioning (May-Benson, 2015:12). People with SMD tend to battle with aggressiveness, anxiety, depression and impulsivity (May-Benson, 2015:12; Miller et al., 2007:137) leading to "withdrawal or avoidance of sensation" (Miller et al., 2007:137).

As mentioned previously, sensory-based motor disorder (SBMD) is a further SPD pattern. As can be seen in Figure 2-3, SBMD is divided into postural disorder and dyspraxia. An individual suffering from a postural disorder has "difficulty stabilizing the body during movement or at rest to meet the demands of the environment or of a given motor task" (STAR Institute for Sensory Processing Disorder, 2017:1). May-Benson (2015:12) adds that apart from postural stability, "strength, muscle tone and endurance" can also be influenced as a result of postural disorders. At social-emotional level, May-Benson (2015:12) explains that people suffering from SDD "often demonstrate decreased self-esteem and confidence and may appear aggressive due to frustration and impulsivity". This also applies to individuals with dyspraxia.

In addition to the social-emotional effect of dyspraxia, May-Benson (2015:12) explains that dyspraxia also manifests in the person's inability to "interact with unfamiliar objects". For this reason, people with SBMD often seem clumsy and demonstrate poor coordination when executing fine, gross or oral-motor tasks (Miller et al., 2007:138). Since dyspraxia is a praxis dysfunction, it has a negative impact on daily activities like generating new ideas, solving problems, dressing, using devices, formulating goals, and executing tasks (Whitney, 2016:1). Miller et al. (2007:138) add that people with dyspraxia find ball activities and other sports challenging as they are unable to judge the distance between themselves and other people or objects.

According to May-Benson (2015:12) and Miller et al. (2007:138), sensory discrimination disorder (SDD), the third SPD pattern, can present itself in one or more of the sensory systems (as demonstrated in Figure 2-8). Other areas that are associated with dysfunction include fine motor and oral motor skills (May-Benson, 2015:12; Miller et al., 2007:138), postural-ocular skills (May-Benson, 2015:12) and other somatic senses (Miller et al., 2007:138). Miller et al. (2007:138) further explain that people with SDD "have difficulty interpreting quality of sensory stimuli and are unable to perceive similarities and differences among stimuli". In addition, such people are unable to identify where sensation is located, in other words they confuse senses. As a result, a person with SDD requires more time than usual to process information and this may cause frustration and low self-confidence as mentioned earlier.

This section provided an account of sensory processing, its three subdivisions (sensory modulation disorder, sensory-based motor disorder and sensory discrimination disorder), and its effect on mental health. The next section provides an overview of assessment tools that measure sensory processing with particular reference to the ASH test which was used to determine sensory patterns of musicians in this study.

2.8 Assessment of sensory processing in adolescents and adults

In order to answer the research questions, two sensory processing assessment tools were considered: the *Adolescent/Adult Sensory Profile* by Catana Brown and Winnie Dunn and the ASH by Teresa A. May-Benson. The *Adolescent/Adult Sensory Profile* is a validated and standardised self-report questionnaire which was designed to measure sensory processing patterns and their impact on functional performance (Brown and Dunn, 2018:1). Elwin, Ek, Kjellin and Schröder (2013:233) point out that the *Adolescent/Adult Sensory Profile* "was developed, validated, and standardised in samples from the general population". In their study, Elwin et al. (2013:239) found that the *Adolescent/Adult Sensory Profile* was unable to identify items related to "seeking of specific sensations within circumscribed preferences and interests on a repetitive basis" which are typical of individuals with autism spectrum disorder. In contrast to this, the validity of the ASH has been confirmed in terms of identifying sensory dysfunction in adults and distinguishing between "typical" adults and those with SPD or autism spectrum disorder (Holland, Teasdale & May-Benson, 2015:390; May-Benson & Teasdale, 2015:253).

2.9 The Adult/Adolescent Sensory History

The *Adult/Adolescent Sensory History* (ASH) was designed by the Spiral Foundation, particularly Teresa May-Benson, over a period of 15 years (May-Benson, 2015:5). It is a validated and standardised self-report questionnaire which is based on Jean Ayre's conception model for sensory processing and sensory integration (May-Benson, 2015:12). It comprises 163 Likert-scale ranking questions. This clinical tool serves a dual purpose: determining sensory processing dysfunction patterns with reference to sensory modulation and discrimination as described by Ayres in her Sensory Integration® theory; and "assist[ing] therapists in clinical reasoning when creating interventions" (May-Benson, 2015:11). The test is unique in that it examines both SMD and SDD (May-Benson, 2015:12). In addition, the ASH assesses functional ability relating to postural control and praxis as well as social and emotional functioning. May-Benson (2015:13) mentions that each of these five functional skills is tested in all of the seven sensory systems (which were discussed under “Senses”).

In order to make provision for special needs, the ASH consists of three questionnaires (*Self-Report Questionnaire*, *Caregiver Questionnaire* and *Abridged Self-Report Supplement* to the *Caregiver Questionnaire*) and a *Medical History Supplement*. The ASH *Self-Report Questionnaire* “is the primary questionnaire for the measure … [for which] standard normative scores may be obtained” (May-Benson, 2015:14). Considering the criteria for participation, as well as the fact that the ASH *Self-Report Questionnaire* can be used independently to achieve the desired results (as an assessment and to answer the research questions), it was decided to use it as the only form of data collection.

The earlier version of the ASH was known as the *Developmental/Sensory History for Adults and Adolescents* (May-Benson, 2015:43). Initial content validity of the *Developmental/Sensory History for Adults and Adolescents* was based on the peer review and feedback of five master occupational therapy clinicians who specialise in adults with sensory processing problems. In 1997, formal construct validity was obtained from a panel of 13 occupational therapists who classified the *Developmental/Sensory History for Adults and Adolescents'* sensory and motor items according to the following categories: visual/visual spatial, auditory, touch, taste/smell, proprioception, vestibular, and motor planning. They further categorised the items as mainly assessing either sensory modulation or sensory discrimination functions. Only when 10 or more of the 13 therapists agreed on the classification was an item considered to be “correctly classified”.

In 1998, the *Developmental/Sensory History for Adults and Adolescents* was piloted (May-Benson, 2015:45). A total number of 238 adults with no major sensory or motor problems participated anonymously. The *Developmental/Sensory History for Adults and Adolescents* was vigorously tested in terms of internal consistency, performance of typical adults, exploratory factor analyses and Rasch analysis. Following this, amendments were made. This led to the *Developmental/Sensory History for Adults and Adolescents (Research Version-Revised)* which consisted of 157 questions

(May-Benson, 2015:52). The *Research Version-Revised* was piloted and following the results, changes were made. Following the final changes, the *Developmental/Sensory History for Adults and Adolescents (Research Version-Revised)* became the ASH.

May-Benson (2015:57) confirms that discriminative validity was ensured prior to standardising the ASH. She explains (2015:65) that this was done through “a retrospective record review utilizing clinical and research versions of the *Developmental/Sensory History for Adults and* Adolescents … [and] the *Developmental/Sensory History for Adults and Adolescents (Research Version-Revised)*”.

After establishing discriminative validity, standardisation was done by means of an online survey during which normative data was collected over a one-year period (February 2014 to January 2015). May-Benson (2015:61) asserts that evidence of reliability and concurrent validity was obtained through test-retest reliability, as well as through examining the relation between the ASH and the *Adolescent/Adult Sensory Profile* scores.

One-tailed Pearson correlations showed a significant overall correlation between the ASH and the *Adolescent/Adult Sensory Profile*. The total scores of both these tests “measure the construct of sensory processing” (May-Benson, 2015:64) which further supports construct validity of the ASH. As previously explained, one of the unique features of the ASH is its modulation and discrimination sections which are not included in the *Adolescent/Adult Sensory Profile* per se. Nevertheless, May-Benson (2015:64-65) explains that the correlation between these two instruments supports the construct validity of the ASH:

> The Modulation and Discrimination Section Scores of the *Adult/Adolescent Sensory History* correlated with the four quadrants of the *Adolescent/Adult Sensory Profile*. Strong correlations with $r > .70$, $p < .001$ were found between the Modulation Section on the Adult/Adolescent Sensory History and both the Sensory Sensitivity and Sensory Avoiding quadrants on the *Adolescent/Adult Sensory Profile* suggest that these sections examine a similar construct

> identified on the Adult/Adolescent Sensory History as sensory modulation. A strong correlation r = .80, p <.001 between the Discrimination section on the Adult/Adolescent Sensory History and the Low Registration quadrant on the *Adolescent/Adult Sensory Profile* suggested that the Low Registration quadrant of the *Adolescent/Adult Sensory Profile* may reflect behaviors consistent with poor discrimination skills. Strong correlations (r = .66, p <.001) between the Discrimination section on the Adult/Adolescent Sensory History and Sensory Sensitivity on the *Adolescent/Adult Sensory Profile* may reflect the high co-occurrence of sensory sensitivity/modulation difficulties with discrimination problems. A moderate correlation (r = .52, p <.001) between the Discrimination section on the Adult/Adolescent Sensory History and Sensory Avoiding quadrant on the *Adolescent/Adult Sensory Profile* was higher than expected as individuals who avoid sensory input most often present with modulation difficulties rather than discrimination problems. The Sensory Seeking quadrant of the *Adolescent/ Adult Sensory Profile* had no significant correlation with sections of the Adult/Adolescent Sensory History suggesting that Sensory Seeking may be more representative of a specific set of behaviors related to sensory processing rather than a stand-alone sensory processing style.

Considering the fact that the ASH is the only sensory processing tool which specifically measures sensory modulation, discrimination and functional ability (May-Benson, 2015:11,13), it was decided to use it as data collection method for this study. Apart from these features, it is fully reliable as it has gone through a vigorous process of validation and standardisation.

2.10 Summary

This chapter mainly focused on sensory aspects which relate to this study. In particular, the human nervous system with reference to different parts of the brain, senses and sensory processing was investigated. Seven senses, namely auditory, olfactory, oral, proprioception, tactile, vestibular and visual, were discussed as they form part of the ASH which was used as data collection tool. As regards sensory processing, aspects directly related to this research were discussed. These included sensory integration, sensory modulation, sensory discrimination, praxis (motor coordination), postural-ocular skills, visual spatial processing, auditory and language processing, vestibular processing, tactile processing, sensory processing sensitivity, as well as social-emotional functioning. In order to understand the implication that some of the results shown on the ASH's report form might have, sensory processing disorder was also examined. Lastly, assessment of sensory processing in adolescents and adults was investigated to provide an overall understanding of sensory processing tools, in particular the ASH. While this chapter focused on the nervous system, senses and sensory processing, the focal point of Chapter 3 is literature related to musicians and their instruments.

CHAPTER 3

MUSICIANS' PERSONALITY TRAITS AND SENSES

3.1 Introduction

One of the distinct characteristics of a doctorate is that it contributes original knowledge to the existing body of research in a particular field (Trafford & Leshem, 2009:305; Hofstee, 2006:xix; Mouton, 2001:5). Since this study is in the true sense of the word "the first of its kind", very little related literature exists on the topic. Realising this, the aim of this chapter shifted from the little that is known to connecting this study pertaining to musicians' sensory patterns to what is already known about the link between musicians, their musical instruments, personality traits and senses.[16] This allows the researcher to draw a parallel between new knowledge which is generated from this study and existing literature concerning the relation between musicians and their instruments. Two areas which have been investigated by several scholars involve musicians' personality traits and their senses.

3.2 Musicians and their personality traits

Although the aim of this study was not to investigate musicians' personality traits per se, the ASH (sensory test which is used in this study), contains a social/emotional component. For this reason this chapter describes musicians' personality traits so as to establish relations between this component of the ASH and previous findings. The first objective of this section is to examine findings pertaining to musicians' personality traits in general. Following the discussion of these broad indicators, the focus is narrowed to personality traits of musicians belonging to specific instrument groups and then personality traits associated with playing a particular instrument within the various instrument groups. Although a number of studies have

[16] The aim of the study was to investigate the relation between musicians' sensory patterns and their primary musical instrument. Most previous studies which investigated the link between musicians and their instruments did not make any mention as to whether the instrument in question is the musician's primary musical instrument. Although this can be inferred, it is possible that it was not accurate in all cases.

investigated the relation between musicians, their instruments and personality traits, limited research has been done recently and therefore many references are more than five years old.

3.2.1 Personality traits of musicians in general

This section focuses on general personality traits of musicians. The research of Dr Anthony Kemp, a musician, music educator and psychologist (Kemp, 1996:v), forms an important part of this section. His work provided the first scientific research on the personality of musicians and is until today regarded as "classic research" (Mihajlovski, 2013:156). Apart from this, there is limited literature discussing general personality traits of musicians, especially in the field of music. Although there are psychological, neurological and neuroscience studies concerning personality traits of musicians, the criteria for "musician" in musician samples is often very broad. For example, the sample of musicians in Corrigall, Schellenberg and Misura's (2013:1) research consisted of undergraduate students who had on average five years of private music lessons and approximately six and a half years of regular playing.

During 1981 and 1982, Kemp published an article consisting of four parts in which he examines the personality structure of musicians with reference to performers, composers and gender (Kemp, 1981a; Kemp, 1981b; Kemp, 1982a; Kemp, 1982b). The first part of this article, "Identifying a profile of traits for the performer", examines personality types of secondary school musicians, conservatoire music students and professional musicians (Kemp, 1981a:4). The group of conservatoire music students consisted of students specialising in performance, as well as students specialising in other fields of music. All professional musicians were either from the Incorporated Society of Musicians' solo performers' section or from professional orchestras.

Cattell and Cattell's Form A of their *High School Personality Questionnaire* (also known as the HSPQ) was used for the secondary school sample, while Forms A and B of *The Sixteen Personality Factor Questionnaire* (16pf®) were used for conservatoire music students and professional musicians. The 16pf® has been examined in terms of its reliability and validity; both these aspects have been confirmed (Cattell & Mead, 2008:137).

Since the current study involves tertiary music students and professional musicians, information concerning conservatoire music students and professional musicians from Kemp's study is mainly focused on. The discussion that follows frequently refers to Cattell's 18 factors which are used in the English version of the 16pf® (fourth edition) which was published in 1968 and used by Kemp in four articles (1981a; 1981b; 1982a; 1982b). Table 3-1 shows Cattell's 18 primary (first-order) factors as tabulated by Kemp (1981c:5-6). Table 3-2 demonstrates the first-order factors which are contained in each of the second-order factors.

Table 3-1: Cattell's first-order factors contained in the 16pf® (in Kemp, 1981a:5-6)

Trait	Negative pole description (-)	Positive pole description (+)
A	**Sizia** Reserved, detached, critical, aloof	**Affectia** Outgoing, warm-hearted, participating
B	**Low intelligence** Dull	**High intelligence** Bright
C	**Low ego strength** At mercy of feelings, emotionally less stable, easily upset	**High ego strength** Emotionally stable, mature, calm
D	**Phlegmatic temperament** Undemonstrative, deliberate, inactive	**Excitability** Excitable, over-active, unrestrained
E	**Submissive** Humble, mild, easily led, accommodating	**Dominance** Assertive, aggressive, competitive
F	**Desurgency** Sober, taciturn, serious	**Surgency** Happy-go-lucky, enthusiastic
G	**Weaker super ego strength** Expedient, disregards rules	**Stronger super ego strength** Conscientious, persistent, moralistic
H	**Threctia** Shy, timid, threat-sensitive	**Parmia** Venturesome, uninhibited, socially bold
I	**Harria** Tough-minded, self-reliant	**Premsia** Tender-minded, sensitive, clinging
J	**Zeppia** Zestful, likes group action	**Coasthenia** Individualistic, internally restrained
L	**Alaxia** Trusting, accepting conditions	**Protension** Suspicious, hard to fool

Trait	Negative pole description (-)	Positive pole description (+)
M	**Praxernia** Practical, "down-to-earth", concerned	**Autia** Imaginative, bohemian, absent-minded
N	**Artlessness** Forthright, unpretentious, genuine but socially clumsy	**Shrewdness** Astute, polished, socially aware
O	**Untroubled adequacy** Self-assured, placid, secure, complacent	**Guilt proneness** Apprehensive, self-reproaching, insecure, worrying
Q1	**Conservatism of temperament** Conservative, respecting, traditional ideas	**Radicalism** Experimenting, liberal, free-thinking
Q2	**Group adherence** Group-dependent, a "joiner" and sound follower	**Self-sufficiency** Self-sufficient, resourceful, prefers own decisions
Q3	**Low self-sentiment integration** Undisciplined, self-conflict, follows own urges	**Higher strength of self-sentiment** Controlled, exacting will-power, socially precise, following self-image
Q4	**Low ergic tension** Relaxed, tranquil, unfrustrated, composed	**High ergic tension** Tense, frustrated, driven, overwrought

Table 3-2: Cattell's 16pf® second-order factors and the first-order factors contained in each second-order factor (Cattell, Eber & Tatsuoka, 1970:116)

Second-order factors	First-order factors
Invia versus exvia[17]	A+, E+, F+, H+ and Q2 (+ and -)
Adjustment versus anxiety	C-, H-, L+, O+, Q3- and Q4 (+ and -)
Pathemia versus cortertia[18]	A-, I-, M-, E+ and L+
Subduedness versus independence	E+, L+, M+, Q1+ and Q2+
Naturalness versus discreetness	N+, A+, M- and O-
Cool realism versus prodigal subjectivity	I+, M+ and L-
Low intelligence versus high intelligence	B+
Low super-ego versus high super-ego	G+, Q3+ and F-

[17] Invia = introversion; exvia = extraversion (Gorsuch & Cattell, 1967:211).
[18] Pathemia = affectivity/sensitivity (Gorsuch & Cattell, 1967:211; Kemp, 1996:16); cortertia = cortical alertness (Cattell, 1973:186).

In the first part of his article (1981a:11), Kemp compared each of the musician groups to a group of non-musicians. Data was quantitatively analysed using the MANOVA program Wilks' Lambda (Λ) and Rao's F approximation. The MANOVA program was used to compare multivariate sample means, while Wilks' Lambda (Λ) "describe[s] the ratio of within-group variance to total sample variance" (Kemp, 1981a:8). Following these calculations, the Rao's F approximation was employed to determine the level of probability.

Kemp (1981a:11) found that all three groups demonstrated similar results regarding sensitivity (I+) and self-sufficiency (Q+), anxiety, pathemia and intelligence. Although introversion was also found among all three groups, students pursuing music performance showed higher levels of introversion. Kemp (1982b:4) cautions that introversion among creative individuals "should not be interpreted as timid withdrawal from social involvement" but should rather be seen as an indication of "inner strength and the richness and diversity of their thought processes". Introversion in musicians is different from the stereotypical "element of shyness" associated with introversion among the general population (Kemp & Mills, 2002:7). Kemp (1996:47) states that "tasks requiring higher levels of concentration are more suited to introverts who appear to be characterized by lower thresholds of arousal".

Research findings with regard to introversion and extroversion are contradictory. Kemp (1982b:3) determined that introversion together with pathemia and intelligence are personality traits which are both evident and a fundamental part of performing musicians since childhood. He also points out that pathemia among musicians consists of sensitivity, imagination and aloofness or patience with aloofness (Kemp, 1996:79). Contrary to Kemp's findings, Rose et al. (2018:4), Butkovic and Dopudj (2017:253) as well as Cameron et al. (2015:823) found that extroversion among musicians is higher than the norm. However, Butkovic and Dopudj only included male participants, while the "musician" sample in the study by Rose et al. is questionable in terms of their level of musical competence and music education. On the other hand, the findings by Rose et al. regarding emotional stability support Kemp's (1982b) findings. Similarly to Kemp, Corrigall et al. (2013:8) found that extraversion could not be generalised. In addition, Corrigall et al. (2013:6) state that there is a link between extraversion and IQ.

Kemp's (1981a) results further indicate that the group of tertiary music students and professional musicians share some second-order factors which are characterised by certain first-order factors. These are indicated in Table 3-3. Differences between the groups include introversion (F-) in the tertiary music student group and anxiety (Q4+) in the tertiary music student group, but Q3+ among male professional musicians and Q4+ among female professional musicians. This is particularly interesting in light of the fact that there is strong relation between adults with SMD, anxiety and the amount of social support (Kinnealey et al., 2011:324) as pointed out in Chapter 2. Results furthermore indicate that the group of tertiary music students specialising in performance have higher levels of introversion, independence and subjectivity than the other music students. This is also evident in the professional musicians group who had similar scores. The only significant difference between the music students and professional musicians was that naturalness (N-) was typical of most professional musicians. Kemp (1981a:11) states that this is in accordance with Cattell (1973) who regards it as a universal characteristic of artists.

Table 3-3: Cattell's 16pf® second-order factors and the first-order factors observed among music students and professional musicians in Kemp's study (1981a:8)

Second-order factors	First-order factors
Introversion[19]	A- and Q2+
Anxiety	C- and O+
Sensitivity	I+ and M+
Intelligence	B+

Another study that was done using Cattell's 16pf® (Form D) is that by Bell and Cresswell (1984). Like Kemp's 1981-1982 research, this article is still frequently referenced in musician personality research. In comparison to Kemp's (1981a; 1982b) research, their sample was significantly smaller. It consisted of 28 secondary school music pupils and 30 music students from the Royal Northern College of Music

[19] The first-order factor A- for introversion is not included in Cattell's classification (Table 3-2).

of which the latter group is of particular relevance to the current study. The student sample consisted of 10 string players (three violins, three violas, three cellos and one double bass), 10 woodwind players (four bassoons, three oboes, two flutes and one clarinet), and 10 brass players (four trumpets, two horns, two trombones and two tubas). Their results in terms of first-order factors for music students were similar to those of Kemp, but differed with regard to most second-order factors. In contrast to Kemp (1981a), Bell and Cresswell's (1984:84) overall results for their student sample show greater assertiveness (E+), self-assurance (O-) and tough-minded realism (I-), as well as a greater tendency to suspiciousness (L+) and critical detachment (A-) than the normative population. Like Kemp, their results indicate that music students demonstrate higher intelligence (B+) than the normative student population. Higher intelligence was also confirmed by Butkovic and Dopudj (2017:253), as well as Mihajlovski (2016:133).

Although scholars generally agree on a higher level of intelligence among musicians, Buttsworth and Smith (1995:598) found that their sample of musicians were less intelligent (B-), as well as more emotionally stable (C+), sensitive (I+) and conservative (Q1-) in comparison to a sample of psychology students. Except for sensitivity (I+) which has also been identified as a general trait of musicians, none of these findings by Buttsworth and Smith (1995) are supported by other researchers. Also, their musician sample, ages 17-41, consisted of musicians from two tertiary Australian music institutions. At the same time, they state that most of these musicians "were in their final year of secondary school" (Buttsworth & Smith, 1995:598). This is particularly interesting considering the fact that earlier studies by Bell and Creswell (1984) as well as Kemp (1981a) indicated the significant difference between the personality traits of music pupils and music students. Although it is notable that Bell and Creswell (1984) contrasted musicians with psychology students, the latter sample cannot be interpreted as normative.

Apart from personality traits which are associated with musicians at different levels (school, tertiary or professional), Kemp (1982b:3) also compares personality traits of music teachers, composers and performers. His findings indicate that music teachers are generally more extroverted, while introversion, independence and subjectivity are associated with performers and composers who are "required to make musical decisions of a creative kind". In terms of creativity, Gibson, Folley and Park (2009:162) further reported that trained musicians show enhanced creativity in comparison to non-musicians. In their research, they refer to previous findings by Folley (2006), one of the authors of this article, and explain that a person's creativity is connected to "cognitive skills and personality traits such as fluency, flexibility, visualization, imagination, expressiveness, openness to experience and increased schizotypal traits[20]" (Gibson et al., 2009:162). Most of these traits have also been identified by other scholars through a variety of personality inventories.

Openness-to-experience is found to be a general character trait of musicians and is highlighted by several studies. As pointed out earlier, Rose et al. (2018:5) determined this by using the TIPI and BFI-10. Kemp (1996:17) relates openness-to-experience to Cattell's imagination (M+) and radicalism (Q1+). He found that for both these traits, music performance students demonstrate stronger imagination (M+) than music students who specialise in other music areas (Kemp, 1981a:9). In his later work, Kemp (1996:66) also links openness to independence. Additionally, openness among music students was also confirmed by Bogunović (2012:120) who used the Revised NEO Personality Inventory (NEO PI-R). Bogunović further established that openness is characterised by significantly high scores for fantasy, aesthetics and feelings.

Using Costa and McCrae's (1992) Big Five personality dimensions, Corrigall et al. (2013:2) revealed that in comparison to non-musicians, "musicians tend to be more creative, imaginative, and interested in change, characteristics that are indicators of openness-to-experience". Similarly, Rose et al. (2018:6) reported that openness-to-experience is a characteristic found in music students regardless of whether they are self-taught, formally taught or used both methods of learning. These researchers used the Ten Item Personality Inventory (TIPI) in combination with the Big Five

[20] Like other personality traits, schizotypy is placed on a positive-negative continuum. Nelson and Rawlings (2010:388-389) explain that on the positive side, schizotypy is "associated with central features of 'flow'-type experience, including distinct shift in phenomenological experience, deep absorption, focus on present experience, and sense of pleasure". ''Negative'' schizotypy traits on the other hand include anhedonia (reduced ability to experience pleasure) and introversion which are associated with mathematical and scientific creativity.

Inventory (BFI-10). They state that rock musicians display particularly high levels of openness-to-experience, as well as neuroticism. Cameron et al. (2015:823) concur with these findings. Also, in comparison to art students, music students' neuroticism scores are significantly higher (Yöndem, Yöndem & Per, 2017:55). Additionally, Pavitra, Chandrashekar and Choudhury (2007:38) used the NEO-Five-Factor Inventory and determined that both musicians and writers demonstrate equally significant higher levels of neuroticism than the general population.

Corrigall et al. (2013:8) established a connection between extraversion and openness-to-experience but were unable to generalise neuroticism in their sample. However, similar to Rose et al. (2018) and as mentioned before, their sample did not consist of music students as such and it is therefore likely that their results are less reliable in terms of the general music population.

Kemp (1981a:9) identified sensitivity (I+) as a general trait of his sample of musicians and states that it relates well to agreeableness on the Big Five Inventory (BFI-10). In Kemp's (1981a:9) sample, music students pursuing music education demonstrated lower sensitivity (I-) scores "supporting the view that classroom music teachers need to be somewhat more resilient than their performing colleagues" (Kemp, 1982b:4). Using the Big Five Inventory (BFI-10) as measuring tool in their study, Butkovic and Dopudj (2017:253) concur that agreeableness is a common trait of musicians. This finding is further confirmed by Cameron et al. (2015:823). They used "Donnellan, Oswald, Baird, and Lucas's (2006) 20-item short form of the International Personality Item Pool (Goldberg, 1999) to assess self-reported traits together with the Big Five dimensions" (Cameron et al., 2015:822).

In contrast to the findings of Kemp (1981a), as well as those of Butkovic and Dopudj (2017) concerning agreeableness, Corrigall et al. (2013:8) argue that agreeableness[21] cannot be generalised among musicians. However, a serious weakness with Corrigall et al.'s (2013) study is that their "musician" sample is too broad and does not exclusively represent music students. (The sample comprised undergraduate students who had on average five years of private music lessons and

[21] Cattell's sensitivity (I+) and outgoingness (A+) correlate with agreeableness in the Big Five Inventory (Kemp, 1996:17).

about six years of playing on a regular basis.) In terms of different personality inventories, it is noteworthy that conflicting results emerged for agreeableness on the Ten Item Personality Inventory (TIPI) and BFI-10 which Rose et al. (2018:4) used in their study. The BFI-10 indicated that in comparison to the norm, musicians are more agreeable, while the opposite was found with the TIPI.

Another general musician personality trait which emerged from Kemp's (1981a:9) sample is self-sufficiency (Q2+) – regardless of the level of musical education and experience (school, tertiary or professional) and area of music specialisation. As far as the researcher could establish, this has not been noted by other studies in terms of a common personality trait among musicians.

Several researchers agree that conscientiousness is another personality trait which is found among most musicians. One of the studies which confirms this was done by Cameron et al. (2015:823) who investigated the personality traits and stereotypes of 280 popular musicians. Their sample included 87 bassists[22], 48 drummers, 115 guitarists and 30 singers. Similarly, Corrigall et al. (2013:8) confirmed that the ability to maintain motivation and discipline are core qualities of successful musical training and musicianship. This is in agreement with other research involving music students (Bogunović, 2012:120; Kemp, 1981a:8).

The study by Rose et al. (2018) produced somewhat different results than those of Bogunović (2012) and Kemp (1981a). They divided their sample of student musicians (N = 275) into self-taught (n = 74), formally taught (n = 62) and partially formally taught (n = 139). As mentioned earlier, they used the TIPI and BFI-10. It is noteworthy that these inventories produced inconsistent results for conscientiousness (and agreeableness) among musicians versus the general population. Table 3-4 provides a summative comparison of the results of the two different personality inventories. Rose et al. (2018) do not provide a combined result for the BFI-10 and TIPI in comparison to the general population. They only make a broad conclusion, "the results support general findings regarding the high levels of

[22] Cameron et al. (2015) do not specify whether "bassist" refers to double bass, bass guitar or a combination of the two instruments.

Openness to Experience as a personality trait in musicians in comparison to the general population", without stating how they arrived at it.

Table 3-4: Comparison of significant differences between the personality traits of musicians and the norm (GP) on the BFI-10 and TIPI (Rose et al., 2018:4)

Personality trait	BFI-10*	TIPI*
Agreeableness	Higher than norm (50.01/47.31)	Lower than norm (4.97/5.23)
Conscientiousness	Higher than norm (50.16/46.89)	Lower than norm (5.07/5.40)
Extraversion	Higher than norm (50.03/49.79)	Higher than norm (4.55/4.44)
Emotional stability/neuroticism	Lower than norm (49.74/51.39)	Lower than norm (4.29/4.83)
Openness to experience	Higher than norm (50.45/45.97)	Higher than norm (6.01/5.38)

*Sample mean (SD) and norm (SD) are indicated in brackets – sample mean is shown first

Rose et al. (2018:5) also found that formally trained musicians scored significantly higher in terms of conscientiousness than self-taught musicians. Although this is an interesting finding, it raises concern regarding the self-taught musicians' influence on the study's overall results. This is especially in light of the fact that this group's levels of competence are not specified, and that the researchers explicitly state that their target group was music students from contemporary popular music performing arts colleges and conservatoires in the UK and North America. It also seems odd that 1.6%, even though it is a small percentage, of the formally trained musicians have not received music theory training (Rose et al., 2018:4).

Anxiety among musicians has been discussed in a large and growing body of literature across disciplines. Its effect, different forms, settings, influence on musicians and interventions have been investigated by scholars like Kenny and Halls (2018); Bandi, Nagy and Vas (2017); Robson and Kenny (2017); Nicholson, Cody and Beck (2015) as well as Langendörfer, Hodapp, Kreutz and Bongard (2006). At the same time, anxiety should also be viewed in light of SPD which might be underlying anxiety (Gourley et al., 2013:919).

Yöndem et al. (2017) investigated personality and psychological traits of music and art students. In total, 120 music students and 125 art students from the Abant Izzet

Baysal University in Turkey participated in the study. The authors found that musicians demonstrate significantly higher scores in terms of anxiety, overall psychological symptom disorders as well as negative self-concept (2017:56). To determine this, they employed a descriptive and comparative research methodology which involved the Turkish version of both the Big Five Inventory and Brief Symptom Inventory as data collection tools.

Sadler and Miller (2010) on the other hand investigated the connection between performance anxiety, personality and experience among musicians. Their sample consisted of 37 undergraduate music performance majors. They determined that in cases where performance anxiety is caused by a form of personality disposition, it can be counterbalanced by formal training over a long period of time (2010:280). Sadler and Miller (2010:285) found a close relation between negative emotionality[23] and increased performance anxiety. On the other hand, low performance anxiety and higher levels of positive emotionality were not distinctively connected. Kemp (1982b:3), however, notes that in terms of emotional state, personality traits like anxiety, emotional instability and ergic tension (C- and Q4+) only develop "later in studenthood".

In a fairly recent study, Langendörfer et al. (2006:169) determined that "worry and the emotional and physiological aspects of performance anxiety decrease with age and experience". Similar to Sadler and Miller (2010), they found that lack of confidence, emotionality and worrying are closely related to performance anxiety. Langendörfer et al. (2006:169) add that anxiety should also be considered in light of conditions like chronic sleep disorders and cardiovascular disorders.

Kemp (1981a:8) found anxiety (C-, O+ and Q4) to be prominent second-order factors among music students, while obtaining significantly high scores C-, L+, O+ and Q3- (among males) and Q4 (among females) for his professional musician sample. Mihajlovski's (2016) study produced the same results. In addition, both scholars

[23] Negative emotionality correlates with "broad individual differences in stress reactivity, mood, and self-concept, essentially a stable disposition to experience negative affect across both nonstress and overtly stressful situations", while positive emotionality has to do with "the primary traits of wellbeing, social potency and achievement" (Sadler & Miller, 2010:281).

found that anxiety intensifies with age (Mihajlovski, 2016:127; Kemp & Mills, 2002:13-14). Mihajlovski (2016:137) states that at behavioural level, anxiety in musicians is often demonstrated in a form of “fragility, instability and impulsivity (C-), general insecurity, passivity and timidity (H-), carrying a sense of duty and guilt-proneness (O+), plus dissatisfaction and inner tension (Q4+)”. This correlates with Kemp’s (1981a:8) results in terms of the two first-order factors C- and O+ for anxiety among music students and professional musicians.

Although anxiety has been established to be an integral part of musicians and creative people (Newton, 2015:3), it has also been established that it is linked to particular groups of instruments, or the instrument of specialisation. This is discussed in more detail under “personality and instrument groups” and “personality and instrument of specialisation”.

Apart from anxiety which is often associated with creative individuals, there is depression (Newton, 2015:4). Using the Kenny Music Performance Anxiety Inventory (K-MPAIr) and State-Trait Anxiety Inventory (STAI), Kenny and Halls (2018:77) reported significant levels of music performance anxiety and depression. While the K-MPAIr is a validated assessment tool that measures music performance anxiety (Kenny & Halls, 2018:71), the STAI measures state and trait anxiety. It “has good to very good internal consistency” with reasonable reliability (Kenny & Halls, 2018:72). This is consistent with the findings of earlier studies by Robson and Kenny (2017), as well as Kenny and Ackermann (2015). Apart from research that has been conducted regarding musicians and depression, Dr John Chong[24] points out that since 1986, the Musicians’ Clinics of Canada have treated more than 10 000 musicians for anxiety and depression among other stress-related medical conditions (Chong, 2015:25). Literature that has been cited here includes only a few recent accounts of the vast number of contributions supporting the interconnection between musicians and depression.

[24] Dr John Chong teaches performance awareness at Glenn Gould School. He is the medical consultant for the National Youth Orchestra of Canada as well as the president of the Performing Arts Medicine Association (Chong, 2015:25).

Kuntz (2012:48) investigated the personality traits of amateur musicians by means of Gough and Heilbrun's (2007) *Adjective Checklist*. This is a self-report personality trait measuring tool consisting of 300 adjectives. Kuntz (2012:57) included 365 musicians of whom the majority were over the age of 50. Of these, 158 indicated they are band musicians, while the remaining 67 participants are orchestral musicians. In this quantitative study, Kuntz contrasted the personality traits associated with orchestral musicians versus those of musicians playing in bands. Her findings indicate that orchestral musicians consider themselves to be more commonplace, conservative, dreamy, fearful, feminine, immature, nervous and reckless than musicians in bands (2012:68). However, not all these characteristics are statistically significant since the number of orchestral musicians who consider the personality traits as representative of the group varies between 4.5% and 35.8%. On the other hand, between 8.9% and 50.6% of musicians playing in bands consider themselves to be ambitious, loud, masculine and unaffected. Another aspect that needs to be considered is the fact that the unequal distribution of orchestral musicians versus band members could have had an influence on the results.

3.2.2 Personality traits and instrument groups

Having discussed personality traits of musicians and discovered general tendencies, this section deals with traits which are associated with particular instrument groups. Literature on this topic is particularly scarce and old. Nonetheless, results from relevant studies generally indicate that there are no significant differences between instrument groups (MacLellan, 2011; Langendörfer, 2008; Kemp, 1982b). In the last part of his four-part article, Kemp (1982b:5) concluded that in terms of professional musicians, Cattell's A-, B+, I+, M+, N- and Q2+ first-order factors could be generalised for all instrument groups. More differences were found among the music student sample. These are shown in Table 3-5; relevant personality traits have been indicated with a spot.

Table 3-5: Comparison between personality traits and instrument groups among music students (Kemp, 1982b:5)

Cattell's first-order factors		Instrument group			
Trait	**Description**	**Strings**	**Wood-winds**	**Brass**	**Key-boards**
A-	Reserved, detached, critical, aloof	●	●	●	● F
B+	Bright	●	●	● F	●
B-	Dull			● M	
C-	At mercy of feelings, emotionally less stable, easily upset	●	●	●	●
F-	Sober, taciturn, serious	●	●		●
G+	Conscientious, persistent, moralistic	●	●		●
G-	Expedient, disregards rules			● M	
I+	Tender-minded, sensitive, clinging	●	●	●	●
M+	Imaginative, bohemian, absent-minded	●	● M	● M	
M-	Practical, "down-to-earth", concerned		● F		●
N-	Forthright, unpretentious, genuine but socially clumsy	●	●	●	●
O+	Apprehensive, self-reproaching, insecure, worrying	●	●	● F	●
O-	Self-assured, placid, secure, complacent			● M	
Q2+	Self-sufficient, resourceful, prefers own decisions	●	●	●	●
Q4+	Tense, frustrated, driven, overwrought	●	●	●	●

M = male; F = female

In contrast to Kemp (1982b), Bell and Cresswell (1984:91) found that student string players are more aloof (A-) and emotionally unstable (C-) than brass and woodwind players. This is particularly interesting considering the fact that Bell and Cresswell (1984:91) also used Cattell's 16pf®. A possible explanation for this might be the significant sample size difference between the two studies. While Bell and Cresswell's (1984:84) sample consisted of 30 music students from the Royal Northern College of Music, Kemp's (1981a:4)[25] sample consisted of 688 music students from 20 different British music conservatoires. In addition, Bell and Cresswell (1984:91) found that their sample of student string players achieved higher scores in terms of conscientiousness (G+) and conservatism (Q1-). They also had a

[25] Although Kemp's comparison of personality differences among different instrument groups is discussed in the fourth part of his article (1982b), he describes his sample in the first part (1981a).

more highly-developed and controlled self-concept (Q3+). Kemp's (1982b) study, on the other hand, does not reflect any significant findings pertaining to factors Q1- and Q3+ among the different instrument groups. However, in his later research, Kemp (1996:147) found that string players in general are more aloof (A-) than other instrumentalists and demonstrate higher levels of self-sentiment (Q3+) and conscientiousness (G+) than woodwind players. This is also confirmed in Bell and Cresswell's (1984:91) findings, except that instead of woodwind players, they generalised their findings to instrumentalists overall.

Pertaining to intelligence, Kemp (1982b) found that musicians are generally more intelligent (B+) than the general population. The only exception was the male student brass players with a B- indicator for intelligence. Using Daniels's Figure reasoning test (TRL) as IQ measurement tool, Mihajlovski (2013:168) on the other hand found that brass players in general exhibit lower intelligence than the other instrument groups. Another interesting finding pertaining to brass players is their high level of socially prescribed perfectionism[26] in comparison to their woodwind counterparts (Langendörfer, 2008:616).

Bell and Cresswell (1984:91) reported significantly higher scores for expedience (G-) and group dependence (Q2+) among student brass players which correlates with Kemp's (1982b) findings. Bell and Cresswell (1984:91) on the other hand identified undisciplined self-conflict (Q3-) to be a significant trait of this group. Buttsworth and Smith (1995:602) add that in their sample of musicians, brass players demonstrated significantly higher scores for extraversion than the other instrument groups. They were also found to be less anxious.

As for woodwind players, Bell and Cresswell (1984:91) concur with Kemp (1982b) that this group is more radical (Q1+) and self-sufficient (Q2+) than both brass and string students. They also mention that, in comparison to string and brass students, woodwind players have lower levels of shrewdness (N+). It emerged in Buttsworth and Smith's (1995:602) study that woodwind players are inclined "to be aloof,

[26] Socially prescribed perfectionism can be described as "the tendency for an individual to believe that others expect perfection from him or her" (Jahromi & Barzegar, 2012:141).

conscientious and tense with second order traits of tough-mindedness and dependency".

In a more recent study, Langendörfer (2008:613) included 122 musicians from six professional orchestras. She used the German version of the NEO-Five-Factor Inventory in combination with scales for anxiety, self-esteem, self-efficacy and perfectionism from other inventories. Langendörfer's (2008) findings mostly correlate with those of Kemp (1982b). However, in contrast to Kemp (1982b), she determined that string players demonstrate a significantly higher level of conscientiousness than woodwind and brass players. Of the three groups, woodwind players achieved the lowest conscientious score. Kemp (1982b) found no major disparities between these instrument groups in terms of Cattell's I+ first-order factor which, together with A+, constitute conscientiousness according to Kemp (1996:17). Kemp's (1981c) research suggests that woodwind players are more introverted in comparison to brass players.

Another interesting approach to musician personality traits is to consider stereotypes of instrumentalists by fellow musicians, as well as non-musicians. Ziv et al. (2013:168) found that the group of non-musicians rated the trumpet players as "less introverted and sensitive than flautists and violinists", while musicians rated them as "tougher than flautists and violinists". The musicians rated violinists "as more egocentric than trumpet players and flautists" (Ziv et al., 2013:171). However, it needs to be pointed out that in terms of this particular part of Ziv et al.'s study, the list of personality traits that was used in their study was compiled by their participants and that data could not be statistically analysed due to the fact that the number of personality traits was too many to conduct meaningful analysis. It should also be taken into account that their control group comprised 22 second-year music students and 26 non-musicians (first-year psychology students). The experimental group comprised 80 first-year psychology students. As pointed out (Ziv et al., 2013:174) the results could have been influenced by the fact that only 22 music students were included in the study.

In contrast to Ziv et al., (2013), Lipton (1987:87) included 227 professional orchestral musicians in his study and asked them to rate the personality traits of their colleagues. Significant findings included the fact that brass players rated string players as more introverted, “not enjoying alcohol”, lacking a sense of humour and “being less sensitive” (Lipton, 1987:86-87). Furthermore, brass players consider themselves “as much more sensitive than did the string players”, while woodwind players rated themselves “as having a more active sense of humor than did the brass players” (1987:89).

Davies (1978:202), a psychologist and talented musician, interviewed 20 professional classical musicians in his study. From these interviews, brass players and string players were found to have polarised views in terms of the other group and of their opinion of themselves. Davies states that these results cannot be generalised. Nonetheless, he included them in his report since “they are thought-provoking, suggestive of questions which might be asked more scientifically, and also, perhaps, amusing” (Davies, 1978:202). The following table presents these opinions.

Table 3-6: Brass players’ perception of themselves and string players and vice versa (Davies, 1978:202-203)

Brass players as seen by string players	**String players as seen by brass players**
Slightly oafish and uncouth	They’re like a flock of bloody sheep
Heavy boozers	Precious
Empty vessels	Oversensitive and touchy
Like to be in the limelight	Humourless
Can’t play quietly	They think they are God’s gift to music
Loud-mouthed and coarse	Take themselves, and the music, very seriously
The “jokers” of the orchestra	A bunch of weaklings, or “wets”
They’re extraverts, big noises	They never go ski-ing, or climbing, or anything
The brass is where all the funnies come from	active in case they hurt their fingers
Don’t practise	
Don’t take things seriously	
Brass players as seen by themselves	**String players as seen by themselves**
Honest	Hard-working
Straightforward	Conscientious
No-messing-about	Aesthetic
Salt-of-the-earth	Sensitive
Good blokes	

Another study that should be mentioned here is that of Mihajlovski (2013). He included 288 Macedonian musicians in his study. Of these, 69 respondents were secondary school music pupils, 104 university music students, and 115 professional musicians with music degrees (Mihajlovski, 2013:160). As with Kemp (1981a and 1982b), only the sample of music students and professional musicians is particularly relevant to the current study. He combined dimensions from Cattell's 16pf®, Eysenck's EPQ, and Costa and McCrae's NEO PI-R (refer to Figure 3-1). Except for L, N and Q1, he used all Cattell's first-order factors, Nepq and Eepq of Eysenck's EPQ, as well as N4, N5, E5, O1, O2, A1, A3 and C5 of the NEO PI-R (Mihajlovski, 2013:163). Figure 3-1 shows the MANOVAs for the four groups of instruments and their deviations from the arithmetic mean (Mihajlovski, 2013:166). As Mihajlovski (2013:165) points out, it is evident from this figure that the brass players' personality traits are the most distinctive, while the woodwinds are the least clearly differentiated group. This was also noted by Bell and Cresswell (1984:89). Brass players deviate significantly from the other groups in terms of traits B-, C+, F+, H+, I-, M-, O-, Q4-, Nepq-, N4-, N5-, E5+, O1-, O2-, A1-, A3- and C5-. While the rest of Mihajlovski's (2013:167) results by and large confirm Kemp's findings (1981a; 1982b), he contributes discrepancies to a more comprehensive understanding which the EPQ and NEO PI-R provide.

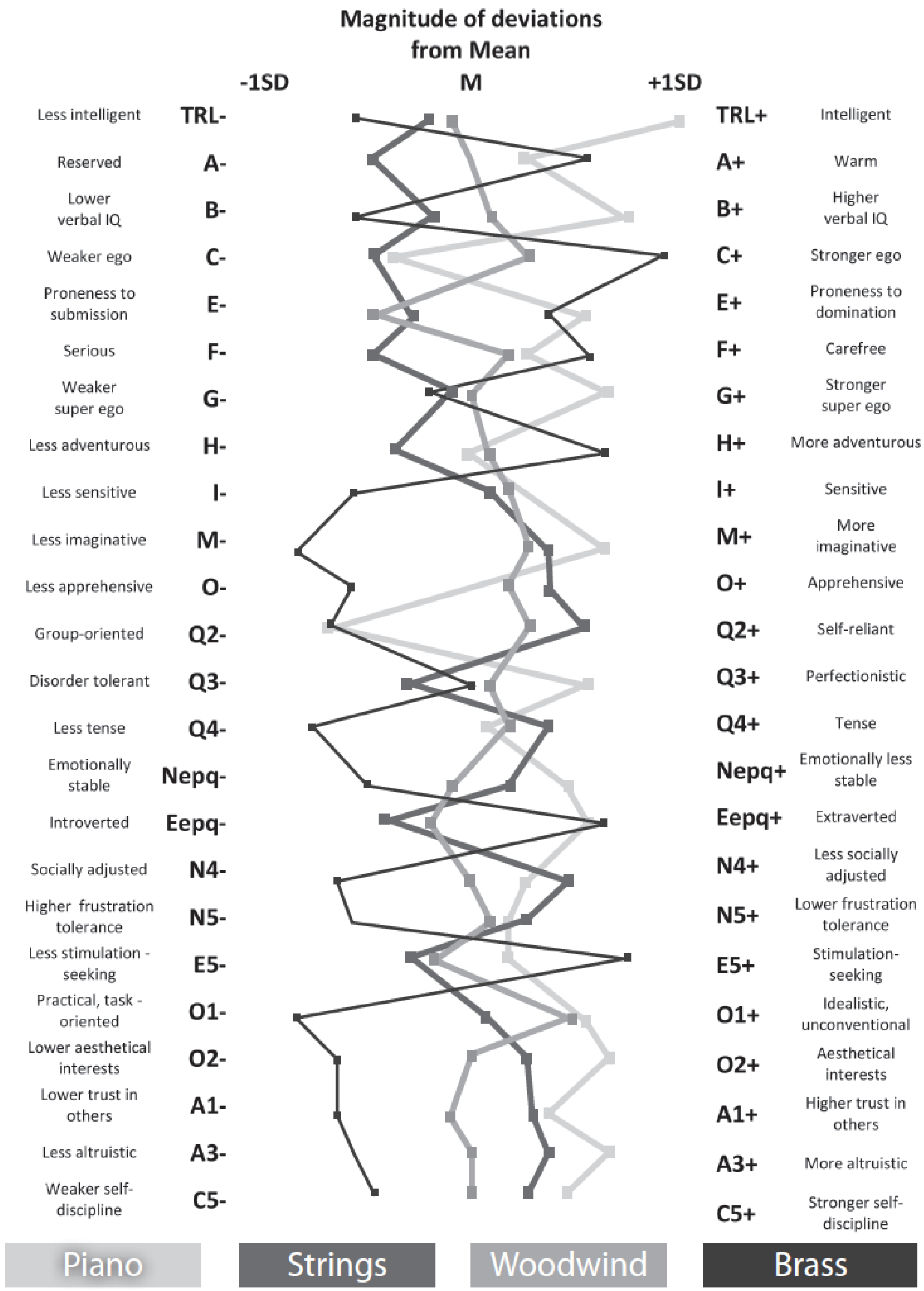


Figure 3-1: MANOVA – four groups of instruments and their deviations from the arithmetic mean (Mihajlovski, 2013:166)

A study which is open to much criticism is that by Bogunović (2012:121). His work lacks a thorough explanation and discussion of how he arrived at his findings. In comparison to a study by Mihajlovski (2013:165) who implemented a similar methodology and documented detailed findings for his group of Macedonian music students, Bogunović's (2012:121) findings with regard to personality differences among different instrumentalists and/or instrument groups are particularly cryptic as can be seen in the following sum of his findings:

> Instrumental groups differ on Extraversion ($F=(3)3.90$, $p<0.03$; Wind players/Singers), Openness ($F=(3)3.95$, $p<0.01$; Wind players/Singers, Music theoreticians, Pianists) and Agreeableness ($F=(3)2.84$, $p<0.04$; Pianists, Music theoreticians). Pianists, themselves, differ from other groups by achieving higher scores on Altruism and Dutifulness, while Strings group showed Aloofness which was ascertained by other authors.

Lastly, MacLellan (2011) also investigated the link between personality traits and instrument groups. However, MacLellan's study is not discussed as part of this literature review as her sample consists of secondary school music pupils, a group which has not been included in this study. Besides, it would be redundant to take account of literature involving secondary school music respondents since their instrument group profiles differ significantly from music students and professional musicians (Kemp & Mills, 2002:8; Kemp, 1981a:8).

3.2.3 Personality traits and instrument of specialisation

Following the discussion of literature concerning personality differences among different instrument groups, it is evident that a combination of consistent and contradictory findings exist among scholars. This section further investigates personality differences within different instrument groups. As in the case of personality and instrument group, only a few contributions discuss personality with regard to specific instruments.

3.2.3.1 Woodwind players

Based on his earlier research, Kemp (1996:153) explains that within the woodwind group, tertiary flute students are particularly imaginative (M+), while oboe students demonstrate low ergic tension (Q4-). What is interesting is that their scores reveal "a total absence of anxiety" and high levels of calmness (Kemp, 1996:155). In his research, Davies (1978:204) found that oboe players are generally obsessed with reed problems. One of the musicians who was interviewed by Davies stated that oboe players are constantly afraid of mechanical problems. This seems contradictory to Kemp's findings. However, this comment in Davies' study was made by one participant only.

In comparison to other woodwind players, bassoonists have the most distinctive personality traits (Kemp, 1996:153). Kemp established that bassoonists have a pronounced low intelligence score (B-). Ben-Tovim and Boyd (2012:41) agree with Kemp and suggest that the bassoon is ideal for "slow learners". As for the other woodwind players, neither high nor low intelligence surfaced as being polarised (Kemp, 1996:153). Kemp (1996:155) did find bassoonists to be more apprehensive than the other woodwind groups. They are also the only woodwind group in which self-sufficiency (Q2+) emerged as a distinguishing trait.

3.2.3.2 Brass players

Ziv et al. (2013:174) found that musicians regard trumpet players "as tougher than flautists or violin players". They point out that this is similar to the findings presented by Cribb and Gregory (1999:110). Ben-Tovim and Boyd (2012:49) assert that trumpet players are individualistic and, although they get along well with others, want to dominate in terms of sound production and leadership. As for the horn players, Ben-Tovim and Boyd (2012:59) state that, in terms of other musicians (including other brass members), they prefer to interact with their fellow horn players. Davies (1978:204) adds that horn players are more arrogant than other brass players and can be prima donnas from time to time.

Kemp (1996:162) further asserts that horn players are more introverted that trumpet players. He (1996:162) also found that student trumpet players exhibit “a lack of discipline and carelessness about rules (Q3-)”. At the same time, trumpeters are found to be “the most extroverted and the least neurotic” of all the musicians (Kemp, 1996:162). Overall, Kemp (1996:158) highlights the fact that in terms of volume, brass instruments can easily overpower the rest of the orchestra. Keeping this in mind, “only particular personalities will seek out this kind of prominence, for it involves a degree of exposure” (1996:158) not all performers, for example string players, are comfortable with.

3.2.3.3 Percussion players

As pointed out by Kemp (1996:163), there is little research concerning the personality traits of percussionists. Except for discussing percussionists in terms of gender, Kemp’s (1996:163) research did not produce significant findings regarding this group of musicians. However, he refers to the research of Wills and Cooper (1988) who investigated musicians in the popular music industry. They determined that drummers are the most extraverted of all the groups. In the study by Cameron et al. (2015:824), drummers rated themselves as more conscientious than bassists, guitarists and singers. At the same time, results indicate that this group consider themselves to be more open to experience than singers, but at the same time, similar to bassists and guitarists (Cameron et al., 2015:824). It also emerged that drummers demonstrate somewhat lower scores in terms of intellect and imagination (2015:827).

3.2.3.4 String players

Research to date focused on the personality traits of orchestral string players rather than other stringed instruments like the guitar. According to Kemp (1996:150), orchestral string players are generally introverted, conscientious, serious, determined and they demonstrate a strong work ethic. A similar comment is made by Ben-Tovim and Boyd (2012:64) who suggest that aspiring violin players should demonstrate intelligence, sensitivity and a high level of conscientiousness since learning the violin takes many years of hard work and dedication to master. Ziv et al. (2013) investigated the character traits of musicians based on the rating of 26 non-musicians and 22 musicians. In this study, musicians rated violinists “as more egocentric than trumpet players or flautists” (Ziv et al., 2013:168). Contrary to Ziv et al. (2013), as well as Ben-Tovim and Boyd (2012), Kemp’s (1996) findings show that string players do “not emerge with as strongly characteristic a personality profile as that of many other instrumentalists”. However, Kemp (1996:147) did find that string players are generally more aloof (A-) than other musicians.

As far as viola players are concerned, Kemp (1996:149; 1981c:35) found that in comparison to other string players, student viola players demonstrated higher emotional stability (C+). He further asserts that cellists are more introverted and aloof (A-) than other string players (Kemp, 1996:150; Kemp, 1981c:35). Similarly, Ben-Tovim and Boyd (2012:68) highlight shyness as typical personality trait of cellists who enjoy the “quiet and unstressful sociability” of the instrument. According to Kemp (1996:150), cellists show higher levels of self-sufficiency (Q2+) and astuteness (N+) than in the case of other string players.

With regard to double bassists, Kemp’s (1996:150) results did not indicate “particular personality differences” in comparison to other string players. On the other hand, Cameron et al. (2015:824) found that “bass players are the most agreeable” in comparison to drummers, guitarists and singers in their study. At the same time both drummers and guitarists rated bassists as most agreeable. In addition, bassists rated themselves as significantly more agreeable and conscientious than guitarists (Cameron et al., 2015:824). Bass players also indicated that they view themselves as more open to experience than drummers and singers, but not guitarists. Furthermore, bassists were regarded as “relatively introverted, emotionally stable, agreeable, and conscientious” (Cameron et al., 2015:825). It needs to be taken into account that their sample involved musicians from the popular music industry. Also, it is unknown whether their sample of bassists consisted of double bass players and/or bass guitar players.

Although the guitar[27] is not included in the standard orchestral strings it sometimes features as solo instrument with the orchestra like in the case of guitar concertos and musical theatre productions. In terms of musician personality studies, it is evident from this literature review that limited research, especially recent research, is available. Even more so, only two studies could be found that investigate the personality of guitarists to some degree. According to a study by Cribb and Gregory (1999:107), guitarists scored the highest in terms of psychoticism and neuroticism. In terms of conscientiousness, guitarists rate themselves higher than singers, but similar to bassists or drummers (Cameron et al., 2015:824). Furthermore, guitarists consider themselves to be more imaginative than bassists and drummers. It should be kept in mind that the type of "guitarist" is unspecified, but since their study involved popular musicians, it is safe to assume that the sample comprised mainly electric guitarists.

3.2.3.5 Keyboard players

Kemp (1996:169; 1981c:35) determined that extroversion (A+ and Q2+), adjustment (Q4-), conservatism (Q1-) and submissiveness (E-) are the main personality traits commonly found among keyboard players. In his later work, Kemp (1996:169) states that pianists are particularly submissive (E-), conscientious (G+) and conservative (Q1-) and have a high degree of self-sentiment (Q3+). In his earlier research, Kemp (1981c:35) asserts that student pianists are particularly outgoing (A+) and group-dependent (Q2-). While extroversion is particularly linked with solo performance, tranquillity (within the Q4- factor) is associated with accompanists. Mihajlovski (2013:168) found that, overall, piano players demonstrate a higher level of "fluid intelligence" than other instrumentalists. Buttsworth and Smith (1995:602) add that keyboard players are "warm-hearted, more emotionally stable, shrewd and the least sensitive of all the instrumental groups".

Using the NEO PI-R, Bogunović (2012:121) determined that, for his sample of secondary school music pupils, music students and professional musicians, pianists

[27] In the context of this study, guitar refers to nylon string guitar (which is associated with classical and flamenco guitar), and steel string guitar with reference to acoustic and electric guitar.

differ from string players, wind players and solo singers[28] with regard to altruism and dutifulness. This is a very broad finding in light of other scholars who emphasise the significant differences between the different developmental stages of musicians (Mihajlovski, 2013:168; Kemp, 1996:169; Kemp, 1982b:5). Furthermore, it is also peculiar that he contrasts a single instrument with instrument groups.

In terms of organists, Kemp (1996:171) found that in comparison to pianists, organists demonstrate a similar level of extraversion with regard to outgoingness (A+) and group dependency (Q2+); adjustment in terms of self-sentiment (Q3+) and low ergic tension (Q4-); and control with reference to conscientious (G+) and submissiveness (E-). Kemp (1996:172) states that shrewdness (N+) is the only significantly different personality trait which organists have in comparison to pianists. At the same time, he points out that this is also a distinguishing trait of cellists. He speculates that this might be linked to “a more competitive disposition” (1981c:35). Additionally, Mihajlovski (2013:168) found that pianists show “clear signs of problematic adaptation” in terms of “*Emotional instability* (C-, Nepq+, N4+, N5+) and *Anxiety* (C-, O+, Q4+)”.

3.2.4 Musical instruments and gender differences

Gender differences (and gender stereotyping) pertaining to musical instruments have been investigated by only a few scholars. Since it is hypothesised that gender plays a role in the sensory patterns of musicians, literature relating to gender differences is discussed in this section.

According to Bogunović’s (2012:121) research, female musicians obtained higher scores than males for openness, agreeableness and conscientiousness. In addition, their personality profiles indicate enhanced imagination, emotion and aestheticism, warmth, straightforwardness, compliance, altruism, caring for other people, and inclination “towards fulfilling duties, achievement and self-discipline” (2012:121). However, Bogunović makes no attempt to present findings concerning the 125 male

[28] Although singers have not been included in the present study, they were included in Bogunović’s (2012) study and are therefore mentioned here.

participants in her study and also fails to draw a correlation between the two genders.

Kemp (1996:113) argues that both genders demonstrate androgyny, in other words, personality traits generally associated with the opposite sex. He found that in comparison to the general population, female musicians are more masculine while male musicians are more feminine. This might be due to the fact that musicians' self-concept is so strongly connected to "being a musician that the maintenance of a rigid gender role stereotype may be felt to be unimportant" (Kemp, 1996:115). Another contributing factor is the stronger level of independence found among most musicians: this goes together with being unbothered by "society's rules and standards" (Kemp, 1996:118). In light of these findings, Buttsworth and Smith's (1995:599) results indicated that their sample of male musicians was found to be more sensitive, shrewd, tender minded and dependent than their female counterparts (Buttsworth & Smith, 1995:599).

In Kemp's (1982a:53) earlier research he observed that "female musicians frequently displayed greater divergence than the male musicians from their respective groups of non-musicians". He established that in terms of human interaction, female musicians demonstrate higher levels of first-order factors A- (aloofness), F+ (surgency), forthrightness (N-) and Q2+ (self-sufficiency) than the general female population. However, as can be seen in Figure 3-2, Kemp's (1982a:52) raw scores for factor F show that female musicians lean towards F- (sober/desurgency) instead of F+ (surgency), indicating a mere typing error.

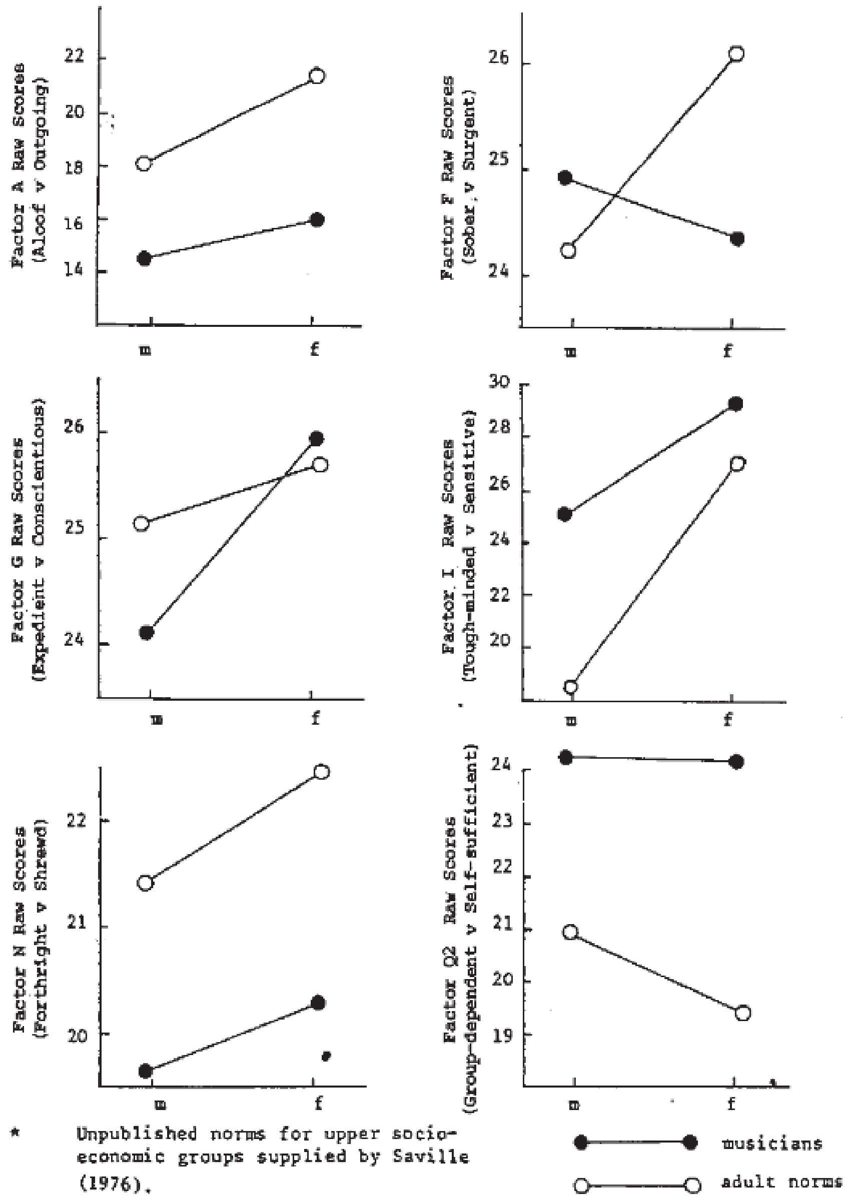


Figure 3-2: "Sex differences on 16pf® first-order factors A, F, G, I, N and Q2 for professional musicians and British general population" (Kemp, 1982a:52)

These graphs that are provided by Kemp (1982a:52) do not indicate sample size, levels of significance or a clear split between the positive and negative poles. This makes it difficult to interpret the graphs with precision: although trends are shown, no additional statistics are provided to explain them. Nonetheless, based on Kemp's (1982a:53) findings pertaining to factors A, F, N and Q2 for female musicians, it is assumed that the difference of approximately 2.0 scale measurements between musicians and non-musicians is considered statistically significant. Based on this assumption, male musicians lean significantly towards aloofness (A-), sensitivity (I+), forthrightness (N-) and self-sufficiency (Q2+) in comparison to the standard male population. It is intriguing that male and female musicians show opposite trends for factors F and G in comparison to their respective genders among the general population.

As for personality trait differences among the two genders, Kemp (1982a:55) found that male woodwind players diverged significantly from the standard male population in terms of being aloof (A-), emotionally stable (C+), imaginative (M+) and relaxed (Q4-). The female musicians on the other hand differed significantly from the standard female population in terms of only one first-order factor, being practical (M-). The female musicians are also dissimilar in terms of being more outgoing (A+) and emotionally less stable (C-). However, these differences are only of moderate significance. Within the woodwind group, the two genders are significantly polarised in terms of A, C, M and Q4. These differences are indicated in Table 3-7.

Table 3-7: Cattell's first-order factors among male and female woodwind players (in Kemp, 1982a:55)

Trait	Negative pole description (-)	Positive pole description (+)
A	Aloof (males)	Outgoing (females)
C	Emotionally less stable (females)	Emotionally stable (males)
M	Practical (females)	Imaginative (males)
Q4	Relaxed (males)	Tense (females)

Concerning gender difference between brass players and the general population Kemp's (1982a:56) results indicate very little significant divergence. In terms of the males, musicians are significantly more inclined towards tough-mindedness (I-) and self-assurance (O-) than the standard population. They also demonstrate lower levels of intelligence (B-) and being more relaxed (Q4-). However, these differences are not as significant. As for the female brass players, the only significantly deviation from the norm was in terms of being more apprehensive (O+) and undisciplined (Q3-). Other than this, no major differences were reported between female brass players and the general female population.

In terms of the string players, it is notable that Kemp (1996; 1982a; 1981c) does not include any findings regarding gender differences among string players. He also does not provide any reason for this, possibly suggesting that there are no significant personality trait differences among male and female string players. However, this deduction seems improbable in terms of personality differences between string players and non-musicians. In another study conducted by Langendörfer (2008:616) it was established that “male first violinists have a greater need for harmony” and “are more empathetic in their job … than male second violinists”. However, she calls attention to the fact that only three male second violinists participated in the study.

Cramer, Million and Perreault (2002) investigated college students' evaluations of musicians playing either a masculine instrument (in this case a drum or a tuba), or feminine instrument (flute or harp). In their study, masculine descriptors included being dominant, displaying leadership and being active (Cramer et al., 2002:164). Feminine qualities referred to being warm, sensitive and caring, while adjustment, happiness and success were considered to be gender-neutral personality traits. Results indicate that both male and female respondents consider female musicians to be more dominant, active and stronger leaders than male musicians. They further established that musicians who play feminine instruments are “perceived as more caring, warm, sensitive, and better adjusted; but less dominant and prone to leadership than musicians of masculine instruments” (Cramer et al., 2002:171). The results of these authors further indicate that genders were judged in the same manner in terms of masculine instruments, but “males playing feminine instruments were perceived as less dominant, active, and better leaders than females playing the same instruments” (2002:164).

Kuntz (2012:63-67) established that there are gender-associated self-reported personality traits which are typical of orchestral musicians and musicians playing in bands. Distinguishing self-report traits that were indicated by the respective groups are shown in Table 3-8; only personality traits which have been indicated by 50% or more of the participants are presented. Of these, 178 were males and 187 females. In terms of ensemble, 67 musicians indicated that they are orchestral musicians, while the other 158 musicians play in bands. It is therefore possible that the big difference in sample size could have had an influence on the results.

Table 3-8: Self-reported traits by male and female musicians in orchestras and bands (Kuntz, 2012:64,66,67)

Self-reported traits by female musicians they consider to be more prevalent among females
Appreciative, capable, determined, good-natured, helpful, independent, kind, organised, responsible, sympathetic, and thoughtful.
Self-reported traits by male musicians they consider to be more prevalent among males
Confident and easy-going.
Self-reported traits selected by males in orchestras more than males in bands
Idealistic and optimistic.
Self-reported traits selected by males in bands more than males in orchestras
Ambitious.
Self-reported traits selected by females in orchestras more than females in bands
None specified.
Self-reported traits selected by females in bands more than females in orchestras
Wide interests and practical.

Lastly, gender distribution per instrument also needs to be considered, particularly in light of the present study. Mihajlovski (2013:162) determined that musicians' personality structure is influenced by gender. Referring to this finding, Mihajlovski (2013:162) states that unequal distribution of respondents through the different instrument groups complicates the interpretation of data. In the case of his study, he asserts that unequal gender distribution would almost certainly skew the results in terms of musicians' personality and IQ which he investigated (Mihajlovski 2013:162).

3.3 Musicians and their senses

Several studies have investigated musicians in terms of their senses in comparison to non-musicians, but not the link between musicians and their sensory patterns from an occupational therapy stance. Nonetheless, several psychological, neurological and neuroscience studies have included musicians in their research, confirming the influence of musical training and musicianship on the brain's structure and function (Kuchenbuch, Paraskevopoulos, Herholz & Pantev 2014; Skoe & Kraus, 2012;

Grahn & Rowe, 2009). For this reason, a number of neurological and neuroscience[29] studies are included in this chapter.

3.3.1 Musicians and non-musicians

Eitan and Rothschild's (2010:449) study investigated how dynamics (piano, mezzo forte or forte)[30], pitch and timbre (flute or violin), vibrato, and the different combinations thereof, influence listeners' perception of audio-tactile metaphors. This is with reference to "sharp–blunt, smooth–rough, soft–hard, light–heavy, warm–cold and wet–dry". Each of these tactile metaphors was placed on a scale of six bi-polar degrees from the one extreme to the other. In total, 40 people participated of whom 20 were musicians. Several findings emerged as a result of Eitan and Rothschild's (2010:457) research. These are indicated in Table 3-9. The majority of participants rated an increase in intensity of tone as heavy. At the same time, they considered high pitches to be light, associating them with "small physical size" (Eitan & Rothschild, 2010:459).

Table 3-9: Summary of significant results with regard to dynamics, pitch timbre, instrument and vibrato (Eitan & Rothschild, 2010:457)

Descriptor	Result
High pitches	Sharper, rougher, harder, lighter, colder and drier than lower pitches.
Dynamics	Louder sounds were rated as sharper, rougher, harder, heavier and colder than quieter sounds.
Instrument	Violin sound was rated as blunter (less sharp), rougher, harder, colder and drier, as compared to flute.
Vibrato	Vibrato sounds were rated as lighter, warmer and wetter than non-vibrato sounds.

Penttinen, Huovinen and Ylitalo (2015) recorded eye movement during tempo-controlled faultless reading and playing of *Mary had a little lamb*, as well as simple variations thereof. The researchers recruited 14 music performance students and 24 education students minoring in music education. Sibelius 6.2.0 (music notation

[29] Kropotov (2009:xxxv) explains that neurology involves the "objective assessment of brain dysfunction", while neuroscience "is a branch of science that studies the brain and its relationship with the mind" (2009:xxxiv). In contrast to medical sciences which concern abnormal human behaviour, neuroscience focuses on typical human behaviour (Kropotov, 2009:xxxiv-xxxv).
[30] The influence of these dynamics was specifically investigated in this particular study.

software) was used to notate and display the melodies, while eye movement (eye-hand span[31] and gaze activity[32]) was recorded with a Tobii TX300 Eye Tracker. Eye-hand span was measured in the "number of beats that a given fixation[33] is ahead of (or behind) the beat currently being executed" (Penttinen et al., 2015:42). On average and at a tempo of 60 beats per minute, the participants' eye-hand span was one second or less.

Overall, Penttinen et al.'s (2015:36) results indicated that music performance students have shorter fixations, longer eye-hand span and greater gaze activity. Although the latter two results seem surprising, Penttinen et al. (2015:36) suggest that it is due to the fact that musicians' spans are more than one beat. However, Penttinen et al.'s (2015:47) results further indicate that eye span is subject to the number of notes per beat. Considering these results, the complexity of score reading due to its numerous variables is highlighted.

Kuchenbuch et al. (2014:1), Li, Luo, Peng, Xie, Gong, Dong, Lai, Li and Yao (2014:1), as well as Gebel, Braun, Kaza, Altenmüller and Lotze (2013:37) concur that musicians are often used in studies which investigate neuroplasticity since musical training over a long period of time changes the anatomy and functions of the brain. Gebel et al. (2013:37) add that "playing an instrument requires neural integration of multiple sensory inputs, including auditory and somatosensory feedback, and fine-motor adjustment within split seconds".

In their study, Kuchenbuch et al. (2014:1) contrasted 15 university music students with 15 non-musicians. Their results indicate that in comparison to non-musicians, musicians demonstrated an enhanced multisensory incongruency response. In other words, musicians possess superior higher-order audio-tactile and auditory processing. This was also confirmed by Güçlü, Sevinc and Canbeyli (2011) who studied duration discrimination among musicians and non-musicians. They

[31] Eye-hand span refers to the time between reading and playing a note (Penttinen et al., 2015:36).
[32] With reference to Penttinen et al.'s (2015:39) study, gaze activity refers to the vision span which is measured in the number of visual beats that are observed simultaneously (Penttinen et al., 2015:39).
[33] The eyes move with short breaks when reading, meaning "they drift from the target and then jump back with a corrective saccade" (Purves et al., 2004:449).

concluded that musicians demonstrated better discrimination in terms of changes to auditory stimuli.

Likewise, Landry and Champoux (2018:373) emphasise that "Long-term musical training is an enriched multisensory training environment that can alter uni- and multisensory substrates and abilities." They compared 17 music students and 20 non-musicians in terms of their reaction times (RTs) for simple and complex sensory tasks. To achieve this, Landry and Champoux (2018:373) employed the crossed arm temporal-order judgement (TOJ) task.

The crossed arm TOJ task is a test for determining "multisensory process of tactile localization which combines tactile and visual information" (Landry & Champoux, 2018:375). It involves several stimulus onset asynchronies (SOAs) during which the hands are stimulated one after another after which the person/s being tested needs to "indicate which hand was stimulated first" (Landry & Champoux, 2018:375). Their results indicate that in comparison to non-musicians, musicians have significantly faster "RTs for all crossed arm conditions and half of the uncrossed conditions" (Landry & Champoux, 2018:379). At the same time musicians had considerably more incorrect responses during the TOJ crossed-arm stimuli. A possible explanation for these mistakes is that musicians' more agile "TOJ RTs leave little time to consolidate conflicting internal and external task-related information when crossing the arms, leading to increased incorrect responses" (Landry & Champoux, 2018:373).

In relatively recent discussion of literature, Reybrouck and Brattico (2015:73) call attention to the effect of repeated stimulation which is experienced over a long period of time within a particular context. In the case of musicians, this involves the processing of pitch, timbre, dynamics and duration of sound. Despite the well-documented influence of these stimuli on musicians' neural processing (versus non-musicians), Reybrouck and Brattico (2015:73) assert that little is known about the effect of basic music features on neuroplasticity. For example, experiencing and expressing emotion through musical performance involves "cognitive and linguistic processes" (2015:73). Apart from this, musicians need to assimilate their own proprioceptive sense with surrounding performance elements in order to form part of a musical and harmonious whole. Reybrouck and Brattico (2015:80) concluded that "the modulating role of musical expertise on emotional processing of music in the brain" is a relatively new field of inquiry; yet, in a growing body of research the significant influence of music on the modulation of emotion and mood in the brainstem, limbic system and other areas of the brain has been confirmed.

Both neuroscience and neurological studies have investigated Mismatch Negativity (MMN) among musicians and musicians versus non-musicians. MMN was discovered by Näätänen, Gaillard and Mantysalo in 1978 in their study (Kropotov, 2009:xliv; Näätänen, Gaillard & Mäntysalo, 1978). MMN, also known as an oddball paradigm, is an involuntary impulse to a change in repetitive auditory sound that is generated by the temporal cortex which is located in the temporal lobe (Kropotov, 2009:218,423). Kropotov (2009:214-215) provides a clear explanation of MMN in the following extract from *Quantitative EEG, Event-Related Potentials and Neurotherapy*:

> In real life, the sensory world is reflected in continuous activity of neurons of the sensory systems. Some part of the world remains constant for a relatively long time and we often are not aware of this unchanging world. Recall, that we do not feel the pressure of the clothing on our body, we are not aware of a gentle noise of the car we are driving in, and we do not see minor changes in the visual scene when we are in the forest and occupied by our thoughts. But if a change occurs, such as somebody touches the sleeve of our dress, or the engine of the car changes its regularity, or a mushroom appears within our gaze, this change might enter our consciousness. It seems the brain is constantly monitoring the sensory world and is comparing incoming stimuli with a sensory model formed by a previous stimulation.

Using MMN, Vuust, Brattico, Seppänen, Näätänen and Tervaniemi (2012:1432) contrasted non-musician university students, classical musicians, jazz musicians and rock musicians. Vuust et al. (2012:1440) found that style of music influences musicians' perceptual and auditory skills. Their results indicate that jazz musicians had "enhanced processing of pith [sic] and sliding up to pitches" (Vuust et al., 2012:1432), as well as larger MMN amplitude[34] than the other participants, indicating "a greater overall sensitivity to sound changes" (2012:1440). Another significant

[34] MMN amplitude and latency have to do with the difference between the deviant stimulus and the norm. While MMN amplitude is measured in microvolts "from the maximum peak to the baseline", MMN latency is measured in milliseconds "from the auditory stimulus onset to the maximum peak" (Lindín, Correa, Zurrón & Díaz, 2013:5).

finding was that “MMN to timbre was left lateralized in classical musicians only” (Vuust et al., 2012:1440). This means the left lateral areas of the temporal cortex demonstrated higher levels of activity during the experiment. Considering their results, Vuust et al. (2012:1440) concluded that the type of musical training, musical style and listening experiences influences the musicians’ functioning of the brain.

In a recent study, Virtala, Huotilainen, Lilja, Ojala and Tervaniemi (2018:317) contrasted musicians and non-musicians with reference to “the level of distortion and harmonic structure of a chord affect its cortical auditory processing”. They recruited 13 music students (4 piano, 4 violin, 1 double bass, 1 guitar, 1 bassoon, 1 saxophone and 1 singer) from universities and music academies and 13 non-musician students. All the participants indicated that they were right-handed and “had no problems related to hearing, language, or basic tasks” (2018:317). It is possible that there might be a degree of subjectivity here since these skills were not formally assessed. Conversely, Virtala et al. (2018:318) used the Wechsler Intelligence Scale, the Wechsler Memory Scale, and the Trail-Making Test A and B to assess participants’ cognitive skills.

Auditory stimuli in Virtala et al.’s (2018) study consisted of synthesised “natural-like electric guitar chord sounds”, four-part voicing “natural to the electric guitar” and distorted chords. There were two types of sound: clean (no added effects – in other words, non-distorted) and distorted; and two types of chords: dyad (D2–A2–D3–A3) and triad (D2–A2–F♯3–A3). In total, there were four types of sound and chord combinations which are shown in Figure 3-3.

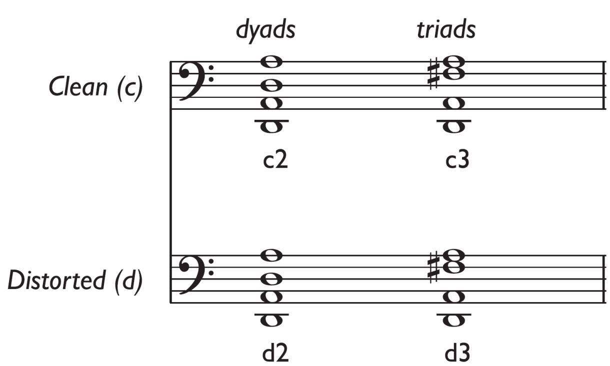


Figure 3-3: Four stimuli: dyads versus triads; both chords presented as clean and distorted (Virtala et al., 2018:319)

Auditory stimuli were presented by means of MMN "where one of the chords acted as a repeating standard stimulus … and the remaining three chords served as occasional deviant stimuli" (Virtala et al., 2018:318). The different combinations of 12 sound and pitch stimuli are shown in Table 3-10.

Table 3-10: Stimuli contrasts (Virtala et al., 2018:319)

Name	Description	Type of deviation
c3/d3	Non-distorted triad among distorted triads	Distortion
c3/d2	Non-distorted triad among distorted dyads	Distortion + harmony
c3/c2	Non-distorted triad among non-distorted dyads	Harmony
c2/d2	Non-distorted dyad among distorted dyads	Distortion
c2/d3	Non-distorted dyad among distorted triads	Distortion + harmony
c2/c3	Non-distorted dyad among non-distorted triads	Harmony
d3/c3	Distorted triad among non-distorted triads	Distortion
d3/c2	Distorted triad among non-distorted dyads	Distortion + harmony
d3/d2	Distorted triad among distorted dyads	Harmony
d2/c2	Distorted dyad among non-distorted dyads	Distortion
d2/c3	Distorted dyad among non-distorted triads	Distortion + harmony
d2/d3	Distorted dyad among distorted triads	Harmony

Note: Abbreviations: c = clean sound (non-distorted sound), d = distorted sound, 3 = triad (with the major third interval), 2 = dyad (without the major third interval).

During the auditory stimuli exposure, participants' brain activity was measured by means of an electroencephalogram (EEG). For six of the sound contrasts, significant results were obtained for both MMN and P3a[35]. For the remaining six combinations, only partially significant results were obtained, either in terms of MMN or P3a (Virtala et al., 2018:326). Scalp topographies of the different sound and pitch stimuli combinations are illustrated in Figure 3-4. Virtala et al.'s (2018:325) findings suggest that musicians "demonstrated larger P3a amplitudes" in comparison to the non-musicians. However, Virtala et al. (2018:328) point out that musicians pay more attention to music stimuli than non-musicians. Consequently, it is possible that neuroscientific comparisons between musicians and non-musicians may be flawed.

[35] P3a is the attention-related component of event-related potentials (ERPs) which measures time interval (Virtala et al., 2018:315; Kropotov, 2009:201, 245-246). Kropotov (2009:249) explains it by means of the following practical example: "Driving a car and listening to a [sic] music enjoying the landscape around. But suddenly a slight change in the engine rhythmic noise attracts your attention."

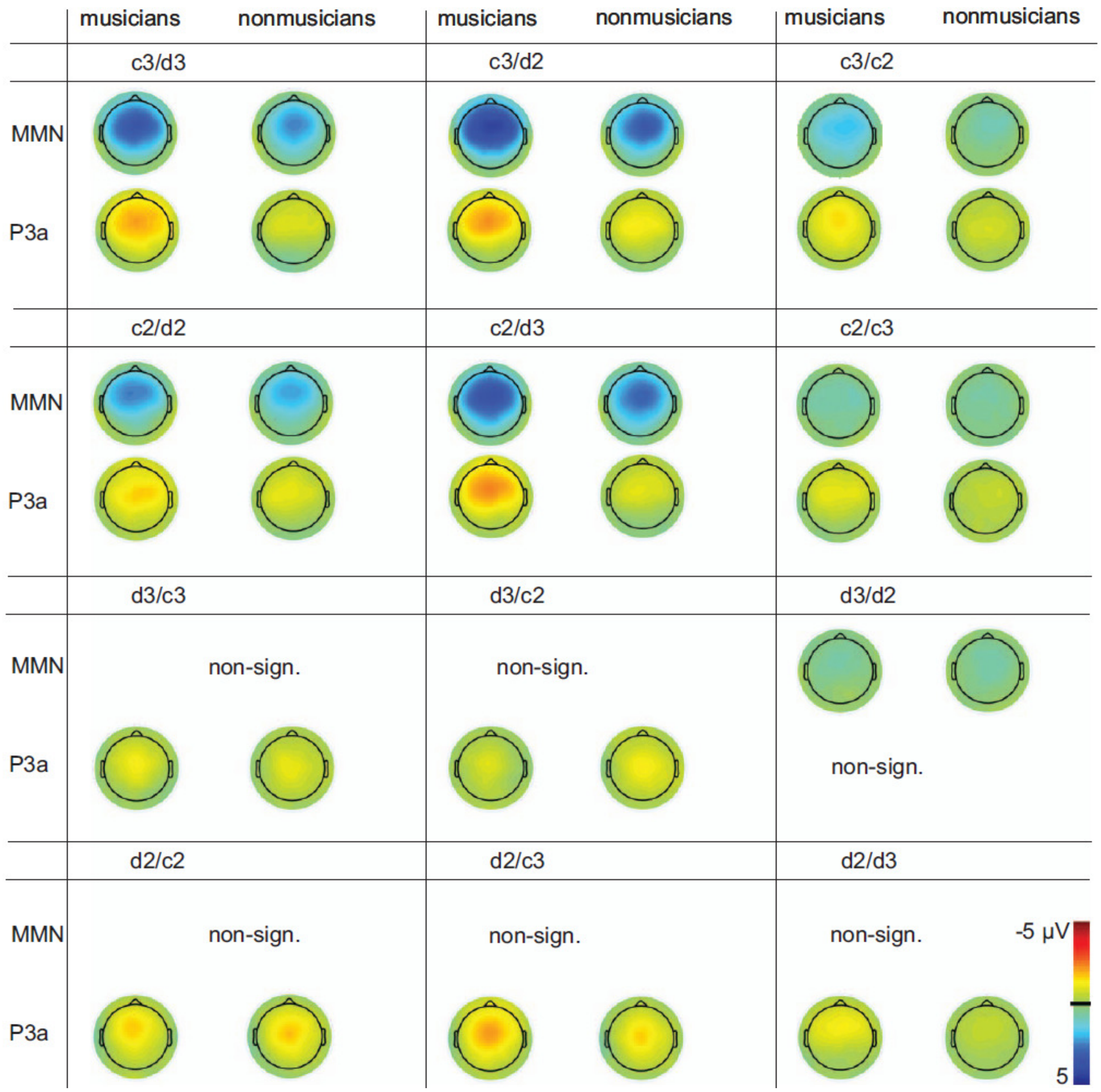


Figure 3-4: Scalp topography illustrating distributions of statistically significant MMN and P3a mean amplitudes among musicians and non-musicians (Virtala et al., 2018:326)

Lastly, an interesting and unexpected result from Virtala et al.'s (2018:328) study was that non-musicians achieved higher scores than the group of musicians, in terms of verbal long-term memory as well as verbal reasoning. Contrary to this, D'Souza, Moradzadeh and Wiseheart (2018:1) found that musicians have better working memory than non-musicians. In their study, D'Souza et al. (2018:1) contrasted bilingual musicians, monolingual musicians, bilingual non-musicians and monolingual non-musicians. D'Souza et al. (2018:6) used the digit span, reading span and operation span to assess working memory. Virtala et al. (2018:318) also used the Wechsler Adult Intelligence Scale's digit span component.

Using a form of EEG known as acoustic change complex (ACC), Liang, Earl, Thompson, Whitaker, Cahn, Xiang, Fu and Zhang (2016:7) obtained significant results in terms of musicians versus non-musicians. Their group of musicians demonstrated superior ability to "detect frequency changes under quiet and noisy conditions". Considerably shorter N1 latency and larger P2 amplitude were observed among the musicians. This means that musicians possess much lower frequency detection thresholds than the norm (Liang et al., 2016:5). Lightfoot (2016:1) explains that the N1-P2 response complex serves as "objective predictor of hearing threshold in adults and older children".

Proverbio and Orlandi (2016) as well as Bishop and Goebl (2014) investigated the effect of instrument-specific musical expertise on audiovisual processing. Proverbio and Orlandi (2016:446) included clarinet and violin music students and a group of non-musicians in their study; Bishop and Goebl (2014:1) recruited clarinet, piano, violin and viola students – no non-musicians were included in their sample. In both studies, video clips of musical performances on the respective instruments were played to the participants. In Proverbio and Orlandi's (2016:446) study, ERPs were recorded and analysed. Their results indicate enhanced prefrontal anterior negativity response (an ERP) in the group of non-musicians, as well as among musicians who watched performances on musical instruments other than their instrument of specialisation (Proverbio & Orlandi, 2016:450). This indicates that higher levels of brain activity occur during the processing of unfamiliar audio-visual stimuli (2016:448). While Bishop and Goebl's (2014:1) experiment involved the identification of instances of asynchronicity of audio-visual stimuli, their results confirm the same effect of expertise with regard to anterior negativity response.

Kolodziej, Ackermann and Adams (2007) studied the relation between gender, music performance expertise and proprioception among 23 music students who specialise in cello performance. The group of musicians was contrasted to a group of non-musician students. "Left-hand finger-movement for differences in string height discrimination" was assessed on a cello-like model with the same dimensions and string action as a cello (Kolodziej et al., 2007:510). Kolodziej et al.'s (2007:515) results, although not of statistical importance, indicate that non-musician males outperformed male musicians while the opposite was true of the female participants. Despite the fact that Kolodziej et al.'s (2007) study did not render statistically significant results, proprioception is important for effectively pressing and holding down strings (2007:511). Insufficient proprioception, as well as sensorimotor integration "has been reported in musicians with focal hand dystonia" (Kolodziej et al., 2007:511). In light of this, the findings of Kolodziej et al.'s (2007) research is important.

Landry and Champoux (2017:156) state that "despite repeated confirmation of anatomical and structural changes in visual, tactile, and auditory regions" among musicians, the effect of long-term musical training on "other multisensory processes at a behavioural level" is yet to be established. To investigate this, Landry and Champoux (2017:156) compared the performance of 16 musicians to a control group consisting of 19 non-musicians by means of an "audio-tactile reaction time task". The task consisted of three stimuli: "50 ms white noise burst" (audio input), vibration (tactile input) by means of a vibrotactile device (participants placed their left index fingers on it), and a concurrent combination of these inputs as auditory-tactile input (Landry & Champoux, 2017:157). Each time the participants became aware of one of these stimuli, they had to click on a computer mouse. The participants' responses were recorded using a cognitive evaluation program. Following an analysis of this data, significant differences were established between the two groups of participants for all three stimuli. Landry and Champoux (2017:158) conclude that musicians have superior reflexes, as well as enhanced multisensory integration in comparison to non-musicians.

3.3.2 Instrument-specific research

Gebel et al. (2013) examined instrument-specific changes in relation to auditory and somatosensory processing. To achieve this, 14 trumpeters were contrasted to 15 pianists by means of functional magnetic resonance imaging (fMRI). The group of pianists had not previously played any brass or woodwind instruments. The researchers specifically compared these musicians since trumpeters "use tight finger and lip interaction", while pianists "use only the extremities for performance"

(2013:37). The Semmes-Weinstein monofilaments test was used to assess the lips' somatosensory responsiveness. Electromyography (EMG) was conducted to test the absence of lip movement during the finger movement tasks and to test that trumpeters and pianists would demonstrate the same lip motion when performing on a trumpet replica. Finger movements of the right-hand's index, middle and ring finger were recorded with a magnetic resonance imaging (MRI) compatible data glove.

The results from Gebel et al.'s (2013:37) study revealed that trumpeters demonstrate "an instrument training-specific activation increase", as well as increased neuro-activity "during actual trumpet playing". In comparison to the trumpeters, the group of pianists attained higher levels of lip activity during the various tasks. The pianists also played louder on the trumpet replica than the trumpeters; possibly counteracting their lack of experience (Gebel et al., 2013:42).

Krause, Pollok and Schnitzler (2009) examined the link between sensorimotor synchronization[36] and musical instrument of specialisation, perceptual discrimination, and the movement trajectory. Their sample of 60 right-handed individuals consisted of 12 professional pianists, 12 amateur pianists, 12 drummers, 12 singers and 12 non-musicians. The participants had to tap "to the onset of a regular auditory and visual pacing signal" using the right index finger (Krause et al., 2009:29). The first part involved tapping to an auditory click, while the second part entailed tapping each time a red circle was projected onto a screen. Cross-modal discrimination was determined for the following combinations of cross-modal stimuli: "auditory–tactile in comparison to tactile–auditory and visual–tactile in comparison to tactile–visual (2009:30). An ultra sound marker was used to determine movement trajectory. Except for the professional pianists, the drummers executed the auditory synchronisation more accurately than the other musicians and non-musicians. The drummers also demonstrated "superior discrimination abilities" during the cross-modal discrimination task. The results suggest that the instrument of specialisation affects synchronisation abilities, and that synchronisation accuracy is related to both perceptual discrimination ability, as well as movement trajectory.

[36] Sensorimotor synchronisation is the ability to accurately coordinate perception and action (Krause et al., 2010:28; Bravi, Cohen, Quarta, Martinelli & Minciacchi, 2016:909).

Clark, Holmes, Feeley and Reddings (2013) tested the hypermobility and proprioception of 28 (6 male and 22 female) music performance students. The distribution of instrumentalists was as follows: “11 strings, 2 harps, 3 pianists, 1 woodwind, and 11 vocalists” (Clark et al., 2013:606). To assess hypermobility and proprioception, the Beighton scoring system for joint hypermobility, and Leeds Hand Proprioceptometer was used. No statistically significant results were obtained (Clark et al., 2013:607). Nonetheless, higher proprioception scores were obtained for the dominant hand. As a result, three participants’ data was omitted due to the fact that they were left-handed. In addition, women scored higher in terms of hypermobility. However, unequal gender distribution could have been the causal factor. Clark et al. (2013:607) were also unable to establish a significant relationship between hypermobility and proprioception.

An interesting finding was that harp and piano players demonstrated significant differences between their dominant and non-dominant hands. Clark et al. (2013:608) attribute this to the fact that “harpists watch their left hand but not their right, and pianists typically play more complex lines with their right hand”. The opposite was found among the string players, woodwind players and vocalists “for whom the non-dominant hand exhibited better proprioception” (Clark et al., 2013:608). Clark et al. do not specify whether all these participants were right-handed: they state that their “findings suggest that musicians have low levels of hypermobility” and that the instrument of specialisation influences skilled musicians’ proprioception (2013:609). However, they do not specify against which norm the musicians have been compared.

Slater et al. (2017) studied the cognitive and sensory processing of 21 singers, 21 percussionists and 18 non-musicians. The *Integrated Visual and Auditory Plus Continuous Performance Test* was used to measure attention and inhibitory control, while frequency discrimination was assessed by means of sub-tests of the IHR Multicentre Battery for Auditory Processing (Slater et al., 2017:954). Following statistical analysis, Slater et al. (2017:959-960) found somewhat significant evidence that percussionists decipher rapid changes in speech qualities more accurately than non-musicians. The percussionists also exhibited superior inhibitory control than either the singers or the non-musicians in the sample.

At the same time, Slater et al. (2017:960) state that percussionists and singers who indicated that they are equally proficient at sight-reading and improvisation have higher levels of inhibitory control than non-musicians. This seems to contradict the foregoing finding. Singers demonstrated enhanced frequency discrimination, as well as “stronger encoding of speech harmonics” than non-musicians (Slater et al., 2017:960). Slater et al. (2017:960) emphasise that a person’s primary instrument and style of music “may influence cognitive and sensory function”. However, they do not elaborate on this statement or the evidence which supports it. Slater et al. (2017: 960) point out that although the aim of their study was not to examine the “causal effects of musical training”, their results correlate with findings from earlier studies which confirm “instrument-specific enhancements of auditory processing”.

In a study that was conducted by Pa and Hickok (2008), the neuro-activity of three professional pianists and four piano performance students was determined by means of fMRI. The participants had to listen to three unfamiliar melodies which varied in intricacy (Pa & Hickok, 2008:364). After listening to each melody once, pianists had to accurately play it on a piano without producing any sound or humming it in their minds. This lasted for either 0, 6 or 12 seconds. This was followed by a 12-second silence after which the next trial started; there were 16 trials in total. A quantitative analysis of data revealed that activity in the posterior superior temporal-parietal area of the brain “was significantly higher for the covert hum versus covert play condition” (Pa & Hickok, 2008:362). In addition, all pianists showed elevated activity in the anterior intraparietal sulcus (outside surface of the parietal lobe) “during the covert play than covert hum condition” (2008:366).

Van Vugt and Tillmann (2014) compared musicians’ auditory-motor coupling thresholds with that of non-musicians. Van Vugt and Tillmann (2014:2) recruited a group of student and professional musicians (20 pianists and 18 brass players), as well as 18 non-musicians. In comparison to the pianists, the latter group reported spending “more time in a day using a computer keyboard than the pianists” (Van

Vugt & Tillmann, 2014:2). Their experiment involved playing 30 artificial woodblock strikes which were separated by different time intervals. Participants were instructed to press a particular key on a USB keypad each time they heard the woodblock. With each strike, the delay between “motor (keystroke) and auditory (tone) events” was measured (Van Vugt & Tillmann, 2014:3). To ensure consistency, participants were told to keep their finger on the executing key and to keep their eyes closed during the procedure. Van Vugt and Tillmann’s (2014:4) results indicate that non-musicians have a significantly higher auditory threshold; in other words, musicians’ responses to the auditory input are swifter. With regard to the group of musicians, no significant difference occurred between the singers and percussionists’ thresholds.

Proverbio and Bellini (2018) contrasted two groups of 32 professional musicians with “comparable expertise”. The one group consisted of pianists with an average of 10 000 hours of practice over a period of 10 years, while the other group of consisted of musicians who specialise in other instruments, but also studied the piano for about three years (Proverbio & Bellini, 2018:16). This group also spent about 10 000 hours practising over a period of 10 years on their primary instrument and approximately 3 000 hours practising the piano over a period of 3 years. Following a statistical analysis of data, Proverbio and Bellini (2018:16) found that N280[37] was larger in the pianists-only group. Proverbio and Bellini (2018:21) conclude that there is a significant disparity between the two groups. As a result, they caution against including “only a few weeks/months of training in a new discipline” in a professional musician sample (Proverbio & Bellini, 2018:15).

3.4 Summary

Apart from the fact that musicians specialise in different instruments, several scholars have investigated the connection between musicians, instruments of specialisation, personality traits and their senses. The purpose of this chapter was to discuss literature which examines the relation between these aspects. This was done by first considering personality traits of musicians in general, after which

[37] N280 is an anterior negative ERP which is commonly associated with language processing (Brunelliere, Hoen & Dominey, 2005:1435). It has to do with “quantitative differences in word length and frequency” (Osterhout, Bersick & McKinnon, 1997:143).

personality traits in the context of instrument groups were discussed. Following this account, literature pertaining to personality traits and instrument of specialisation was discussed. This involved string, woodwind, brass, percussion and keyboard players. Musicians' personality traits were then discussed in light of gender differences. Lastly, literature which focuses on musicians' senses was considered from two main perspectives: musicians in general versus non-musicians, and instrument-specific research.

Orchestral string players are generally more aloof, introverted, conscientious and show higher levels of self-sentiment. Within the string group, violinists are particularly associated with intelligence, sensitivity and a high level of conscientiousness, while violists are emotionally more stable, and bassists are the most agreeable. Cellists on the other hand are considered to be the most introverted and aloof of the group. As for the non-orchestral strings, guitarists in general (without reference to type of guitar or style) are considered to be more imaginative, neurotic and psychotic. However, these traits of guitarists are based on very limited research.

Like string players, woodwind players are found to be more aloof and conscientious, but not as strongly as string players. Furthermore, woodwind players are typically nervous, radical and self-sufficient. Flute players appear to be particularly imaginative, while their oboe counterparts have low ergic tension and no anxiety. Of the woodwind players, bassoonists are the most distinct with lower levels of intelligence, elevated apprehensiveness and greater self-sufficiency.

Brass players' personality traits have been found to be the most distinctive. Brass players are associated with extraversion, expedience and group dependence. Some scholars also found them to demonstrate lower intelligence. Among the brass players, trumpet players and horn players are the most divergent. Trumpeters are extroverts, individualistic and take the lead. They are also the least neurotic of all the musicians. Horn players on the other hand are known for being more arrogant, introverted, sometimes prima donnas, and preferring to interact with horn players.

As for percussionists, not much research has been done. Based on two studies, drummers have been found to be more extroverted, but less intelligent and imaginative than other musicians. Pertaining to keyboard players, extroversion, adjustment, warm-heartedness, emotional stability, shrewdness, conservatism, submissiveness and not being over sensitive are distinct qualities. Pianists are particularly submissive, conscientious and conservative with a high level of self-sentiment. Performance pianists are different from accompanists in that they are more extroverted. In comparison to pianists, organists demonstrate similar personality traits, but diverge in terms of being significantly shrewder.

In comparison to their respective non-musician gender counterparts, both male and female musicians are more androgynous, aloof, intelligent, forthright and self-sufficient. These differences are more significant between male musicians and non-musicians. Also, in comparison to non-musicians, male woodwind players are considerably more aloof, emotionally stable, imaginative and relaxed. Conversely, male brass players are more tough-minded and self-assured. In terms of female brass players, the only significant deviation from the norm is that they are more apprehensive. However, gender distribution may impact results and it is therefore important to consider an unequal spread of gender before arriving at any conclusions.

Pertaining to musicians and their senses, it has been established that dynamics, pitch, timbre, vibrato, and the different combinations of these elements influence listeners' perception of tactile metaphors. Depending on the instrument of specialisation, there is an increased neuro-activity in different parts of the brain. For example, drummers are significantly better at carrying out auditory synchronisation than other musicians.

It was established that a number of neurological and neuroscience studies have investigated the difference between musicians and non-musicians regarding the anatomy and functioning of their brains. Researchers unanimously concur that there is a difference between musicians' and non-musicians' neural activity. MMN is often used to determine such differences. In comparison to non-musicians, musicians have better working memory, and demonstrate greater awareness and responsiveness to sound and touch. In order for musicians to experience and express emotion during musical performance, a certain degree of proprioception is involved, as well as cognitive and linguistic skills. Musicians demonstrate an enhanced multisensory incongruency response, have shorter fixations, longer eye-hand span and greater gaze activity. While neurological evidence points to differences between musicians and non-musicians, such findings should be viewed in light of the fact that musicians are more sensitive to sensory stimuli. It is therefore possible that neuroscientific comparisons between musicians and non-musicians are not completely objective.

Reflecting on the literature that was reviewed in this chapter, it is evident that there is a connection between musicians, their personality traits and their senses. At the same time, it concludes the discussion of all relevant literature that was reviewed. This account provides a detailed backdrop against which this study's findings are viewed in Chapter 6.

Taking into account the various quantitative designs and methodologies which were used by the studies that were reviewed, the next chapter, Chapter 4, provides an explanation of the research design and objectives of the current study. This is followed by a discussion of the process by which participants were sampled and data was collected, as well as a description of the statistical procedures that were employed for data analysis.

CHAPTER 4

METHODOLOGY AND PRESENTATION OF DATA

4.1 Introduction

Hofstee (2006:107) states that, together with the thesis subject, the methodology is the most important aspect which determines the outcome of a thesis. It is essential that the researcher aligns the aim of the particular study with a most suitable methodology that will steer the study towards this aim/these aims by utilising the most appropriate method of data collection and analysis. Taking into account the significance and effect of the methodology, the purpose of this chapter is to systematically provide an explanation of the methodological foundation for addressing the research problem.

Considering existing literature as well as the gap in literature pertaining to the relation between musicians, their main instrument and their sensory patterns, the focus of the study is to firstly investigate whether there are differences in the sensory patterns of musicians that play musical instruments belonging to different instrument groups (woodwinds, brass, percussion, keyboards and strings). Secondly, the study aims to determine whether sensory pattern differences occur within a particular instrument group, for example different instruments (flute, oboe, clarinet, bassoon and saxophone) within the woodwind group. Finally, I intended to investigate whether gender disparities occur within a particular instrument group, for example woodwinds.

In the discussion that follows, attention is given to the research design, research objectives, data collection procedures, research population, ethical considerations, measuring instruments, and statistical analysis techniques to address the research problem and answer the main research question and sub-questions. The research problem involves the fact no music or occupational therapy research has been conducted concerning the relation between musicians playing a particular instrument and their sensory patterns. While the main research question aims to address this problem, the sub-question expands on it through investigating the differences and similarities between the sensory patterns of musicians from different instrument groups.

4.2 Research design

Mouton (2001:55) compares a research design to the process of designing a house. In order for an architect to draw up plans, he/she needs to be clear on the ideas and needs of the customer in order to generate a most suitable design to match the client's expectations. Likewise, a researcher needs to have clarity in terms of the research design which will answer the research question/s and provide the most accurate results.

Creswell (2009:4), along with Maree and Pietersen (2007a:145), explains that there are three main research designs namely quantitative, qualitative and mixed methods. Quantitative research involves an objective and systematic process by which numeric data is gathered from a sample in order to generalise to a population. Most often this data is then statistically analysed in order to study the relation among the variables that were tested (Creswell, 2009:4; Maree & Pietersen, 2007a:145). All of these authors (Creswell, 2009:12; Maree & Pietersen, 2007a:149) concur that quantitative research can be categorised as either experimental or non-experimental.

While the aim of experimental research is to determine probable cause/s, non-experimental research (also referred to as descriptive research) "establishes only relations between variables" (Ivankova, Creswell & Plano Clark, 2007:257). A typical example of experimental research is the pretest-posttest design in which the cause (influence) and effect (outcome) of a specific treatment are measured by means of a control group and experimental group in which some form of manipulation occurs (Maree & Pietersen, 2007a:150). With non-experimental research however, none of the variables are manipulated. According to Creswell (2009:12), as well as Maree and Pietersen (2007a:152), one of the most widely used non-experimental research designs is surveys. Two prominent characteristics of surveys are that they normally include a big sample, and that "many variables are measured, and multiple hypotheses are tested" (Maree & Pietersen, 2007a:155). Creswell (2009:59) points out that surveys can take different forms such as questionnaires, interviews and structured observations.

In the context of quantitative inquiry, Creswell (2009:12) states that "survey research provides a quantitative or numeric description of trends, attitudes or opinions of a population by studying a sample of that population". Hofstee (2006:122,132) points out that although a questionnaire can be an excellent way of obtaining people's "opinions, desires and attitudes", they can also be subject to bias and give rise to deceiving results due to aspects like the type of questions that are included, phrasing of questions, sample size, and the representativeness of the sample. An effective way to avoid this, as well as personal bias, is to choose an existing measuring instrument which is reliable and validated (Creswell, 2009:59; Ivankova et al., 2007:258). Another downfall of surveys is that the researcher is not able to interact with the respondents and therefore limits the context in which information is provided.

Quantitative survey research typically employs predetermined closed-ended questions which require a "yes" or "no" response. Although a few open-ended questions are also sometimes included, Hofstee (2006:132-133) cautions against too many of these as the data "can be difficult to interpret/analyse". Ivankova et al. (2007:258) explain that following data collection, a numeric value is allocated "to each response category and variable" by means of computer software designed for this purpose. For further analysis, Ivankova et al. (2007:258) explain that:

> Data analysis consists of describing trends, comparing groups and related variables, and is conducted at two levels: (1) descriptive statistics that indicate general tendencies in the data, and (2) inferential statistics that analyse the data from the sample to draw conclusions about the unknown population.

In contrast to quantitative research which focuses on numeric data and data analysis, qualitative research is more concerned with analysing words (Creswell, 2009:3; Ivankova et al., 2007:257, 259). Instead of observing a particular phenomenon from the "outside", qualitative research allows the researcher to understand the phenomenon from the participants' point of view based on their experiences. Some frequently used qualitative research strategies involve case studies, ethnography and narrative research (Creswell, 2009:15). For these kinds of studies, data is often collected from the participants in their environment. Such data is analysed by means of categorising (coding) it into themes after which the researcher interprets the data (Creswell, 2009:4; Ivankova et al., 2007:259). A great challenge in the interpretation of results is bias and the degree to which the results can be generalised (Hofstee, 2006:123; Mouton, 2001:148).

While quantitative research is concerned with numbers and qualitative research with words, a mixed methods approach utilises both these methods (Creswell, 2009:4). Creswell (2009:4) elaborates on this basic understanding by pointing out that mixed methods require "philosophical assumptions, the use of quantitative and qualitative approaches, and the mixing of both approaches". An example of such an approach is conducting a survey followed by interviewing the participants (Ivankova et al., 2007:262). Creswell (2009:4) adds that a mixed methods research design is ideal for inquiries where the "overall strength of a study is greater than either qualitative or quantitative research". Creswell (2009:207), as well as Ivankova et al. (2007:265,271), emphasises the complex nature of mixed methods and that the researcher must be clear on what data is collected at what point in time, as well as how and when mixing of the two sets of data will take place. Another important aspect to consider is the weighting of the quantitative and qualitative data. They can carry the same amount of weight or the one may weigh more than the other (Bryman, 2012:632; Creswell, 2009:206-207). Considering the complexity of a mixed methods design, Maree (2007:276) stresses the importance of determining if a mixed methods approach will enhance a better understanding of the research problem and if there are any specific advantages such an approach would offer.

Considering different research designs, it was decided that a quantitative non-experimental research design would be most suitable in terms of this specific study. Several aspects led to this decision. First of all, the research questions seek to establish relations between musicians and their instruments. This calls for non-experimental research. It was decided to make use of a survey as data collection tool so as to be able to "generalize from a sample to a population so that inferences can be made about some characteristic" (Creswell, 2009:146). A further reason for using a quantitative non-experimental survey design is found in existing studies that sought to establish a link between musicians and their instruments. Studies by scholars like Payne (2014), MacLellan (2011), Colley and Maltby (2008), as well as Kemp (1981a; 1981b; 1982a; 1982b)[38], employed the same research design. Interviews were not considered to be a viable option as they would be too time consuming and costly bearing in mind the number of participants required for statistically significant results.

As pointed out by Creswell (2009:59) and Ivankova et al. (2007:258), subjectivity can be a major challenge with survey design. An effective way to avoid this is to determine if there is an existing reliable and validated measuring instrument which can be used to answer the research questions and accomplish the aim of the study. The *Adult/Adolescent Sensory History* (ASH), a quantitative data collection and analysis tool, met these criteria. (The ASH was discussed in detail under 2.7 in Chapter 2.) It was used as cross-sectional data collection device considering the large sample from which data was collected over two years. A cross-sectional survey entails once-off data collection from more than one participant (Bryman, 2012:711). This is in contrast to a longitudinal study where data is collected from a sample on more than one occasion (Bryman, 2012:712).

Since the purpose of the study was to compare specific groups of musicians (independent variables) in terms of various dependent variables, a criterion group design was used. Creswell (2009:50) explains that variables (for example age, gender, attitudes and behaviours) are divided into dependent and independent variables. Independent variables are independent from other variables being measured; they influence dependent variables. A dependent variable on the other hand is a result depending on an independent variable or variables. A criterion group design is a way of purposive sampling in which participants who meet specific

[38] This four-part article, titled "The personality structure of the musician", was published between 1981 and 1982. It is widely cited and considered to be a seminal source in terms of the link between musicians and their instruments.

criteria are strategically recruited so as to arrive at the research goals (Bryman, 2012:418-419). In this case, the group of participants was national or international professional musicians, music lecturers, music teachers, or final year/postgraduate music students specialising in performance.

Using this research design, sensory patterns were identified as the dependent variable and instrument group was identified as the independent variable. Information regarding the sensory patterns of respondents was obtained by using a self-report questionnaire consisting of 163 items. This questionnaire is discussed in detail under “The Adult/Adolescent Sensory History” in Chapter 2. The 163 items provide measurements on nine subscales: visual and spatial, auditory and language, movement (vestibular), taste and smell, touch (tactile), proprioception, postural control, motor coordination, and social/emotional functioning. The responses to the items of these sub-scales were used to calculate scores on three sensory sections, their subsections and variables. The three sensory sections are modulation and discrimination, functional problems, and motor/social components. The subsections and variables of each of these main groups are shown in Table 4-1. Each of the subdivisions, with the exception of postural control, has specific variables for which total scores for respondents were obtained. Other than postural control itself, this subsection does not have other variables as in the case of the other subsections. The totals that were obtained on these variables were calculated by the Spiral Foundation’s statistician and are not available to people outside the Spiral Foundation. Consequently, it was not possible to separately calculate the reliability of the different variables.

Table 4-1: Main sections, subsections and variables of sensory patterns as set out on the ASH*'s* report form

Main section	Subsections	Variables
Modulation and discrimination	Modulation	Visual; auditory; vestibular; taste and smell; tactile
	Discrimination	Visual; auditory; vestibular; taste and smell; tactile; proprioceptive
Functional problems	Sensory seeking	Visual seeking/oculo-motor; seeks movement; seeks touch
	Sensory over-responsivity	Imposed touch; hygiene; water; atypical pain response; gravitational insecurity
Motor and social	Postural control	Postural control total
	Motor co-ordination	Motor planning; sequencing; oral motor planning; fine motor
	Social/emotional	Depressed; aggressive/impulsive; anxious

4.3 Research objectives and hypotheses

As shown in Table 4-1, the aim of the study was to investigate the research hypotheses regarding the three main sections (modulation and discrimination, functional problems, and motor/social components). Therefore, in each case a main section was taken and the hypothesis of the specific variables (last column of Table 4-1) of that section was investigated.

Considering this background, the following research hypotheses were formulated:

Research hypothesis 1

There are significant differences concerning the average **modulation and discrimination** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

Research hypothesis 2

There are significant differences concerning the average **functional problem** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

Research hypothesis 3

There are significant differences concerning the average **motor/social components** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

Research hypothesis 1(a) are indicated in statistical terms below. The same statistical hypothesis can be formulated for research hypotheses 2(a) and 3(a). This means that only the variable names will differ for these hypotheses.

In the case of research hypothesis 1(a) the following statistical hypothesis can be formulated:

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7 = \mu_8 = \mu_9 = \mu_{10} = \mu_{11} = \mu_{12} = \mu_{13} = \mu_{14} = \mu_{15} = \mu_{16} = \mu_{17} = \mu_{18} = \mu_{19}$$

$$H_1 : \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5 \neq \mu_6 \neq \mu_7 \neq \mu_8 \neq \mu_9 \neq \mu_{10} \neq \mu_{11} \neq \mu_{12} \neq \mu_{13} \neq \mu_{14} \neq \mu_{15} \neq \mu_{16} \neq \mu_{17} \neq \mu_{18} \neq \mu_{19}$$

where: μ_1 = the average modulation/discrimination variables for the population of **bassoon** players

μ_2 = the average modulation/discrimination variables for the population of **cello** players

μ_3 = the average modulation/discrimination variables for the population of **clarinet** players

μ_4 = the average modulation/discrimination variables for the population of **double bass** players

μ_5 = the average modulation/discrimination variables for the population of **harp** players

μ_6 = the average modulation/discrimination variables for the population of **flute** players

μ_7 = the average modulation/discrimination variables for the population of **French horn** players

μ_8 = the average modulation/discrimination variables for the population of **classical/nylon string guitar** players

μ_9 = the average modulation/discrimination variables for the population of **electric/steel string guitar** players

μ_{10} = the average modulation/discrimination variables for the population of **oboe** players

μ_{11} = the average modulation/discrimination variables for the population of **organ** players

μ_{12} = the average modulation/discrimination variables for the population of **percussion** players

μ_{13} = the average modulation/discrimination variables for the population of **piano** players

μ_{14} = the average modulation/discrimination variables for the population of **saxophone** players

μ_{15} = the average modulation/discrimination variables for the population of **trombone** players

μ_{16} = the average modulation/discrimination variables for the population of **trumpet** players

μ_{17} = the average modulation/discrimination variables for the population of **tuba** players

μ_{18} = the average modulation/discrimination variables for the population of **viola** players

μ_{19} = the average modulation/discrimination variables for the population of **violin** players.

Research hypotheses 1(b) – (d) are indicated in statistical terms below. The same statistical hypothesis can be formulated for hypotheses 2(b) – 2(d) and 3(b) – 3(d). This means that only the variable names will differ for these hypotheses. In the case of hypotheses 1(c) and 1(d) below, only the woodwind group is mentioned – the same statistical hypothesis applied to the other instrument groups.

In the case of research hypothesis 1(b) the following statistical hypothesis can be formulated:

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$$

$$H_1 : \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5$$

where:

μ_1 = the average modulation/discrimination variables for the population of **woodwind** players

μ_2 = the average modulation/discrimination variables for the population of **brass** players

μ_3 = the average modulation/discrimination variables for the population of **percussion** players

μ_4 = the average modulation/discrimination variables for the population of **keyboard** players

μ_5 = the average modulation/discrimination variables for the population of **string** players.

In the case of research hypothesis 1(c) the following statistical hypothesis can be formulated:

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$$

$$H_1 : \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5$$

where:

μ_1 = the average modulation/discrimination variables for the population of **woodwind** players with **flute** as main instrument

μ_2 = the average modulation/discrimination variables for the population of **woodwind** players with **oboe** as main instrument

μ_3 = the average modulation/discrimination variables for the population of **woodwind** players with **clarinet** as main instrument

μ_3 = the average modulation/discrimination variables for the population of **woodwind** players with **bassoon** as main instrument

μ_5 = the average modulation/discrimination variables for the population of **woodwind** players with **saxophone** as main instrument.

In the case of research hypothesis 1(d) the following statistical hypothesis can be formulated:

$$H_0 : \mu_1 = \mu_2$$

$$H_1 : \mu_1 \neq \mu_2$$

where: μ_1 = the average modulation/discrimination variables for the population of **men** in the **woodwind** group

μ_2 = the average modulation/discrimination variables for the population of **women** in the **woodwind** group.

Following these statistical hypotheses, the method of data collection is discussed next.

4.4 Data collection

While the research design can be compared to drawing up a building plan, the method of data collection can be compared to the process by which the plan is implemented (Mouton, 2001:55). This section systematically explains how data was collected.

4.4.1 Sampling

Sampling is divided into two main groups, probability sampling and non-probability sampling. Probability sampling is used to recruit participants from a specific population where each individual has an equal chance of being selected, ensuring that the sample is representative of a wider population (Creswell, 2009:155; Maree & Pietersen, 2007b:172). Non-probability sampling on the other hand means that some people have a better chance of being selected than others (Bryman, 2012:713).

According to Bryman (2012:190-193), as well as Maree and Pietersen (2007b:172), probability sampling is divided into four main types of sampling: random sampling (also known as simple random sampling), systematic sampling, stratified sampling, and cluster sampling (also known as multi-stage cluster sampling). With random sampling, each individual has an equal chance of being included in the sample. Systematic sampling refers to participants being selected "according to a fixed interval" (Bryman, 2012:717), for example every fifth person out of 20 people. Maree and Pietersen (2007b:172) explain that in stratified sampling, a population is divided into "homogeneous, non-overlapping groups" known as strata. Lastly, cluster sampling is a form of stratified sampling where clusters (groups smaller than strata) are identified and then individuals are randomly selected from the cluster (Bryman, 2012:709; Creswell, 2009:148). Instead of strata, clusters are sampled. Considering the criteria for participation in this study, random sampling was used as sampling method since any person could participate who met the selection criteria and was among the first approximately 70 people to volunteer.[39]

Although any person who met the research criteria could participate, the aim was to include as many South African musicians as possible. Except for the fact that I am based in South Africa, this provided the Spiral Foundation with the opportunity to obtain a South African normative sample. With this in mind and considering the large number of musicians required for each of the groups, it was decided to invite all the fulltime/part-time professional South African musicians who I am acquainted with or was able to get in touch with. Additionally, six orchestras, four brass bands and music staff of 27 secondary schools that offer Subject Music, all in South Africa, were invited to participate, plus the University of the Free State's music staff and students.

Most of the fulltime/part-time South African professional musicians who were invited to participate completed the questionnaire. The questionnaire was available in hard copy and online. The majority of musicians completed the online version of the questionnaire. Different platforms were used to obtain the contact details of

[39] Some groups of musicians had a higher number of volunteers while other groups had fewer volunteers. As long as the total number of participants did not exceed 1500 as per agreement with the Spiral Foundation, the researcher allowed volunteers to participate who met the research criteria.

musicians. They included the following: ClassicSA, Facebook, LinkedIn, MusicLessonsSouthAfrica, and the South African Society of Music Teachers (SASMT). A number of musicians also offered to share the link to the online questionnaire with professional musicians they are in contact with. The majority of South African musicians who participated come from across the country, while only a few live abroad. These represent different races and genders.

In terms of the six orchestras from across South Africa, all but one was keen to take part in the study. The only concern was that completing the questionnaire would take up too much rehearsal time. Consequently, they preferred sending the link of the online questionnaire to their orchestra members. Unfortunately, the number of online responses received was not very high. Only two of the brass bands participated in the study. The other two bands did not respond to the invitation. Both the participating brass bands are based in Pretoria and completed hardcopy questionnaires.

Of the 27 secondary schools that offer Subject Music, 21 schools' heads/directors of music indicated that it would be the easiest to share the link to the online questionnaire with their music colleagues. As in the case of the orchestras, schools in favour of the online version did not produce high numbers of participants. On the other hand, most of the hardcopy questionnaires that were distributed among the remaining six schools were returned.

Another target group involved music lecturers and final year music students from South African universities. However, it was decided to omit them from the population due to the fact that it would be too time consuming to submit and obtain separate ethical clearance from each of the universities via the Research Information Management System (RIMS).

Although the original intent was to include as many South African musicians as possible, the number of responses was far below 70 respondents for most of the instruments. In order to produce the desired number of respondents, seven Belgian orchestras were contacted. The reason for contacting these particular orchestras was convenience sampling meaning the sample is "easily and conveniently available" (Maree & Pietersen, 2007b:177). At the time, I was in Belgium and decided to seize the opportunity to recruit further participants. Although three of the orchestras offered to print the questionnaire for their orchestra members, they, like the other Belgian orchestras, decided to distribute the link of the online questionnaire among the orchestra members. Unfortunately, the number of responses was very low.

Being still far from the target number of musicians, it was decided to place advertisements on Facebook musician groups and pages to invite people who met the research criteria to contact me if they were interested in participating. In the end, advertisements were place on 107 of these groups and pages. Searches were also conducted on LinkedIn, for example "violinist", and invitations were sent to people who evidently met one or more of the criteria based on the academic and professional details provided on the profiles. The link to the questionnaire was only made known to people who met the criteria for participation. This was done either via Messenger (available on Facebook for personal messages) or email in cases where respondents provided their email addresses as preferred method of communication. In cases where it was not apparent if a person who responded to one of the advertisements met the criteria, further details were requested regarding his/her musical background, experience and/or qualifications.

Using social media platforms turned out to be the most successful method of recruitment. This supports the findings of studies that identified Facebook as a viable platform for social research, especially in terms of reaching a larger number of participants of a target population (Carter-Harris, 2016:144; Rife, Cate, Kosinski & Stillwell, 2014:69).

Ultimately, after nearly two years of data collection between 2015 and 2017, 1416 musicians from more than 60 countries participated. There were three countries with more than 100 people per country who participated: United States of America (approximately 510 participants), South Africa (approximately 350 participants) and England/UK (approximately 185 participants). These are approximate numbers as not all participants indicated their nationality. All musicians indicated that they belong to one or more of the following categories: fulltime/part-time professional musician, music teacher, music lecturer or final year tertiary music student. The sampling techniques which were used for recruitment purposes are discussed below.

Although the initial group comprised 1416 respondents, the final group consisted of 1327 respondents due to the fact that some of them did not complete one or more sections of the questionnaire and were thus omitted. The distribution of the whole research group in terms of instrument group, type of instrument and gender is shown in Table 4-2.

Table 4-2: Division of research participants according to instrument group, type of instrument and gender

Instrument group	Instrument	Male		Female		Total	
		N	%	N	%	N	%
Woodwinds	Flute	13	17.6	61	82.4	74	21.1
	Oboe	13	17.8	60	82.2	73	21.0
	Clarinet	29	38.7	46	61.3	75	21.4
	Bassoon	36	48.6	38	51.4	74	21.1
	Saxophone	32	59.3	22	40.7	54	15.4
	Total	**123**	**35.1**	**227**	**64.9**	**350**	**26.4**
Brass	French Horn	30	40.0	45	60.0	75	25.6
	Trumpet	69	86.3	11	13.7	80	27.3
	Trombone	63	87.5	9	12.5	72	24.6
	Tuba	54	81.8	12	18.2	66	22.5
	Total	**216**	**73.7**	**77**	**26.3**	**293**	**22.1**
Percussion	**Total**	**61**	**83.6**	**12**	**16.4**	**73**	**5.5**
Keyboards	Piano	23	30.3	53	69.7	76	52.8
	Organ	45	66.2	23	33.8	68	47.2
	Total	**68**	**47.2**	**76**	**52.8**	**144**	**10.9**
Strings	Harp	8	12.1	58	87.9	66	14.2
	Violin	11	16.2	57	83.8	68	14.6
	Viola	17	25.4	50	74.6	67	14.4
	Cello	22	31.9	47	68.1	69	14.8
	Double bass	48	72.7	18	27.3	66	14.2
	Classical/nylon string guitar	58	73.4	21	26.6	79	16.9
	Electric/steel string guitar	46	90.2	5	9.8	51	10.9
	Total	**210**	**45.1**	**256**	**54.9**	**466**	**35.1**
	Grand Total	**678**	**51.6**	**648**	**48.4**	**1326**	**100.0**

While the percussionists had the lowest representation (5.5%), the string players had the highest representation in the group that was surveyed (35.1%). One keyboard respondent did not indicate his/her gender, hence the total number of 1326 respondents. As far as the percussion group is concerned, no distinction was made between the types of instruments (as orchestral percussion/the drum set as a whole is regarded as the instrument) and consequently this group was not included in hypotheses 1(c), 2(c) and 3(c). Regarding the hypotheses that involve comparison of gender, the percussion group was not included as only 12 respondents indicated their gender as female. The group was therefore too small to conduct meaningful analysis.

The ASH which was used as measuring instrument in the study is discussed next. This measuring instrument is mostly used by occupational therapists to determine sensory processing patterns for intervention purposes. In the context of this study it was used it to determine whether there is a relation between musicians, their main instrument and their sensory patterns.

4.4.2 Participants

Data was collected from five instrument groups namely woodwinds, brass, percussion, keyboards and strings. In the end, participants ranged between 18 and 71 years of age. The criteria for participation were that respondents had to fall into one or more of the following categories: fulltime/part-time professional musician, music teacher, music lecturer or final year tertiary music student whose primary instrument is one of the instruments listed in Table 4-3. These were the only criteria. No demographic information such as gender, age (as long as participants were 18 years or older), race, nationality, location, and medical history or conditions were included in the selection of participants. In order to provide statistically significant results, the aim was to recruit 70 people per instrument. This number of participants is based on the number of sections and questions in the ASH. Data collection concluded when the targeted number of musicians was reached to produce statistically significant results.

Table 4-3: Instruments included in the study

Woodwinds	Brass	Percussion	Keyboards	Strings
Flute	French Horn	Orchestral percussion	Piano	Harp
Oboe	Trumpet	Drum kit	Organ	Violin
Clarinet	Trombone			Viola
Bassoon	Tuba			Cello
Saxophone				Double bass
				Classical/nylon string guitar
				Electric/steel string guitar

4.4.3 Procedures

As indicated above, most participants were recruited via social media advertisements. These invitations were short and informal. Invitations to orchestras, bands and heads/directors of music were formal and provided more detail. Examples of these invitations have been included under Appendices 1-3 respectively. Methods of communication included social media messages, emails and phone calls.

All respondents who participated in the study completed either a hard-copy or electronic version of the ASH. As mentioned earlier, only a few participants completed a printed copy of the ASH. These questionnaires were distributed and collected by me. The majority of participants completed the questionnaire online. The online version was hosted by SurveyMonkey, an online survey tool. People who offered to participate were provided with the link to the ASH. Before doing so, the researcher checked that the potential participant met the criteria for participation.

Participants who completed the questionnaire on SurveyMonkey entered the data themselves, while I manually entered the responses of participants who filled in the hardcopy version of the ASH. For this I used an Excel spreadsheet which was provided by the Spiral Foundation and stored in a Dropbox folder which I could access as could my supervisors and the Spiral Foundation. Once a month, the Spiral Foundation's statistician scored the new entries and updated the Excel spreadsheet. After receiving the scored data from the Spiral Foundation, the ASH *Scoring Program©* was used to generate report forms for participants. After completing the questionnaire, participants could not generate their own report forms but all results were emailed to those who opted to have their results. A generic explanation of the results and terms used in the report form were sent together with each participant's results. A copy of these explanations is included under Appendices 4-5.

4.4.4 Measuring instrument

The ASH (refer to Appendix 6), a self-report questionnaire, was used as measuring instrument.[40] It was designed to identify problems in terms of sensory discrimination, sensory modulation, postural-ocular skills, praxis/motor coordination and social-emotional functioning (May-Benson, 2015:13). The rationale behind this is that there is a growing number of adolescents and adults who struggle with sensory processing and sensory integration. May-Benson (2015:11) agrees with other researchers who found that between 5-67% of people, including as many as 98% of autistic children, have difficulty processing and integrating sensory information. May-Benson (2015:12) explains that a limited number of "assessments identify sensory processing problems and support clinical reasoning for intervention planning".

The ASH assesses sensory processing dysfunction patterns with reference to sensory modulation and sensory discrimination, as well as functional skills with reference to postural control, praxis and social and emotional functioning (May-Benson, 2015:12). To achieve this, numeric data is collected through 163 Likert scale questions. It comprises nine categories: visual and spatial, auditory and language, movement (vestibular), taste and smell, touch (tactile), proprioception, postural control, motor coordination, and social/emotional functioning (May-Benson, 2015:12). Each of these categories (as well as sensory modulation and sensory discrimination), as well as the number of questions each consist of are shown in Table 4-4.[41] It also provides a short definition of each concept. Figure 4-1 on the other hand provides a breakdown of the ASH in terms of what it assesses and how it

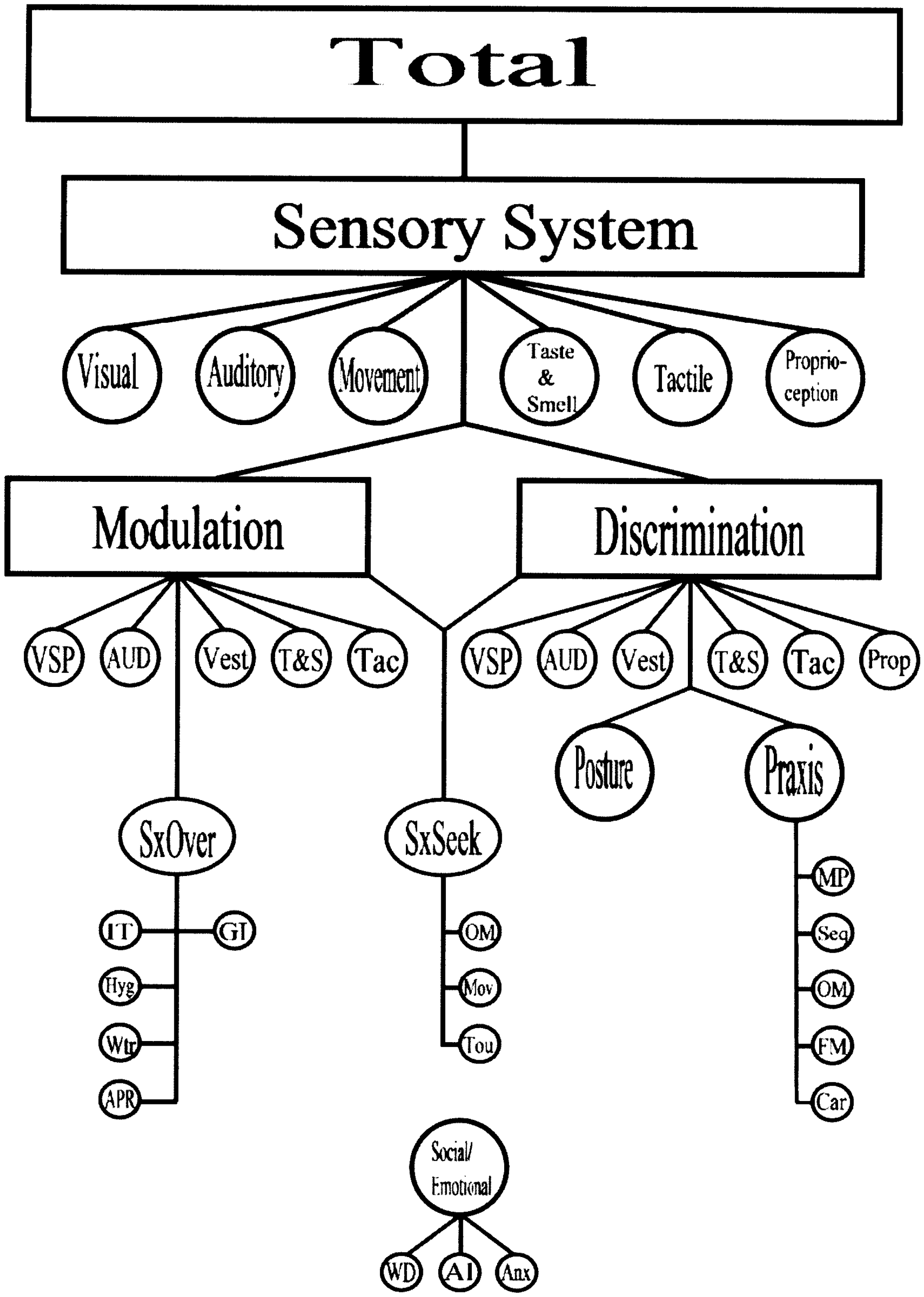
[40] Initially there were two questionnaires, the ASH (of which the first page was omitted), as well as a biographic questionnaire which I designed. During the course of my study, the focus changed from sensory patterns which influence a musician's choice of primary instrument to the relation between musicians' sensory patterns and their primary musical instrument, as well as the sensory patterns of musicians from different instrument groups. Following this change in focus, the information that was obtained through the biographic questionnaire became redundant and was therefore omitted in terms of data analysis.

[41] A detailed description of each of these categories, as well as the way in which they were developed, validated and standardised, is discussed in Chapter 2.

arrives at its total score. The abbreviations refer to criteria used on the ASH report form. Their meanings are shown below Figure 4-1.

Table 4-4: ASH sections, number of items (questions) per section and short definition of each section (May-Benson, 2015:20)

Definition of Total and Section Scores	
Score	**Definition**
Total Score	Sum total of all 163 items. Reflects overall functional performance in sensory processing, postural, motor and social skills.
Sensory Section Scores	Sum total of each section which includes:
Visual Spatial Processing	Sum total of 29 items. Reflects functional skills related to visual processing, visual-spatial skills, oculomotor control, and visual hypersensitivity.
Auditory & Language Processing	Sum total of 12 items. Reflects functional skills related to auditory processing, auditory discrimination, auditory hypersensitivity and following verbal directions.
Movement (Vestibular) Processing	Sum total of 28 items. Reflects functional problems related to hypersensitivity to movement, vestibular discrimination, gravitational insecurity and seeking movement inputs.
Taste & Smell	Sum total of 11 items. Reflects functional skills related to hypersensitivity to taste and smell situations.
Touch (Tactile) Processing	Sum total of 33 items. Reflects functional problems related to hypersensitivity to touch, tactile discrimination, and seeking of touch experiences.
Proprioceptive Processing	Sum total of 10 items. Reflects functional problems related to proprioceptive discrimination.
Sensory Modulation	Sum total of 58 sensory items across sensory systems. Reflects difficulties in regulation of sensory inputs. Modulation scores by sensory system are also available. Functional problems are seen in over-responsivity to sensory inputs and avoidance of activities.
Sensory Discrimination	Sum total of 67 sensory items across sensory systems. Reflects difficulties in perceiving and using the qualities of sensory inputs. Discrimination scores by sensory system are also available. Functional problems are seen in skill performance.
Postural Control	Sum total of 11 items. Reflects difficulties with postural control, stability, strength and postural tone.
Motor Coordination/Praxis	Sum total of 12 items. Reflects performance in gross and fine motor skill areas.
Social-Emotional	Sum total of 17 items. Reflects functioning in social/emotional regulation including depression and withdrawal; anxiety; and aggression and impulsivity.



Abbreviations: **AI** = Aggressive/Impulsive; **Anx** = Anxious; **APR** = Atypical Pain Response; **AUD** = Auditory; **Car** = Difficulty driving a car; **FM** = Fine Motor; **GI** = Gravitational Insecurity; **Hyg** = Tactile-related Hygiene; **IT** = Discomfort with Imposed Touch; **Mov** = Seek movement; **MP** = Motor Planning; **OM** = Oral Motor Planning; **Prop** = Proprioceptive; **Seq** = Sequencing; **SxOver** = Sensory Over-Responsivity; **SxSeek** = Sensory Seeking; **T&S** = Taste and Smell; **Tac** = Tactile; **Tou** = Seek Touch; **Vest** = Vestibular; **VSP** = Visual-Spatial Processing; **WD** = Withdrawn/Depressed; **Wtr** = Discomfort with Water

Figure 4-1: Conceptual model of the ASH (May-Benson, 2015:35)

In addition to the nine categories, the ASH includes unique features which are modulation and discrimination scores, as well as clinically relevant functional subsection scores.[42] The modulation and discrimination scores are determined by the ASH *Scoring Program©* which is used for scoring purposes. A total of 58 questions from the sensory systems make up the modulation score, while 67 items are used to derive the discrimination total (May-Benson, 2015:20). The questions which make up the modulation and the scores are unspecified and not included in the *Adult/Adolescent Sensory History User's Manual*. May-Benson (2015:20) further explains that:

> Some of the sensory and motor sections have clinically relevant functional subsection scores which fall under categories of Sensory Seeking Behaviors, Sensory Over-Responsivity Behaviors, Motor Coordination Difficulties and Social-Emotional Functioning. As most of these functional subsections consist of only a few items, they may not be reliable for identifying a global sensory processing problem.

In order to determine functional scores for each of the sensory processing sections, responses are interpreted by the ASH *Scoring Program©*. In order to provide for incomplete answers, May-Benson (2015:29) states that of the 163 questions, "up to 16 items may be missed as long as no one section has more than 20% responses missing". As for the subsections, up to 10% of the answers may be omitted.

4.4.5 The ASH Scoring Program©

After data was collected through the ASH, it was transferred to the ASH *Scoring Program©*, the program that is provided by the Spiral Foundation for scoring purposes and is included when purchasing the ASH. Once a person had completed the questionnaire, I copied the responses into the program after which a report form could be generated automatically. On these report forms results are shown in standard scores which, at the choice of the administrator, may be displayed as z-

[42] These aspects were discussed in Chapter 2.

scores or scaled scores[43]. I decided to use z-scores since they are frequently indicated in this manner (Pietersen & Maree, 2007:194). Z-scores indicate the number of standard deviations above or below the mean (Rumsey, 2010:47). The reason for using standard scores is that a person's score can be viewed in relation to other people's scores instead of merely looking at the person's raw score (in other words, individual score) which does not carry much meaning on its own (Pietersen & Maree, 2007:194).

I used standard z-scores on all report forms throughout. Figure 4-2 shows an example of a report form containing these scores. All terms used on the report were explained in Chapter 2 under "Senses", "Sensory processing" and "Sensory processing disorder".

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[43] The ASH *Scoring Program*©'s standard scores are indicated as standard Z-scores (m = 0.0, sd = ± 1) or standard scaled scores (m = 100, sd = ± 15) (May-Benson, 2015:19).

Spiral foundation — Sensory Processing Institute for Research and Learning

Adult/Adolescent Sensory History

Report Form

Teresa May-Benson, ScD, OTR/L, FAOTA

Name:	Anonymous	**Age:**	33 years, 1 months	**Completion Date:**	22/03/2016
Gender:	Male	**Form completed by:**	Self		
Race:	Caucasian	**Ethnicity:**			
Diagnoses:					

	Raw Score	z-scores	Interpretation
Total Score	378	-1.48	Mild
Sensory Section Subscores			
Visual-Spatial Processing	55	-0.73	Typical
Auditory & Language Processing	41	-1.91	Mild
Movement (Vestibular Processing)	61	-0.97	Typical
Taste & Smell	19	0.16	Typical
Touch (Tactile Processing)	84	-2.15	Definite
Proprioception	20	-0.50	Typical
Sensory Modulation & Discrimination Subscores			
Modulation	154	-1.91	Mild
Visual	32	-1.11	Mild
Auditory	28	-2.35	Definite
Vestibular	18	-0.46	Typical
Taste & Smell	9	0.52	Typical
Tactile	67	-2.28	Definite
Discrimination	130	-0.82	Typical
Visual	23	-0.17	Typical
Auditory	13	-0.72	Typical
Vestibular	43	-1.05	Mild
Taste & Smell	10	-0.37	Typical
Tactile	17	-1.04	Mild
Proprioceptive	24	-0.36	Typical

	Raw Score	z-scores	Interpretation
Functional Problem Subscores			
Sensory Seeking			
Visual Seeking/ Oculo-Motor	10	-0.62	Typical
Seeks Movement	11	-0.32	Typical
Seek Touch	10	-1.19	Mild
Sensory Over-Responsivity			
Discomfort with Imposed Touch	22	-2.43	Definite
Tactile-Related Hygeine	12	<-3.50	Definite
Discomfort with Water	15	-2.90	Definite
Atypical Pain Response	6	-0.53	Typical
Gravitational Insecurity	24	-0.97	Typical
Motor/Social Section Subscores			
Postural Control	24	-0.18	Typical
Motor Coordination	27	-1.26	Mild
Motor Planning	14	-1.14	Mild
Sequencing	13	-1.13	Mild
Oral Motor Planning	11	-0.41	Typical
Fine Motor	9	-0.14	Typical
Difficulties Driving a Car	5	0.47	Typical
Social/Emotional	47	-1.63	Mild
Withdrawn/Depressed	21	-1.40	Mild
Aggressive/Impulsive	21	-2.01	Definite
Anxious	5	0.44	Typical

Figure 4-2: ASH report form

Apart from the z-scores which are indicated on the report form, all scores are further classified as typical performance, mild difficulties or definite difficulties. May-Benson (2015:20) explains that typical performance, as found in 84% of people without disabilities, “represents normative scores which are above -1.0 standard deviations from the typical mean”. Mild difficulties on the other hand “represents normative scores which fall between -1.0 and -2.0 standard deviations below the typical mean” (May-Benson, 2015:19). May-Benson further asserts that with reference to musicians and the results of this study, mild difficulties include people who are more sensitive or alert than the typical person (T. May-Benson. Personal communication. 9 August 2018). The levels described here (typical performance, mild difficulties and definite difficulties) are illustrated in Figure 4-3. Figure 4-3 also shows that in terms of scaled scores, the higher the scaled score, the further the score leans towards the negative side, indicating a higher level of difficulty in a particular sensory area. Normative scores which fall -2.0 standard deviations or more below the typical mean indicate definite difficulty (May-Benson, 2015:19). In most cases, this indicates functional problems. She adds, however, that further assessment of the particular section and its subsections is often necessary in order to confirm dysfunction. With reference to SPD, a person who is able to function effectively by means of adaptive behaviour (despite a pattern of mild or even definite sensory processing difficulty) do not necessarily have a sensory processing dysfunction (Dunn, 2009:19; Lane et al., 2000:2).

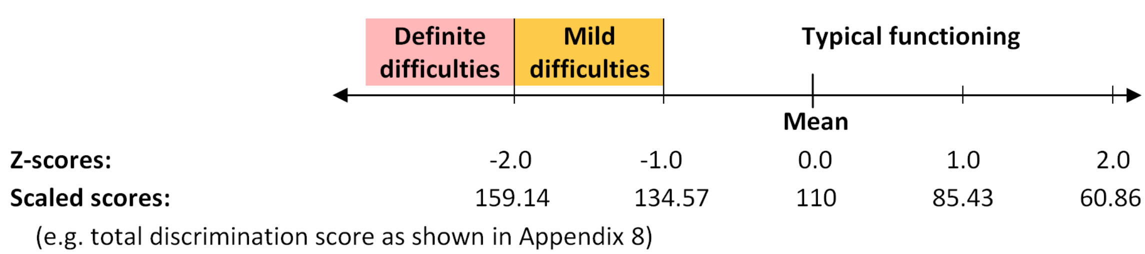

Figure 4-3: Z-scores and what they indicate in terms of the ASH report form

Before examining the hypotheses, the reliability of the measurements for the ASH was investigated. The internal consistency for the items of the respective subscales (visual and spatial; auditory and language; movement; taste and smell; proprioception; postural control; motor coordination and social/emotional) was calculated by means of the Cronbach’s α-coefficients with SPSS computer software (SPSS Incorporated, 2015). This is shown in Table 4-5.

Table 4-5: Alpha coefficients for the ASH subscales

Subscale	α coefficient
Visual and spatial	.813
Auditory and language	.863
Movement (vestibular)	.835
Taste and smell	.704
Touch (tactile)	.852
Proprioception	.867
Postural control	.656
Motor coordination	.844
Social/emotional	.816

From Table 4-5 it is clear that, with the exception of subscales "Postural control" and "Taste and smell" (with only acceptable coefficients), all other scales have good internally consistent measurement readings.

4.5 Validity

Validity refers to the trustworthiness of results (Maree & Pietersen, 2007a:151). There are two types of validity: internal validity and external validity. Internal validity has to do with "ensuring sufficient control over variables" (Maree & Pietersen, 2007a:151) and refers to "experimental procedures, treatments, or experiences of the participants" (Creswell, 2009:162). It is important to be aware of (and address) any threats to internal validity which may influence the researcher's abilty to draw a valid conclusion from the data that was gathered from a particular population.

There were four threats to the study's internal validity: selection, instrumentation, mortality and regression. In order to avoid selecting participants who have "certain characteristics that predispose them to have certain outcomes" (Creswell, 2009:163), I made use of random sampling. The same measure was taken to avoid regression, in other words selecting participants with extreme scores. Concerning mortality, in other words participants who fail to complete the experiment (questionnaire in this case), I recruited a large sample as suggested by Creswell (2009:163). Lastly, to ensure the reliablitity of instrumentation, it was decided to use the ASH which had already been examined for reliability and validity.

External validity refers to the degree to which results can be generalised (Maree & Pietersen, 2007:151). In this case, the target group was professional musicians who specialise in a particular musical instrument. In order to generalise the results to the entire musician population, musicians were recruited from across the world. Most of these musicians were recruited via Facebook. In terms of using Facebook as a reliable way to recruit participants, Grieve, Witteveen and Tolan (2014:532) found that "both social media [Facebook] and offline data were equivalent in terms of internal reliability and patterns of relationships among constructs. However, participants were more likely to report higher levels of ethical relativism when completing the measure via social media".

4.6 Ethical considerations

I followed all the necessary procedures as required by the University of the Free State. Ethical clearance was sought and granted (ethical clearance number: UFS-HSD2015/0500). In cases where orchestras and bands were approached, the necessary permission (and ethical clearance in one case) was obtained. Advertisements on Facebook pages and groups were in accordance with Facebook's *Pages, Groups and Events Policies* (Facebook, 2016:1).

In terms of participation, a letter of consent was included in both the online and hardcopy version of the questionnaire (refer to Appendix 7). In this letter, participants were informed of various aspects pertaining to the study. These included the purpose of the study, the criteria for participation, the length of the questionnaires[44], that participation was voluntary and that they were free to withdraw at any point. Participants were assured that their identity and information would be treated with great care and confidentiality. If they so preferred, they were also provided with the option to use a pseudonym. Furthermore, the contact details of the university's research co-ordinator and the supervisors were provided should any concern arise regarding the way in which the research was being conducted or about the rights of participants. It was explained that no risks were involved and that no remuneration was offered.

[44] As explained in Footnote 3, there were initially two questionnaires.

However, participants were notified that in exchange for participation, they could have the report form showing their results. They were also given an option to receive the findings of the study. Only a small number of participants were not interested in knowing the outcome of their results and in these cases, report forms were not emailed to them. In cases where participants' overall results showed definite difficulty, or where participants had questions which extended beyond my field of expertise, they were advised to consult an occupational therapist who is trained to make a diagnosis or do further assessment based on the report. It was also made known that the results of the study would be shared with them should they be interested.

Lastly, all paper-based questionnaires that were completed were stored in a safe place. These questionnaires will remain in safe keeping for three years as stipulated by the University of the Free State. Once this period has expired, the questionnaires will be destroyed. Online data is stored in Dropbox and is password protected. In addition, Dropbox offers secure cloud storage which "is designed with multiple layers of protection, distributed across a scalable, secure infrastructure" (Dropbox, 2018:1). Following this account of ethical considerations, the statistical procedures which were used are discussed next.

4.7 Statistical procedures

To investigate the research hypotheses, the average scores of the different variables were compared. In all cases, One-Way MANOVAs were done (one independent and several dependent variables are applicable) to determine whether significant differences occurred in the mean scores. If a significant *F*-value (according to the Hotelling-Lawley test statistic) was found, one-way analyses of variance (ANOVA) were used to determine which of the dependent variables had significant differences among their means. If the independent variable (instrument group and type of instrument) consisted of more than two categories, the Scheffé post hoc *t*-test was used to determine between which of these groups differences occur (Howell, 2013).

It was important to firstly investigate whether the data complied with the assumptions when a MANOVA was used. To comply with the assumption of independence of observations, participants were recruited from across the globe and a stringent alpha level (e.g. $p < .01$) was applied during the analyses of the data. With regard to the second assumption dealing with unexpected values, the data set was investigated for extreme values. No substantial deviations were found. This was followed by calculating the kurtosis and skewness quotients for all the scales. The scale of which the skewness was > |2| and/or the kurtosis > |4|, were identified and excluded from further analyses as they were deemed unsuitable for factor analysis. The last assumption, namely the homogeneity of variances, is discussed together with the results of the MANOVA. To investigate this assumption the Levene's Test (for variances) was utilised.

Furthermore, in order to comment on the meaningfulness of statistically significant results that could arise following the investigation, the practical significance of the results was also examined. As measure of practical significance, effect sizes (Steyn, 1999) were calculated. During the comparison of more than two population means (as with research hypothesis 1 and 3), one-way variance analyses were performed in which case the following guideline values (f) was used: 0.1 = small effect; 0.25 = medium effect and 0.4 = large effect.

The 1% level of significance was used in this study. Only results that tend to medium (0.2 or larger) to big effect sizes are discussed in more detail. The SPSS computer software (SPSS Incorporated, 2016) was used to perform these analyses.

4.8 Summary

This chapter explained the methodology that was followed to address the research questions. The research design provided a framework for the study which included an explanation of different research designs and reasons for choosing a quantitative non-experimental criterion group research design with a questionnaire as method of data collection. Following the research design, the research objectives and hypotheses where discussed after which a detailed account was given of how data was collected. This involved a delineation of sampling, the participants, procedures, the ASH which was used as measuring instrument, as well as the ASH Scoring Program©. Next, a description of the steps that were taken to ensure internal and external validity were discussed. The same applied to ethical considerations. Lastly, the statistical procedures which were implemented to conduct data analysis in the following chapter were explained.

CHAPTER 5

DATA ANALYSIS

5.1 Introduction

This chapter systematically presents a detailed quantitative analysis of the data that was collected by means of the ASH (*Adult/Adolescent Sensory History*). It is divided into the respective hypotheses. The first hypothesis deals with the modulation and discrimination variables, after which hypothesis 2 examines the functional problem variable. Lastly, hypothesis 3 investigates the motor/social components. Each of these hypotheses is considered in terms of the main research question and its three sub-questions. For reference, the research hypotheses are stated below:

Research hypothesis 1

There are significant differences concerning the average **modulation and discrimination** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

Research hypothesis 2

There are significant differences concerning the average **functional problem** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

Research hypothesis 3

There are significant differences concerning the average **motor/social component** variable scores for:

(a) musicians who play a particular instrument in comparison to other musicians
(b) different instrument groups
(c) musicians within each particular instrument group
(d) gender within each particular instrument group.

For each of these hypotheses, a detailed analysis was done. Each of these hypotheses is tested and discussed in the sections below.

5.2 Modulation and discrimination

This section addressing hypothesis 1 analyses modulation[45] and discrimination[46] in terms of the three hypotheses. Descriptive statistics are first provided after which a comparison is respectively drawn between the 19 instruments, different instrument groups, and then type of instrument and gender within each of the instrument groups.

5.2.1 Descriptive statistics

Table 5-1 shows the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the modulation and discrimination variables for the whole group of participants. Both the modulation and discrimination variables are divided into the following sensory components: auditory, proprioceptive, tactile, taste and smell, vestibular, and visual. Columns 7 and 8 of Table 5-1 are provided to further determine if the data complies with the assumption of extreme values (refer to paragraph 2 under "Statistical procedures" in Chapter 4). The *p*-values of the Levene's Test for homogeneity of variances are reported in the last column.

[45] Process by which the brain integrates sensory information with previous information, memories and knowledge in order to execute a suitable response.
[46] The ability to distinguish and interpret different sensory qualities.

Table 5-1: Descriptive statistics regarding the modulation and discrimination variables for the total group

Variables	N	Minimum	Maximum	$\overline{X}$	SD	Skew-ness	Kurtosis	Levene's *p*-value
Discrimination								
Auditory	1327	5	25	13.76	3.86	.113	-.254	.102
Proprioceptive	1327	12	50	26.64	6.90	.387	.119	.397
Tactile	1326	9	37	17.95	4.46	.351	.461	.811
Taste and smell	1327	5	22	11.07	2.84	.164	-.045	.083
Vestibular	1327	21	91	40.66	10.03	.789	1.107	.945
Visual	1327	15	60	27.33	7.44	.793	1.085	.788
Total	**1327**	**69**	**255**	**137.42**	**25.82**	**.485**	**.827**	**.940**
Modulation								
Auditory	1327	7	35	22.31	5.75	-.012	-.367	.766
Tactile	1327	24	102	56.33	12.25	.218	.143	.763
Taste and smell	1327	6	30	13.47	3.87	.632	.692	.001
Vestibular	1327	7	35	17.77	5.72	.269	-.347	.613
Visual	1326	17	61	35.35	6.52	.200	.079	.104
Total	**1327**	**70**	**242**	**145.22**	**24.00**	**.182**	**.234**	**.663**

Table 5-1 clearly shows that no unusual values emerged. Both the skewness and kurtosis indexes fall within the limits for all the variables concerned. Thus, it can be assumed that the data relating to these specific variables distribute normally for the entire group.

5.2.2 Comparison of 19 different instruments

Research hypothesis 1(a) was investigated by comparing the 19 group playing different musical instruments' average modulation and discrimination scores using a one-way multivariate variance analysis (MANOVA). As indicated in paragraph 2 of "Statistical procedures" in Chapter 4, it is important to test the homogeneity of variances between the five instrument groups before conducting a MANOVA. As multivariate test, the Hotelling Trace was used and the following result, namely ($F_{198;14236}$ = 1.710; p = 0.000; f = 0.15) was obtained. This result indicates that the differences on the 1% level are significant and that the result has a small to medium effect size. In order to determine for which of the dependent variables there are significant differences in the average scores for the five groups, one-way variance analyses (ANOVA) were done. The latter procedure firstly provides an indication of which dependent variables exhibit significant differences and secondly, for which groups (using the Scheffé test) these differences occur. Table 5-2 indicates the sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size for the modulation and discrimination variables for the 19 different instruments

Table 5-2: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size on modulation and discrimination variables for the 19 different instruments

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Discrimination						
Auditory	117.37	18	6.52	0.434	0.981	
Proprioceptive	951.55	18	52.86	1.110	0.336	
Tactile	4691.33	18	22.57	1.138	0.308	
Taste and smell	154.54	18	8.59	1.072	0.375	
Total	7571.75	18	420.65	0.629	0.880	
Vestibular	2754.14	18	153.01	1.535	0.070	
Visual	835.58	18	46.42	0.836	0.659	
Modulation						
Auditory	1960.12	18	108.90	3.407*	0.000	0.21
Tactile	4691.33	18	260.63	1.759	0.025	
Taste and smell	323.19	18	17.96	1.206	0.247	
Total	20958.86	18	1164.38	2.056	0.006	
Vestibular	1859.67	18	103.32	3.252*	0.000	0.21
Visual	1755.15	18	97.51	2.335*	0.001	0.18

* $p \leq = 0.001$ (Bonferroni correction)

F-values significant at the 1% level were found for three of the modulation variables (auditory, vestibular and visual) so that null hypothesis can be rejected in these cases. The corresponding effect sizes indicate that all three variables show a medium effect size. The Scheffé test was used to determine specific differences. The means and standard deviations for the 19 respective instrument groups for the auditory modulation variable are provided in Table 5-3.

Table 5-3: Means and standard deviations for the 19 different instruments in terms of auditory modulation

Instrument	N	$\overline{X}$	SD
Bassoon	73	22.70	5.32
Cello	69	23.29	5.67
Clarinet	75	22.83	5.94
Double bass	66	22.98	4.84
Harp	66	22.65	5.82
Flute	74	22.72	5.77
French horn	75	22.49	5.21
Classical/nylon string guitar	79	22.42	5.18
Electric/steel string guitar	51	22.53	6.45
Oboe	73	22.71	5.78
Organ	68	22.87	6.32
Percussion	73	20.27	5.57
Piano	76	24.16	5.19
Saxophone	54	21.41	6.02
Trombone	72	19.63	5.90
Trumpet	80	20.65	6.16
Tuba	66	20.64	5.87
Viola	67	22.63	4.66
Violin	68	24.18	5.70

The ASH's typical range for auditory modulation is between 10.19 and 20.81.[47] Scores below 10.19 merely indicate they are further into the typical range. On the other hand, scores above 20.81 indicate possible mild auditory modulation difficulties. However, in the case of musicians, this might rather point towards sensitivity than difficulties per se. The ASH's mean scores, standard deviations and typical ranges are shown in Appendix 8. Except for percussion, trombone, trumpet and tuba, all intruments' means are above the normal range of the standard population, but within the mild difficulties range.

The Scheffé test results are shown in the next table. Due to the large variety of musicians (19 groups) comparing the statistically significant averages, they are presented in tabular form. Table 5-4 indicates the information regarding auditory modulation for the groups that achieved significant differences in means.

[47] In terms of statistical analysis, scaled scores were used. As explained under "The ASH *Scoring Program©*" in Chapter 4, the higher the scaled score, the higher the chances of sensory difficulty in a particular sensory area.

Table 5-4: Comparison of musicians with regard to auditory modulation

Group 1	Group 2	Interpretation
Trombone Percussion	Bassoon Cello Clarinet Double bass Harp Flute French horn Classical/nylon string guitar Electric/steel string guitar Oboe Organ Piano Viola Violin	Group 1 musicians achieve significantly **lower** average scores for auditory modulation than Group 2 musicians
Piano Violin	Saxophone Trumpet Tuba	Group 1 musicians achieve significantly **higher** average scores for auditory modulation than Group 2 musicians

Although there is a significant difference between some of these instruments, differences need to be considered inconjuction with the ASH's ranges: typical performance (above -1.0 standard deviations from the typical mean), mild difficulties (between -1.0 and -2.0 standard deviations below the typical mean) and definite difficulties (below -2.0 standard deviations from the typical mean).

The next analysis involved a comparison between the different instruments in terms of vestibular modulation. Table 5-5 provides the means and standard deviations for the 19 respective groups of instruments for the vestibular modulation variable.

Table 5-5: Means and standard deviations for the 19 different instruments in terms of vestibular modulation

Instrument	N	$\overline{X}$	SD
Bassoon	73	18.08	6.40
Cello	69	18.49	5.84
Clarinet	75	18.24	5.77
Double bass	66	17.36	5.92
Harp	66	19.39	5.84
Flute	74	18.78	5.21
French horn	75	18.53	5.34
Classical/nylon string guitar	79	18.32	5.21
Electric/steel string guitar	51	16.37	5.86
Oboe	73	17.93	5.11
Organ	68	17.51	5.32
Percussion	73	15.88	5.81
Piano	76	18.26	5.51
Saxophone	54	17.93	5.12
Trombone	72	15.88	5.44
Trumpet	80	15.65	5.27
Tuba	66	16.21	6.27
Viola	67	19.43	5.99
Violin	68	19.10	5.80

Although there are significant differences between these groups of instrumentalists regarding their vestibular modulation, all scores fall within the ASH's typical range (10.01 – 20.99) of the standard population. Nonetheless, Table 5-6 shows the information regarding vestibular modulation for the groups that have achieved significant differences in means.

Table 5-6: Comparison of musicians with regard to vestibular modulation

Group 1	Group 2	Interpretation
Percussion Trombone Trumpet	Cello Clarinet Harp Flute French horn Classical/nylon string guitar Piano Viola Violin	Group 1 musicians achieve significantly **lower** average scores for vestibular modulation than Group 2 musicians

Group 1	Group 2	Interpretation
Electric/steel string guitar Tuba	Harp Flute Viola Violin	Group 1 musicians achieve significantly **lower** average scores for vestibular modulation than Group 2 musicians
Tuba	Cello French horn	Group 1 musicians achieve significantly **lower** average scores for vestibular modulation than Group 2 musicians
Trumpet	Bassoon Oboe Saxophone	Group 1 musicians achieve significantly **lower** average scores for vestibular modulation than Group 2 musicians

Next, the different instrument groups' visual modulation is analysed. Table 5-7 shows the means and standard deviations for the 19 respective instrument groups as far as the visual modulation variable is concerned.

Table 5-7: Means and standard deviations for the 19 different instruments in terms of visual modulation

Instrument	N	$\overline{X}$	SD
Bassoon	73	35.85	5.43
Cello	69	35.26	6.76
Clarinet	75	35.43	6.02
Double bass	66	35.74	6.56
Harp	66	32.94	6.29
Flute	74	34.16	6.40
French horn	75	34.36	6.33
Classical/nylon string guitar	79	37.51	6.57
Electric/steel string guitar	51	37.24	6.60
Oboe	73	34.58	6.33
Organ	68	35.47	7.16
Percussion	73	37.07	7.26
Piano	76	34.11	7.27
Saxophone	54	35.91	6.84
Trombone	72	34.86	5.78
Trumpet	80	36.51	6.27
Tuba	66	35.61	6.36
Viola	67	34.99	5.93
Violin	68	34.25	6.37

The typical range of the standard population for visual modulation is between 19.05 and 31.35. It is therefore significant that all 19 groups of muscians scored above this range. Table 5-8 indicates the information regarding visual modulation for the groups that achieved significant differences in means.

Table 5-8: Comparison of musicians with regard to visual modulation

Group 1	**Group 2**	**Interpretation**
Classical/nylon string guitar Electric/steel string guitar Percussion	Harp Flute French horn Piano Violin	Group 1 musicians achieve significantly **higher** average scores for visual modulation than Group 2 musicians
Classical/nylon string guitar Electric/steel string guitar	Oboe	Group 1 musicians achieve significantly **higher** average scores for visual modulation than Group 2 musicians
Classical/nylon string guitar	Trombone	Group 1 musicians achieve significantly **higher** average scores for visual modulation than Group 2 musicians
Trombone	Bassoon Double bass Saxophone Trumpet Tuba	Group 1 musicians achieve significantly **lower** average scores for visual modulation than Group 2 musicians

5.2.3 Comparison of instrument groups

In order to investigate research hypothesis 1(b), the five instrument groups were compared in terms of the modulation and discrimination variables. The Levene's Test has consequently been employed. (The *p*-values of the Levene's Test were shown in Table 5-1 under 5.2.1, descriptive statistics.) With the exception of the modulation of taste and smell ($p = 0.001$), none of the variables shows significant differences in variances for the five groups. With respect to the modulation of taste and smell, the percussion group emerged with a significantly higher standard deviation than the other four groups. Consequently, the result of this variable must be interpreted with greater circumspection.

The next step involved the testing of research hypothesis 1(b). This was done by comparing the average modulation and discrimination scores of the five instrument groups (woodwinds, brass, percussion, strings and keyboards) using a one-way multivariate variance analysis (MANOVA). The Hotelling Trace was used as multivariate test. Following this procedure, the following result was obtained: ($F_{44;5234}$ = 3.246; p = 0.000; f = 0.20). This indicates that the differences on the 1% level are significant and that the result has a small effect size. In order to determine for which dependent variables there are significant differences among the means for the five groups, one-way analyses of variance (ANOVA) were done. The latter procedure firstly provided an indication of which dependent variables show significant differences and secondly, for which groups these differences occur by means of using the Scheffé test. Table 5-9 shows the sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size on modulation and discrimination variables for the total group.

Table 5-9: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size on modulation and discrimination variables for the total group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Discrimination						
Auditory	21.79	4	5.45	0.365	0.834	-
Proprioceptive	402.67	4	100.67	2.117	0.076	-
Tactile	100.97	4	25.24	1.271	0.279	-
Taste and smell	44.40	4	11.10	1.387	0.236	-
Vestibular	1396.38	4	349.09	3.503*	0.007	0.10
Visual	170.58	4	42.65	0.770	0.545	-
Total	**1591.87**	**4**	**397.97**	**0.597**	**0.665**	**-**
Modulation						
Auditory	1347.36	4	336.84	10.498*	0.000	0.21
Tactile	2394.99	4	598.75	4.036*	0.003	0.11
Taste and smell	225.38	4	56.35	3.806*	0.004	0.10
Vestibular	952.18	4	238.04	7.411*	0.000	0.15
Visual	283.99	4	71.00	1.673	0.154	-
Total	**13768.60**	**4**	**3442.15**	**6.085***	**0.000**	**0.13**

* p ≤ = 0.01

F-values significant at the 1% level were found for the vestibular discrimination variables, as well as for five of the modulation variables (auditory, tactile, taste, vestibular and total). Consequently, the null hypothesis could be rejected in all these cases. Although the *F*-values produced statistically significant results, the effect sizes indicated that for only one variable (auditory modulation) a medium effect size was obtained. The other statistically significant results show small effect sizes. Consequently, only the result with a medium effect size was further investigated. In order to determine specific differences, the Scheffé test was used. Table 5-10 indicates the means and standard deviations for the auditory modulation variable among the five respective instrument groups.

Table 5-10: Means and standard deviations for the five instrument groups: auditory modulation

Instrument group	N	$\overline{X}$	SD
Woodwinds	350	22.54	5.74
Brass	293	20.87	5.86
Percussion	73	20.27	5.57
Keyboards	145	23.59	5.77
Strings	466	22.96	5.46

The Scheffé test results indicate that as far as the brass and percussion groups are concerned, no significant differences emerged in terms of the auditory modulation scores. Secondly, it was found that for both groups the average auditory modulation scores differed in terms of means from the three remaining groups (woodwinds, strings and keyboards).

It is apparent from Table 5-10 that the brass and percussion groups achieved a significantly lower mean score in terms of auditory modulation than the other three groups. In terms of the ASH, this indicates that the percussion groups' auditory modulation is at the high end of the norm, while the brass group is just above the norm. The woodwind, keyboard and string players' auditory modulation is further away from the norm, enhancing the chances of modulation difficulty or sensitivity.

Following this analysis, musicians playing a particular instrument within each instrument group were compared in terms of modulation and discrimination variables. These results are presented and discussed in the next section.

5.2.4 Comparison of type of instrument and gender within each particular instrument group

Research hypothesis 1(c) and (d) was investigated by determining whether significant differences emerged regarding the average modulation and discrimination variables scores concerning the type of instrument and/or gender within each instrument group. (Table 4-3 of Chapter 4 shows the instrument groups and the instruments within each group.) However, the percussion group is not included in the comparison with regard to type of instrument or gender. This is due to the fact that the drum kit and orchestral percussion were classified as “the same instrument” in this study and only a very small group of females participated. As a result, meaningful analysis could not be conducted. Nonetheless, the results for the other four groups are presented and discussed below.

5.2.4.1 Woodwinds

Table 5-11 shows the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis; as well as the Levene's Test probability values (*p*) for the modulation and discrimination variables in terms of the woodwinds group. The latter values are indicated separately for the two independent variables (type of instrument and gender).

Table 5-11: Descriptive statistics regarding the modulation and discrimination variables for the woodwind group

Variables	N	Min	Max	$\overline{X}$	SD	Skewness	Kurtosis	Levene's *p*-value	
								Gender	Instr[48]
Discrimination									
Auditory	350	5	25	13.95	4.01	.021	-.469	.317	.936
Proprioceptive	350	12	50	26.95	6.98	.296	-.214	.008	.001
Tactile	350	9	32	18.19	4.36	.269	.049	.202	.934
Taste and smell	350	5	22	11.33	2.88	.323	.127	.463	.928
Vestibular	350	21	89	41.34	10.12	.891	1.099	.143	.196
Visual	350	15	59	27.09	7.24	.588	.392	.604	.382
Total	**350**	**83**	**247**	**138.83**	**25.69**	**.430**	**.483**	**.173**	**.552**

48 Instrument.

Variables	N	Min	Max	$\overline{X}$	SD	Skewness	Kurtosis	Levene's *p*-value	
								Gender	Instr
Modulation									
Auditory	350	7	35	22.54	5.74	-.122	-.371	.548	.838
Tactile	350	31	102	57.40	12.16	.461	.332	.201	.514
Taste and smell	350	6	27	13.86	3.95	.432	.205	.748	.979
Vestibular	350	7	35	18.21	5.54	.367	-.059	.173	.436
Visual	349	19	61	35.14	6.19	.246	.679	.799	.736
Total	**350**	**93**	**234**	**147.11**	**23.65**	**.436**	**.598**	**.734**	**.823**

From the data which is presented in Table 5-11, it is clear that no unusual values occur. Furthermore, it is evident that the skewness and kurtosis values for the woodwind group fall within the limits for all variables. It can therefore be assumed that data relating to all these variables for the woodwind group distribute normally. As a result it complies with the assumption that there are no extreme values and that the data is not distributed exceptionally askew. In addition, it is evident that in terms of the ASH[49], all discrimination mean scores are at the high end of the typical range of the standard population. As far as modulation is concerned, vestibular modulation is the only variable which falls within the typical range (high end thereof). All other modulation variables are at the low end of the mild difficulties range, with visual modulation being the closest to the middle of the mild difficulties range.

The homogeneity of variances for gender, along with type of instrument (flute, oboe, clarinet, bassoon and saxophone) was also investigated. To achieve this, the Levene's Test was utilised. The *p*-values of the Levene's Test are shown in the last two columns of Table 5-11. With the exception of proprioceptive discrimination (gender: $p = 0.008$, and type of instrument: $p = 0.001$), none of the other variables show significant differences in variances. In terms of proprioceptive discrimination, the female woodwind players show a significantly higher standard deviation than the male woodwind players. In terms of instrument type, the clarinetists show a significantly higher standard deviation compared to other instrument players. The results of this variable must therefore be interpreted with greater circumspection. A multivariate variance analysis (MANOVA) was performed, while the Hotelling Trace served as multivariate test. The results are shown in Table 5-12.

[49] Appendix 7 indicates the mean scores and standard deviations of the ASH.

Table 5-12: MANOVA results with type of instrument and gender as independent variables for the woodwind group

Independent variable	*F*	df	*p*	*f*
Type of instrument	0.851	44; 1330	0.744	-
Gender	6.116	11; 337	0.000	0.41

* p ≤ = 0.01

Regarding modulation and discrimination variables, Table 5-12 shows that no significant differences occur within the woodwind group concerning type of instrument and gender. In this case, the null hypothesis is therefore retained. In terms of gender, the result ($F_{11;337}$ = 6.116; p = 0.000; f = 0.41) indicates that at the 1% level significant differences between the variables occur and thus the null hypothesis can be rejected. In this case, the result produces a large effect size which indicates that the finding is of great practical importance. In order to determine for which of the dependent variables there are significant differences in means with regard to gender, one-way analyses of variance (ANOVA) were done. The results are presented in Table 5-13. Since only two groups are in question, no post hoc *t*-tests were performed.

Table 5-13: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding modulation and discrimination variables for gender in the woodwind group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Discrimination						
Auditory	2.91	1	2.91	0.182	0.670	-
Proprioceptive	655.05	1	655.05	13.911*	0.000	0.20
Tactile	5.03	1	5.03	0.266	0.607	-
Taste and smell	4.20	1	4.20	0.510	0.476	-
Vestibular	707.96	1	707.96	7.031*	0.008	0.14
Visual	40.15	1	40.15	0.769	0.381	-
Total	**2347.58.9**	**1**	**2347.58.9**	**3.605**	**0.058**	
Modulation						
Auditory	52.14	1	52.14	1.588	0.208	-
Tactile	223.58	1	223.58	1.527	0.217	-
Taste and smell	82.78	1	82.78	5.413	0.021	-
Vestibular	814.64	1	814.64	28.597*	0.000	0.21
Visual	206.92	1	206.92	5.474	0.020	-
Total	**2064.88**	**1**	**2064.88**	**3.745**	**0.054**	**-**

* p ≤ = 0.01

F-values significant at the 1% level were found for the proprioceptive and vestibular discrimination variables, as well as for the vestibular modulation variables. Consequently, the null hypothesis could be rejected in all three cases. Although the *F*-values yielded statistically significant results, the effect sizes indicate that for only two of the variables (proprioceptive discrimination and vestibular modulation) a medium effect sizes were obtained. Thus, only results with a medium effect size are further investigated. The means of the two genders in the woodwind group are provided in Table 5-14.

Table 5-14: Means and standard deviations for gender in the woodwind group regarding variables proprioceptive discrimination and vestibular modulation

Variables	**Males**			**Females**		
	N	$\overline{X}$	***SD***	**N**	$\overline{X}$	**SD**
Proprioceptive discrimination	123	25.11	6.07	266	27.97	7.26
Vestibular modulation	123	16.14	4.83	266	19.34	5.60

The data presented in Table 5-14 clearly shows that for both variables, the female woodwind players achieved a significant higher average score in comparison to the males. Although the females' proprioceptive discrimination and vestibular modulation scores are at the high end of typical functioning, both genders' proprioceptive discrimination scores fall within the typical range of the standard population.

5.2.4.2 Brass

In this section, possible differences for the brass groups' modulation and discrimination variables are investigated regarding the type of instrument and gender. Table 5-15 presents the brass player's means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the modulation and discrimination variables. The latter values are indicated separately for the two independent variables namely type of instrument and gender.

Table 5-15: Descriptive statistics regarding the modulation and discrimination variables for the brass group

Variables	N	Min	Max	$\overline{X}$	SD	Skewness	Kurtosis	Levene's *p*-value	
								Gender	Instr
Discrimination									
Auditory	293	5	24	13.74	3.77	.003	-.263	.964	.780
Proprioceptive	293	12	50	26.93	7.08	.335	.163	.330	.203
Tactile	293	9	37	17.98	4.62	.320	.639	.695	.596
Taste and smell	293	5	19	11.12	2.88	.049	-.197	.565	.501
Vestibular	293	21	81	39.10	9.70	.974	1.509	.462	.751
Visual	293	15	59	27.03	7.16	.791	1.105	.902	.291
Total	**293**	**69**	**255**	**135.89**	**26.43**	**.677**	**1.874**	**.461**	**.775**
Modulation									
Auditory	293	7	35	20.87	5.86	.165	-.253	.756	.298
Tactile	293	24	96	54.00	12.56	.274	.358	.459	.793
Taste and smell	293	6	30	12.76	3.54	.764	1.691	.638	.807
Vestibular	293	7	34	16.57	5.66	.356	-.347	.291	.113
Visual	293	17	50	35.35	6.21	.038	-.382	.219	.917
Total	**293**	**70**	**242**	**139.55**	**24.58**	**.255**	**.559**	**.907**	**.896**

It is evident that no unusual values occur in Table 5-15. Both the skewness and kurtosis values for the brass group fall within the limits for all variables. Thus, it can be assumed that data distributes normally considering these variables within the brass group. It can also be assumed that the data complies with the assumption that no extreme values occur and that data distribution is even. Furthermore, it is clear that tactile discrimination is the only discrimination variable which are at the bottom end of the ASH's mild difficulties range. All other variables are at the high end of the typical range. Concerning modulation, the auditory, tactile and visual variables are at the low end of mild difficulties, while both the taste and smell, and vestibular modulation variables are at the high end of the typical range.

The homogeneity of variances for type of instrument and gender within the brass group was also investigated. The *p*-values of the Levene's Test show that none of the variables indicate significant differences in variances with regard to either gender or the five instrument groups. It can therefore be accepted that it complies with the assumption of homogeneity of variances. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-16.

Table 5-16: MANOVA results with the type of instrument and gender as independent variables for the brass group

Independent variable	*F*	df	*p*	*f*
Type of instrument	1.814	33; 833	0.004	0.26
Gender	4.993	11; 281	0.000	0.40

* p ≤ = 0.01

Table 5-16 shows that in terms of type of instrument and gender there are significant differences regarding the modulation and discrimination variables within the brass group. This finding applies to musicians playing different brass instruments (French horn, trumpet, trombone and tuba) ($F_{11;337}$ = 1.814; p = 0.004; f = 0.26), as well as to gender ($F_{11;337}$ = 6.116; p = 0.000; f = 0.41). Both results are significant at the 1% level and the corresponding effect sizes indicate that the respective result are of either medium or great practical importance. In both cases, the null hypothesis can therefore be rejected.

In order to determine for which of the dependent variables there are significant differences in means for the type of instrument and gender distribution in the brass group, one-way analyses of variance (ANOVA) were done. These results are respectively shown in Tables 5-17 and 5-19. (Table 5-19 follows after further analysis in Table 5-18.)

Table 5-17: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding modulation and discrimination variables for the brass group's four types of instruments

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Discrimination						
Auditory	45.24	3	15.08	1.063	0.365	-
Proprioceptive	237.29	3	79.10	1.589	0.192	-
Tactile	134.54	3	44.84	2.125	0.097	-
Taste and smell	17.86	3	5.95	0.713	0.545	-
Vestibular	516.91	3	172.30	1.848	0.139	-
Visual	108.15	3	36.05	0.700	0.552	-
Total	**3274.89**	**3**	**1091.63**	**1.572**	**0.196**	**-**

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Modulation						
Auditory	316.71	3	105.57	3.142	0.026	-
Tactile	612.98	3	204.33	1.299	0.275	-
Taste and smell	42.82	3	14.27	1.144	0.332	-
Vestibular	400.04	3	133.35	4.303*	0.005	0.23
Visual	203.16	3	67.72	1.768	0.153	-
Total	**3143.44**	**3**	**1047.81**	**1.747**	**0.157**	**-**

* p ≤ = 0.01

At the 1% level, only vestibular modulation variables showed significant differences for the type of instrument (within brass group) so that the null hypothesis could be rejected in this specific case. The result shows a medium effect size and can therefore be considered to be of practical importance. The averages of the four types of instruments of the brass group are provided in Table 5-18. As there are four groups involved, the Scheffé test was used to determine particular differences.

Table 5-18: Means and standard deviations for the four types of instruments in the brass group regarding vestibular modulation

Variables	Vestibular modulation		
	N	$\overline{X}$	SD
French horn	75	18.53	5.34
Trumpet	80	15.65	5.27
Trombone	72	15.88	5.44
Tuba	66	16.21	6.26

According to the Scheffé results, there are no significant differences in the average vestibular modulation score for the French horn and Tuba players. However, significant differences in means are evident between French horn players and the trumpeters as well as those playing the French horn and trombone. Although this appears to be a significant result, all four instruments' scores fall within the typical range of the norm with French horn being at its high end. Next, one-way variance analysis with gender as the independent variable was conducted for the brass group. The results are shown in Table 5-19.

Table 5-19: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding modulation and discrimination variables for gender in the brass group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Discrimination						
Auditory	1.19	1	1.19	0.084	0.772	-
Proprioceptive	580.45	1	580.45	12.026*	0.001	0.20
Tactile	0.824	1	0.824	0.038	0.845	-
Taste and smell	5.75	1	5.75	0.690	0.407	-
Vestibular	2141.32	1	2141.32	24.602*	0.000	0.28
Visual	0.007	1	0.007	0.000	0.991	-
Total	**5577.43**	**1**	**5577.43**	**8.181***	**0.005**	**0.14**
Modulation						
Auditory	271.96	1	271.96	8.112*	0.005	0.14
Tactile	1872.23	1	1872.23	12.330*	0.001	0.20
Taste and smell	38.35	1	38.35	3.090	0.080	-
Vestibular	271.37	1	271.37	8.693*	0.003	0.17
Visual	8.21	1	8.21	0.000	0.999	-
Total	**6792.65**	**1**	**6792.65**	**11.651***	**0.001**	**0.19**

* $p \leq = 0.01$

F-values that are significant at the 1% level are found for three of the discrimination variables (proprioceptive, vestibular and total score) and four of the modulation variables (auditory, tactile, vestibular and total modulation score) and therefore the null hypothesis can be rejected in these cases. Although the *F-values* yield statistically significant results, small effect sizes were obtained for three of the variables (discrimination total, auditory modulation, and vestibular modulation) and will therefore not be discussed further. The means for gender among the brass players for variables of which medium effect sizes were obtained are provided in Table 5-20.

Table 5-20: Means and standard deviations for gender among the brass players regarding proprioceptive discrimination, vestibular discrimination, tactile modulation and modulation total

Variables	Male			Female		
	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Proprioceptive discrimination	216	26.09	6.69	77	29.29	7.62
Vestibular discrimination	216	37.48	9.22	77	43.62	9.63
Tactile modulation	216	52.49	12.58	77	58.23	11.56
Modulation total	216	136.67	24.45	77	147.61	23.25

It is clear from Table 5-20 that the female brass players obtained significantly higher scores than the males for all four variables. For all four variables, the females' scores are slightly higher than the standard population. This analysis indicates that in comparison to the average person, female brass players have slight proprioceptive and vestibular discrimination difficulty. On the other hand, they demonstrated increased sensitivity to tactile modulation, as well as overall modulation.

5.2.4.3 Strings

In this section, possible differences in the modulation and discrimination variables for strings players are investigated with reference to the instrument they play, as well as their gender. Table 5-21 indicates the string player's means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the modulation and discrimination variables. The latter values are indicated separately for the two independent variables (type of instrument and gender).

Table 5-21: Descriptive statistics regarding the modulation and discrimination variables for the string group

Variables	N	Min	Max	$\overline{X}$	SD	Skewness	Kurtosis	Levene's *p*-value	
								Gender	Instr
Discrimination									
Auditory	466	5	24	13.66	3.82	.242	.043	.855	.274
Proprioceptive	466	12	50	26.70	6.98	.459	.248	.035	.159
Tactile	466	9	34	17.99	4.44	.431	.602	.795	.971
Taste and smell	466	5	19	10.92	2.78	.075	-.181	.372	.970
Vestibular	466	22	77	40.89	9.97	.477	.033	.822	.509
Visual	466	15	60	27.38	7.49	.817	1.035	.959	.215
Total	**466**	**71**	**247**	**137.55**	**25.76**	**.366**	**.496**	**.077**	**.989**
Modulation									
Auditory	466	7	35	22.96	5.46	-.064	-.222	.944	.068
Tactile	466	26	95	56.76	11.80	.223	.127	.310	.753
Taste and smell	466	6	29	13.49	3.75	.725	.938	.683	.556
Vestibular	466	7	35	18.42	5.81	.180	-.428	.260	.943
Visual	466	17	54	35.41	6.58	.131	-.330	.042	.990
Total	**466**	**88**	**220**	**147.05**	**23.12**	**.123**	**.064**	**.041**	**.421**

From the data that is presented in Table 5-21 it is evident that there are no unusual values. Both the skewness and kurtosis values fall within the limits for all the variables pertaining to the string players. Thus, it can be assumed that the data relating to these specific variables for the string group distributes normally and therefore complies with the assumption that no extreme values occur and that the data distributed fairly normally.

Additionally, it is apparent that in terms of the ASH's means, tactile discrimination is the only discrimination variable which is at the bottom end of the mild difficulties range. All other discrimination variables are at the high end of the typical range. Relating to modulation, the auditory, tactile and visual variables are at the low end of mild difficulties, while the taste, smell and vestibular modulation variables are at the high end of the typical range.

The Levene's Test was used to investigate homogeneity of variances between males and females (gender) and type of instrument (harp, violin, viola, cello, double bass, classical/nylon string guitar and electric/steel guitar) for this group. The *p*-values of the Levene's Test show that there are no significant differences in homogeneity of variances for either gender or the seven string instrument. For this reason, it complies with the assumption of homogeneity of variances. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-22.

Table 5-22: MANOVA results showing the type of instrument and gender as independent variables for the string group

Independent variable	***F***	**df**	***p***	***f***
Type of instrument	1.298	66; 2684	0.055	-
Gender	8.065	11; 454	0.000	0.40

* p ≤ = 0.01

Table 5-22 shows that in the string group, the type of string instrument does not have a significant impact on the modulation and discrimination variables. In this case, the null hypothesis is retained. In terms of gender, the result ($F_{11;454}$ = 8.065; p = 0.000; f = 0.40) indicates that at the 1% level of significance, differences occur between the variables and thus the null hypothesis can be rejected. This result therefore produces a large effect size which indicates that the finding is of great practical importance. In order to determine for which of the dependent variables significant differences in means occur with regard to gender, one-way analyses of variance (ANOVA) were done. These results are shown in Table 5-23. Since only two groups are involved, no post hoc *t*-tests were performed.

Table 5-23: Sum of squares, degrees of freedom, mean squares, *F* -value, significance level and effect size regarding modulation and discrimination variables for gender among the string players

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Discrimination						
Auditory	0.18	1	0.18	0.013	0.910	-
Proprioceptive	0.01	1	0.01	0.000	0.990	-
Tactile	34.08	1	34.08	1.731	0.189	-
Taste and smell	5.32	1	5.32	0.687	0.408	-
Vestibular	1034.53	1	1034.53	10.630*	0.001	0.14
Visual	267.85	1	267.85	4.820	0.029	-
Total	**53.37**	**1**	**53.37**	**0.080**	**0.777**	**-**
Modulation						
Auditory	34.88	1	34.88	1.171	0.280	-
Tactile	319.47	1	319.47	2.300	0.130	-
Taste and smell	20.51	1	20.51	1.459	0.228	-
Vestibular	549.49	1	549.49	16.807*	0.000	0.20
Visual	1297.73	1	1297.73	31.915*	0.000	0.26
Total	**247.32**	**1**	**247.32**	**0.462**	**0.497**	**-**

* p ≤ = 0.01

For the vestibular discrimination variables, as well as the vestibular and visual modulation variables, *F*-values significant at the 1% level were found. As a result, the null hypothesis could be rejected in all three cases. Although these *F*-values yield statistically significant results, the effect sizes indicate that medium effect sizes occurred for only two of the modulation variables. Consequently, only the results with a medium effect size were further examined. Averages which were obtained for the string players' genders are specified in Table 5-24.

Table 5-24: Means and standard deviations of gender among the string players with regard to vestibular and visual modulation

Variables	Male			Female		
	N	$\overline{X}$	SD	N	$\overline{X}$	*SD*
Vestibular modulation	68	17.22	5.54	75	19.41	5.85
Visual modulation	68	37.25	6.85	75	33.90	5.96

Interesting results emerge from Table 5-24. With regard to vestibular modulation, there is a significant difference between the two genders. The female string players attained a significantly higher mean score than the males, yet still within the norm. For visual modulation, however, both genders scored in the mild difficulties range. The male string players' vestibular modulation score falls solidly within the mild difficulties range indicating even greater visual modulation sensitivity than their female counterparts.

In the next subsection, an analysis of possible differences in modulation and discrimination variables among keyboard players is provided. It is done by first analysing data concerning the type of instrument after which modulation and discrimination differences are considered in terms of gender.

5.2.4.4 Keyboards

Table 5-25 presents the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis as well as the Levene's Test probability values (p) for the modulation and discrimination variables for the Keyboard group. The latter values are indicated separately for the two independent variables (type of instrument and gender). With this group, only two types of instruments (piano and organ) occur and therefore post hoc t-tests were not necessary if it was found that significant differences in means do not occur in terms of the type of instrument.

Table 5-25: Descriptive statistics regarding the modulation and discrimination variables for the keyboard group

Variables	N	Min	Max	$\overline{X}$	SD	Skew-ness	Kurtosis	Levene's *p*-value	
								Gender	Instr
Discrimination									
Auditory	145	5	24	13.77	3.76	.276	-.230	.567	.277
Proprioceptive	145	12	44	25.10	6.28	.495	.383	.419	.567
Tactile	144	9	29	17.22	4.45	.189	-.202	.106	.974
Taste and smell	145	5	20	10.97	2.55	.281	.533	.251	.284
Vestibular	145	25	75	42.23	10.45	.607	-.008	.601	.970
Visual	145	15	60	27.81	8.14	.955	1.787	.894	.192
Total	**145**	**80**	**220**	**137.08**	**25.07**	**.376**	**.178**	**.740**	**.505**
Modulation									
Auditory	145	10	35	23.59	5.77	.054	-.529	.801	.043
Tactile	145	30	86	57.61	12.45	-.152	-.402	.256	.448
Taste and smell	145	6	27	13.81	3.95	.511	.442	.984	.564
Vestibular	145	7	30	17.95	5.42	.004	-.583	.291	.784
Visual	145	17	58	34.79	7.21	.339	.435	.760	.965
Total	**145**	**86**	**203**	**147.74**	**23.89**	**-.099**	**-.286**	**.342**	**.267**

It is evident that no unusual values appear in Table 5-25. Both the skewness and kurtosis values fall within the limits for all the variables within the keyboard group. Hence, it can be assumed that the data relating to these specific variables for keyboard players distribute normally and thus comply with the assumption that no extreme values were recorded or that the data is distributed askew. In addition, it is evident that similar to the brass and string players, the keyboard group's tactile discrimination is at the bottom end of the mild difficulties range. All other variables are at the high end of the typical range. In terms of modulation, the same pattern which was found among the brass and string players emerged for the keyboard group: auditory, tactile and visual modulation are at the low end of mild difficulties, while taste, smell and vestibular modulation are at the high end of the typical range of the standard population.

Next, the keyboard group's homogeneity of variances for type of instrument and gender was investigated. The *p*-values of the Levene's Test indicate that none of the variables show significant differences in variances for neither the two genders nor the five instrument groups. It can therefore be assumed that the requirements for homogeneity of variances are met. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. These results are shown in Table 5-26.

Table 5-26: MANOVA results for the keyboard group with type of instrument and gender as independent variables

Independent variable	***F***	**df**	***p***	***f***
Type of instrument	1.167	11; 132	0.316	-
Gender	3.096	11; 131	0.001	0.45

* p ≤ = 0.01

As shown in Table 5-26, there are no significant differences with regard to the average modulation or discrimination scores which were obtained for keyboard players (piano and organ). In this case, the null hypothesis can be retained. In the case of gender, the result ($F_{11;131}$ = 3.096; p = 0.001; f = 0.45) indicates that at the 1% level significant differences between the variables occur and thus the null hypothesis can be rejected. In this event, the result produces a large effect size which indicates that the finding is of great practical importance. In order to determine which of the dependent variables indicate significant differences in means for the two genders, one-way analyses of variance (ANOVA) were performed. The results are shown in Table 5-27.

Table 5-27: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding modulation and discrimination variables for the keyboard players' gender

Variables	**Sum of squares**	**df**	**Mean square**	***F***	***p***	***f***
Discrimination						
Auditory	0.001	1	0.001	0.000	0.994	-
Proprioceptive	54.77	1	54.77	1.385	0.241	-
Tactile	5.97	1	5.97	0.303	0.583	-
Taste and smell	5.61	1	5.61	0.889	0.347	-
Vestibular	603.60	1	603.60	6.013	0.015	-
Visual	39.73	1	39.73	0.592	0.443	-
Total	**244.89**	**1**	**244.89**	**0.388**	**0.534**	**-**

Variables	Sum of squares	df	Mean square	F	p	f
Modulation						
Auditory	70.35	1	70.35	2.116	0.148	-
Tactile	1.214	1	1.21	0.008	0.930	-
Taste and smell	4.118	1	4.12	0.264	0.608	-
Vestibular	276.99	1	276.99	9.996*	0.002	0.27
Visual	595.97	1	595.97	12.323*	0.001	0.28
Total	**6.315**	**1**	**6.32**	**0.011**	**0.916**	**-**

* $p \leq = 0.01$

No significant differences in the average discrimination scores were found on any of the variables in terms of gender. The null hypothesis can thus be retained in all these cases. *F*-values that are significant at the 1% level were found for two of the modulation variables (vestibular and visual). Thus, the null hypothesis can be rejected in these two cases. For both these variables, the *F*-values shows medium effect sizes and it can therefore be assumed that the results are of moderate practical importance. The means of the two keyboard groups' gender variables are of medium effect sizes. The results which were obtained are shown in Table 5-28.

Table 5-28: Means and standard deviations of gender in the keyboard group with regard to vestibular and visual modulation

Variables	Males			Females		
	N	$\overline{X}$	***SD***	**N**	$\overline{X}$	***SD***
Vestibular modulation	68	16.43	4.93	75	19.21	5.55
Visual modulation	68	36.94	6.80	75	32.85	7.09

It is notable that the means in Table 5-28 are similar to those of the string players (Table 5-24). Concerning vestibular modulation, the female musicians achieved a significantly higher average score. Despite this difference, the females are still within the typical range of the norm leaning towards mild difficulties, while the males' scores fall within the middle of the typical range. As for visual modulation, both genders' scores are above the norm. While the females' scores are at the bottom of the mild difficulties range, the males' scores are firmly within the mild difficulties range which indicates greater visual modulation sensitivity.

This concludes the analysis of the modulation and discrimination variables in terms of each particular instrument group, as well as different instruments and gender within the various instrument groups. In the section that follows, attention is given to research hypothesis 2. In this case, emphasis is placed on the variables concerning the category “functional problems”.

5.3 Functional problems

As explained in Chapter 2, the term “functional problem” refers to dysfunction in an occupational area, caused by several contributing factors. This section examines research hypothesis 2 which has to do with functional problems within each of the 19 instruments, each particular instrument group, as well as the different instruments and gender within the groups.

5.3.1 Descriptive statistics

Table 5-29 presents the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis for the functional problem variables in terms of the whole sample of musicians. Columns 7 and 8 of Table 5-29 are included to further determine if the data complies with the assumption of extreme values (which were explained in paragraph 2 of “Statistical procedures” in Chapter 4). In the last column, the *p*-values of the Levene's Test are shown.

Table 5-29: Descriptive statistics regarding the functional problem variables for the total group

Variables	N	Min	Max	$\overline{X}$	SD	Skew-ness	Kurto-sis	Levene’s *p*-value
Sensory over-responsivity								
Gravitational insecurity	1327	9	45	21.09	6.72	.397	-.170	.255
Tactile-related hygiene	1327	5	22	8.18	2.87	1.174	1.703	.566
Discomfort with imposed touch	1325	6	30	15.81	4.37	.278	-.155	.262
Atypical pain response	1327	3	15	7.15	1.92	.093	.026	.042
Discomfort with water	1327	5	24	10.19	3.51	.850	.557	.174
Sensory seeking								
Movement	1327	5	25	12.27	3.01	.281	.304	.254
Visual seeking/oculo-motor	1327	6	28	11.76	3.22	.572	.662	.824
Touch	1327	4	18	9.57	2.58	.255	-.178	.054

By considering the data shown in Table 5-29, it is apparent that there are no unusual values. Both the skewness and kurtosis values fall within the limits for all the variables involved. Thus, it can be assumed that the data relating to functional problem variables distribute normally for the entire group. Furthermore, it is clear that in terms of gravitational insecurity, tactile-related hygiene and discomfort with imposed touch, all variables are at the high end of the typical range. Atypical pain response and discomfort with water, however, are at the low end of mild difficulties. Concerning the sensory seeking variables, visual seeking/oculo-motor is slightly above the typical range, while the movement and touch variables are at the high end of the range.

5.3.2 Comparison of 19 different instruments

Research hypothesis 2(a) was examined by comparing the 19 groups playing different instruments' average functional problem scores using a one-way multivariate variance analysis (MANOVA). For the multivariate test, Hotelling Trace was used and the following result, namely ($F_{144;10378} = 1.632$; $p = 0.000$; $f = 0.15$) was obtained. This result indicates that the differences on the 1% level are significant and that the result has a small to medium effect size. In order to determine which of the dependent variables demonstrate significant differences in averages for the 19 groups, one-way variance analyses (ANOVA) were done. The latter procedure firstly provides an indication of for which dependent variables there are significant differences and secondly, for which groups these differences occur (using the Scheffé test). Table 5-30 indicates the sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size for the functional problem variables for the 19 different instruments.

Table 5-30: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding the functional problem variables for the 19 different instruments

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Sensory over-responsivity						
Gravitational insecurity	2472.53	18	137.36	3.130*	0.000	0.20
Tactile-related hygiene	210.15	18	11.68	1.429	0.109	
Discomfort with imposed touch	458.38	18	25.47	1.339	0.154	
Atypical pain response	42.98	18	2.39	0.644	0.867	
Water discomfort	335.09	18	18.62	1.518	0.075	
Sensory seeking:						
Movement	276.78	18	15.38	1.716	0.031	
Visual seeking/oculo-motor	556.20	18	30.90	3.062*	0.000	0.20
Touch	104.74	18	5.82	0.873	0.613	

* p ≤ = 0.001 (Bonferroni correction)

F-values significant at the 1% level were found for two of the functional problem variables (gravitational insecurity and visual seeking/oculo motor) so that the null hypothesis can be rejected in these cases. The corresponding effect sizes indicate that both variables show a small to medium effect size and the Scheffé test has been used to determine the specific differences. Table 5-31 indicates the means and standard deviations for the 19 respective groups for the gravitational insecurity variable.

Table 5-31: Means and standard deviations for the 19 different instruments in terms of gravitational insecurity

Instrument	N	$\overline{X}$	SD
Bassoon	73	21.82	6.42
Cello	69	21.01	6.41
Clarinet	75	21.20	7.36
Double bass	66	19.88	6.46
Harp	66	22.61	7.14
Flute	74	22.16	6.25
French horn	75	21.27	6.05
Classical/nylon string guitar	79	21.70	5.85
Electric/steel string guitar	51	20.31	7.27
Oboe	73	21.29	6.40
Organ	68	22.75	7.18
Percussion	73	18.96	6.51
Piano	76	23.08	7.22
Saxophone	54	20.39	6.52

Instrument	N	$\overline{X}$	SD
Trombone	72	18.90	6.58
Trumpet	80	19.25	5.67
Tuba	66	19.02	7.15
Viola	67	22.78	6.72
Violin	68	22.29	6.81

Although there are significant differences between these groups of instrumentalists regarding the gravitational insecurity variable, all scores fall within the ASH's typical range (12.03 – 24.17) of the standard population. Although this result is not further discussed, information concerning gravitational insecurity for the groups that achieved significant differences in means is indicated in Table 5-32.

Table 5-32: Comparison of musicians with regard to gravitational insecurity

Group 1	Group 2	Interpretation
Percussion Trombone Tuba	Bassoon Harp Flute Classical/nylon string guitar Organ Piano Viola Violin	Group 1 musicians achieve significantly **lower** average scores for gravitational insecurity than Group 2 musicians
Group 1	**Group 2**	**Interpretation**
Double bass Trumpet	Harp Organ Piano Viola	Group 1 musicians achieve significantly **lower** average scores for gravitational insecurity than Group 2 musicians
Trumpet	Flute Violin	Group 1 musicians achieve significantly **lower** average scores for gravitational insecurity than Group 2 musicians
Piano	Electric/steel string guitar Saxophone	Group 1 musicians achieve significantly **higher** average scores for gravitational insecurity than Group 2 musicians

The next analysis involved the different instrument groups' visual seeking/oculo-motor functioning. Table 5-33 indicates the means and standard deviations for the respective 19 groups for the visual seeking/oculo-motor variable.

Table 5-33: Means and standard deviations for the 19 different instruments in terms of the visual seeking/oculo-motor variable

Instrument	N	$\overline{X}$	SD
Bassoon	73	11.54	2.63
Cello	69	11.58	3.74
Clarinet	75	11.68	3.02
Double bass	66	12.48	3.16
Harp	66	11.20	2.87
Flute	74	11.55	3.26
French horn	75	11.01	2.95
Classical/nylon string guitar	79	12.19	3.19
Electric/steel string guitar	51	12.53	3.11
Oboe	73	11.40	3.14
Organ	68	11.82	3.46
Percussion	73	12.70	3.44
Piano	76	10.91	3.04
Saxophone	54	12.09	3.94
Trombone	72	11.82	3.04
Trumpet	80	12.86	3.42
Tuba	66	12.68	2.96
Viola	67	11.00	3.05
Violin	68	10.69	2.82

From Table 5-33 it is evident that musicians visual seeking/oculo-motor functioning is at the high end or above the typical range (5.84 – 10.96) of the standard population. It is therefore significant that all 19 groups of muscians scored above this range. Except for piano and violin, all intruments' mean scores are above the typical range. The information regarding the visual seeking/oculo-motor variable for the groups which showed significant differences in means is indicated in Table 5-34.

Table 5-34: Comparison of musicians with regard to the visual seeking/oculo-motor variable

Group 1	Group 2	Interpretation
Double bass Electric/steel string guitar Percussion Trumpet Tuba	Harp French horn Piano Viola Violin	Group 1 musicians achieve significantly **higher** average scores for visual seeking/oculo-motor than Group 2 musicians

Group 1	Group 2	Interpretation
Oboe	Percussion Trumpet	Group 1 musicians achieve significantly **lower** average scores for visual seeking/oculo-motor than Group 2 musicians
Trumpet	Bassoon Cello Trumpet	Group 1 musicians achieve significantly **higher** average scores for visual seeking/oculo-motor than Group 2 musicians
Violin	Classical/nylon string guitar Saxophone	Group 1 musicians achieve significantly **lower** average scores for visual seeking/oculo-motor than Group 2 musicians

5.3.3 Comparison of instrument groups

To investigate research hypothesis 2(b), the five instrument groups were compared with regard to the functional problem variables. As indicated in paragraph 2 under “Statistical procedures” in Chapter 4, it is important to test for homogeneity of variances between the five instrument groups regarding all the variables concerned before executing a MANOVA. The Levene's Test has been used for this and the *p*-values of this test were shown in Table 5-29 under 5.3.1, descriptive statistics. Following this procedure, no significant Levene's Test values for any of the variables were obtained. It can therefore be assumed that the data meets the requirements for the assumption of homogeneity of variances for the five instrumental groups.

Research hypothesis 2(b) was then investigated by comparing the five instrument groups (woodwinds, brass, percussion, strings and keyboards) with the average functional problem scores using a one-way multivariate variance analysis (MANOVA). The Hotelling Trace was used as multivariate test. This led to the following result: ($F_{32;5246} = 2.337$; $p = 0.000$; $f = 0.12$). It indicates that the differences on the 1% level are significant and that the result has a small effect size. Since the result does not provide a medium effect size, it was not further investigated. Consequently, the null hypothesis could be maintained. In other words, there are no significant differences in means regarding the eight functional problem variables for the five instrument groups.

The next step involved comparing the musicians playing different instruments within each instrument group, as well as gender differences within the groups with regard to the functional problem variables. The results are presented and discussed in the next section.

5.3.4 Comparison of type of instrument and gender within the various instrument groups

Subsequently, research hypothesis 2(c) and (d) was investigated by determining, per instrument group, whether significant differences exist in the average functional problem variables regarding the type of instrument and/or gender. As mentioned previously, the percussion group could not be compared according to type of instrument (as it is regarded as one instrument) or gender as only a very small group consists of female players and therefore it was not meaningful to analyse. Only the results of the other four groups are therefore presented and discussed below.

5.3.4.1 Woodwinds

The means ($\overline{X}$); standard deviations (SD); skewness and kurtosis as well as the Levene's Test probability values (*p*) for the functional problem variables for the woodwind group are indicated in Table 5-35. The latter values are indicated separately for the two independent variables (type of instrument and gender).

Table 5-35: Descriptive statistics regarding the functional problem variables for the woodwind group

Variables	N	Min	Max	$\overline{X}$	SD	Skew-ness	Kur-tosis	Levene's *p*-value	
								Gender	Instr
Sensory over-responsivity									
Gravitational insecurity	350	9	43	21.42	6.59	.496	.217	.866	.088
Tactile-related hygiene	350	5	22	8.16	2.97	1.285	1.174	.212	.520
Discomfort with imposed touch	349	6	28	16.15	4.44	.305	-.153	.839	.264
Atypical pain response	350	3	12	7.21	1.91	.072	-.523	.977	.338
Discomfort with water	350	5	23	10.43	3.59	.829	.379	.515	.010
Sensory seeking									
Movement	350	5	25	12.35	2.95	.503	1.416	.234	.882
Visual seeking/oculo-motor	350	6	26	11.61	3.18	.566	.828	.217	.456
Touch	350	4	18	9.61	2.46	.263	.070	.801	.098

It is evident from Table 5-35 that no unusual values emerged. Both the skewness and kurtosis values fall within the limits for all the variables for the woodwind group. It can therefore be assumed that the data relating to these specific variables for the woodwind group distribute normally and thus comply with the assumption that no extreme values occur or that the data is distributed exceptionally askew. Additionally, it is apparent that while all the sensory over-responsivity variables are at the low end of the mild difficulties range, gravitational insecurity is the only variable that is within the typical range (high end). With reference to sensory seeking behaviour, the movement variable is at the high end of the ASH's typical range. On the other hand, visual seeking/oculo-motor and touch are slightly above the typical range.

Also for this group, homogeneity of variances between males and females (gender) and type of instrument (flute, oboe, clarinet, bassoon and saxophone) was investigated by means of Levene's Test. The *p*-values of this test are shown in the last two columns of Table 5-35. With the exception of discomfort with water (type of instrument: $p = 0.010$), none of the other variables shows significant variations in variances. In terms of instrument type, the clarinet players (SD = 7.36) show a significantly higher standard deviation compared to the other woodwind players. The results of this variable must therefore be interpreted with greater circumspection. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-36.

Table 5-36: MANOVA results with type of instrument and gender as independent variables for the woodwinds group

Independent variable	***F***	**df**	***p***	***f***
Type of instrument	1.017	32; 1342	0.442	-
Gender	4.428	8; 340	0.000	0.32

* p ≤ = 0.01

Table 5-36 shows that there are no significant differences regarding the functional problem variables among woodwind players with regard to the type of instrument they specialise in.[50] In this case, the null hypothesis is retained. In terms of gender,

[50] In this context (here and elsewhere in the thesis), "musicians playing different types of instruments" refers to musicians playing a particular instrument within a particular group of instruments, for example clarinet which forms part of the woodwind group. It does not refer to musicians who play more than one instrument.

the result ($F_{8;340}$ = 4.428; p = 0.000; f = 0.32) indicates that at the 1% level, significant differences occur between the variables and thus the null hypothesis was rejected. Furthermore, the result produces a medium effect size which indicates that the finding is of average practical importance. In order to determine for which of the dependent variables there are significant differences in means with regard to gender, one-way analyses of variance (ANOVA) were done. These results are shown in Table 5-37.

Table 5-37: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding functional problem variables for gender in the woodwind group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Sensory over-responsivity						
Gravitational insecurity	616.04	1	616.04	14.707*	0.000	0.21
Tactile-related hygiene	6.22	1	6.22	0.704	0.402	-
Discomfort with imposed touch	21.44	1	21.44	1.088	0.298	-
Atypical pain response	0.062	1	0.062	0.017	0.897	-
Discomfort with water	17.95	1	17.95	1.391	0.239	-
Sensory seeking						
Movement	0.44	1	0.44	0.051	0.822	-
Visual seeking/oculo-motor	137.93	1	137.93	14.238*	0.000	0.20
Touch	6.07	1	6.07	1.003	0.317	-

* $p \leq = 0.01$

F-values that are significant at the 1% level have been found for gravitational insecurity and visual seeking/oculo-motor, two of the functional problem variables. Consequently, the null hypothesis can be rejected in both cases. The corresponding effect sizes of these statistically significant results indicate that the results are of moderate practical importance. These are therefore shown in Table 5-38 and then further discussed.

Table 5-38: Means and standard deviations for gender in the woodwind group regarding the gravitational insecurity and visual seeking/oculo-motor variables

Variables	Male			Female		
	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Gravitational insecurity	123	19.63	5.91	266	22.41	6.76
Visual seeking/oculo-motor	123	12.48	3.32	266	11.16	3.00

In terms of the gravitational insecurity, Table 5-38 shows that the female woodwind players achieved a significantly higher average score in comparison to the males. Furthermore, in terms of gravitational insecurity, the males are firmly within the typical range, while the females are at its high end. This pattern is inverted concerning the visual seeking/oculo-motor variable. In this case, the males are firmly within the mild difficulties range, whereas the females are at the low end of the range.

In the next subsection, the brass group is examined for possible differences with regard to the functional problem variables. This was investigated according to type of brass instrument (French horn, trumpet, trombone and tuba), as well as gender.

5.3.4.2 Brass

Table 5-39 presents the brass group's means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the functional problem variables. The latter values are indicated separately for the two independent variables (type of instrument and gender).

Table 5-39: Descriptive statistics of the functional problem variables for the brass group

Variables	N	Min	Max	$\overline{X}$	SD	Skew-ness	Kurto-sis	Levene's *p*-value	
								Gender	Instr
Sensory over-responsivity									
Gravitational insecurity	293	9	45	19.59	6.41	.522	.287	.523	.301
Tactile-related hygiene	293	5	17	8.02	2.67	.937	.643	.799	.054
Discomfort with imposed touch	292	6	30	15.18	4.49	.545	.223	.072	.631
Atypical pain response	293	3	15	7.21	2.09	.013	.119	.928	.758
Discomfort with water	293	5	22	9.72	3.29	.865	.816	.236	.871
Sensory seeking									
Movement	293	5	21	12.27	3.04	.040	-.128	.653	.350
Visual seeking/oculo-motor	293	6	22	12.08	3.18	.314	-.157	.311	.697
Touch	293	4	17	9.61	2.71	.183	-.327	.088	.668

From Table 5-39 it is clear that no unusual values are apparent, and that both the skewness and kurtosis values fall within the limits of all the variables. As a result, it can be assumed that the data relating to these specific variables for the brass group distribute normally and thus comply with the assumption that no extreme values occur. In terms of the ASH's means for the sensory over-responsivity variables, it is evident that the gravitational insecurity mean is solidly within the typical range, while discomfort with water and imposed touch are at the high end of the range. Tactile-related hygiene and atypical pain response, however, are at the low end of mild sensitivity. With reference to sensory seeking behaviours, the visual seeking/oculo-motor variable's mean is at the bottom end of the mild difficulties range, whilst the movement and touch variables are at the high end of the typical range.

Similar to the other instrument groups, homogeneity of variances for gender and type of instrument was also investigated for the brass group. The *p*-values of the Levene's Test show that no significant differences in variances occurred for any of the variables for the different instruments in the brass group or for gender. In this case, the data thus complies with the assumption of equal variances. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-40.

Table 5-40: MANOVA results with type of instrument and gender as independent variables for the brass group

Independent variable	*F*	df	*p*	*f*
Type of instrument	1.602	24; 839	0.034	-
Gender	3.918	8; 283	0.000	0.32

*   p ≤ = 0.01

For the type of instrument independent variable, Table 5-40 shows that there are no significant differences in means regarding the functional problem variables that are significant, at least at the 1% level. Consequently, the null hypothesis can be retained. Furthermore, Table 5-40 shows that for gender ($F_{8;283}$ = 3.918; p = 0.000; f = 0.32) significant differences occur which are significant at the 1% level so that null hypothesis can be rejected in this case. The corresponding effect size indicates that the result for gender is of medium size and that it is of moderate practical importance.

In order to determine for which of the dependent variables there are significant differences in means for the two genders within the brass group, one-way variance analyses (ANOVA) were done. These results are indicated in Table 5-41.

Table 5-41: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding the functional problem variables for gender in the brass group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Sensory over-responsivity						
Gravitational insecurity	633.25	1	633.25	16.343*	0.000	0.23
Tactile-related hygiene	8.82	1	8.82	1.241	0.266	-
Discomfort with imposed touch	172.96	1	172.96	8.817*	0.003	0.17
Atypical pain response	0.62	1	0.62	0.141	0.708	-
Discomfort with water	16.26	1	16.26	1.496	0.222	-
Sensory seeking						
Movement	15.98	1	15.98	1.730	0.189	-
Visual seeking/oculo-motor	53.08	1	53.08	5.325	0.022	-
Touch	10.33	1	10.33	1.405	0.237	-

* p ≤ = 0.01

F-values that are significant at the 1% level have been found for two of the functional problem variables (gravitational insecurity and imposed touch). Based on this, the null hypothesis can be rejected in both cases. The gravity insecurity result produced a medium effect size which means that the result is of moderate practical importance and will therefore be further discussed. The averages for the two genders of the brass group concerning the variables for which medium effect sizes were obtained are provided in Table 5-42.

Table 5-42: Means and standard deviations for gender in the brass group regarding the gravitational insecurity variable

Variable	Male			Female		
	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Gravitational insecurity	123	18.75	6.07	266	22.09	6.64

Table 5-42 clearly shows that in comparison to the male brass players, the female participants achieved a significant higher average score on gravitational insecurity. Although there is a significant gender disparity, both genders' gravitational insecurity scores are soundly within the normal range. The next section investigates the possible differences in functional problem variables for the string group regarding the type of instrument (violin, viola, cello and double bass, harp and guitar), as well as gender.

5.3.4.3 Strings

Table 5-43 indicates the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the functional problem variables for the string group. The latter values are indicated separately for the two independent variables (type of instrument and gender).

Table 5-43: Descriptive statistics regarding the functional problem variables for the string group

Variables	N	Min	Max	$\overline{X}$	SD	Skew-ness	Kurto-sis	Levene's *p*-value	
								Gender	Instr
Sensory over-responsivity									
Gravitational insecurity	466	9	43	21.56	6.67	.323	-.253	.095	.554
Tactile-related hygiene	466	5	22	8.25	2.87	1.268	2.130	.000	.296
Discomfort with imposed touch	466	6	29	15.85	4.12	.148	-.047	.898	.392
Atypical pain response	466	3	14	7.13	1.84	.132	.226	.769	.492
Discomfort with water	466	5	23	10.14	3.46	.928	.801	.088	.062
Sensory seeking									
Movement	466	5	23	12.30	3.04	.237	.033	.087	.254
Visual seeking/oculo-motor	466	6	25	11.65	3.20	.556	.329	.201	.369
Touch	466	4	18	9.60	2.53	.346	-.261	.771	.013

It is apparent from Table 5-43 that no unusual values are found. For the string group, both the skewness and kurtosis values fall within the limits for all the variables. Thus it can be assumed that the data relating to these specific variables for the string group distributes normally. Additionally, it is apparent that while the sensory over-responsivity variables of gravitational insecurity and discomfort with water are at the high end of the typical range, tactile-related hygiene, discomfort with imposed touch and atypical pain response are at the low end of the mild difficulties range. Concerning the sensory seeking variables, visual seeking/oculo-motor is at the bottom end of the mild sensitivity range. Conversely, the movement and touch variables are at the high end of the typical range.

The homogeneity of variances for type of instrument and gender has also been investigated for the string group. The *p*-values of the Levene's Test show that for one of the variables, namely tactile hygiene, a significant Levene's Test value has been obtained at the 1% level. With the exception of this variable, it can be assumed that homogeneity of variances occurred for the two genders of the functional problem variables. As for the type of instrument, no significant Levene's Test values were found, so that the assumption of homogeneity of variances is met in this case. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-44.

Table 5-44: MANOVA results with type of instrument and gender as independent variables for the group of string players

Independent variable	***F***	***df***	***p***	***f***
Type of instrument	1.817	48; 2702	0.001	0.18
Gender	9.327	8; 457	0.000	0.38

* p ≤ = 0.01

Table 5-44 shows that at the 1% level ($F_{48;2702}$ = 1.817; p = 0.000; f = 0.38) there are statistically significant differences for musicians playing different types of string instruments regarding the functional problem variables. However, the corresponding effect size of 0.18 indicates that the result is of little practical importance and consequently it is not discussed further. In the case of gender, the result ($F_{8;457}$ = 9.327; p = 0.000; f = 0.40) indicates that at the 1% level there are also significant differences regarding the variables and thus the null hypothesis can be rejected. In this case, the result produces a large effect size which indicates that the finding is of great practical importance. In order to determine for which of the dependent variables there are significant differences in means with regard to gender, one-way analyses of variance (ANOVA) were done. These results are shown in Table 5-45.

Table 5-45: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding modulation and discrimination variables for gender within the string group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Sensory over-responsivity						
Gravitational insecurity	695.05	1	695.05	16.114*	0.000	0.18
Tactile-related hygiene	105.22	1	105.22	13.141*	0.000	0.17
Discomfort with imposed touch	74.09	1	74.09	4.404	0.036	-
Atypical pain response	2.08	1	2.08	0.616	0.433	-
Discomfort with water	9.87	1	9.87	0.826	0.364	-
Sensory seeking						
Movement	26.14	1	26.14	2.835	0.093	-
Visual seeking/oculo-motor	244.38	1	244.38	25.042*	0.000	0.23
Touch	3.22	1	3.22	0.504	0.478	-

* p ≤ = 0.01

F-values significant at the 1% level were found for three of the functional problem variables (gravitational insecurity; tactile hygiene and visual/oculo-motor) so that the null hypothesis can be rejected in these three cases. Although these *F*-values yield statistically significant results, the effect sizes indicate that only the visual/oculo-motor variable was of medium effect size. Consequently, only the result of this variable was investigated. The means of the two genders in the string group is provided in Table 5-46.

Table 5-46: Means and standard deviations for gender in the string group regarding the visual seeking/oculo-motor variable

Variables	Male			Female		
	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Visual seeking/oculo-motor	210	12.45	3.24	256	10.99	3.02

The results in Table 5-46 indicate that, in comparison to female string players, the male string players achieved a significantly higher average score for visual seeking/oculo-motor skills. While the males' visual seeking/oculo-motor score is solidly within the mild difficulties range, the females' score is at the low end of the range.

Following this presentation of data pertaining to the strings, the next subsection examines possible differences in the functional problem variables for the keyboard players regarding their primary instrument (piano or organ) and gender.

5.3.4.4 Keyboards

Table 5-47 indicates the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the functional problem variables for the keyboard group. The latter values are shown separately for the two independent variables (type of instrument and gender).

Table 5-47: Descriptive statistics regarding the functional problem variables for the keyboard group

Variables	N	Min	Max	$\overline{X}$	SD	Skew-ness	Kurto-sis	Levene's *p*-value	
								Gender	Instr
Sensory over-responsivity									
Gravitational insecurity	145	9	38	22.92	7.18	.004	-.844	.876	.771
Tactile-related hygiene	145	5	19	8.32	2.99	.954	.803	.232	.987
Discomfort with imposed touch	145	6	26	16.22	4.47	-.066	-.779	.358	.218
Atypical pain response	145	3	13	6.94	1.82	.072	.406	.144	.654
Discomfort with water	145	5	21	10.86	3.76	.482	-.411	.228	.897
Sensory seeking									
Movement	145	5	20	11.63	2.69	.387	.020	.006	.587
Visual seeking/oculo-motor	145	6	28	11.34	3.26	1.331	4.327	.386	.460
Touch	145	4	18	9.31	2.55	.325	.397	.525	.975

The data presented in Table 5-47 clear shows that no unusual values are found. However, the keyboard players demonstrated a high positive kurtosis value indicating a leptocardial distribution for the visual seeking/oculo-motor variable. This means that the distribution of the scores around the average for this variable is very small. With exception of this variable, the assumption that data is distributed normally can be accepted. It is further apparent that while all the sensory over-responsivity variables are at the low end of the mild difficulties range, gravitational insecurity is the only variable that is within the typical range (high end). Concerning the sensory seeking variables, visual seeking/oculo-motor is at the low end of the mild difficulties range, whereas the movement and touch variables are at the high end of the typical range.

The homogeneity of variances for type of instrument and gender was also investigated for the keyboard group. The *p*-values of the Levene's Test show that at the 1% level a significant Levene's Test value was obtained for seeking movement, one of the sensory seeking variables. With the exception of this variable, it can be assumed that homogeneity of variances occur in terms of the two genders for the functional problem variables. As for the type of instrument, no significant Levene's Test values were found, so that the assumption of homogeneity of variances is met in this case. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-48.

Table 5-48: MANOVA results with type of instrument and gender as independent variables for the keyboard group

Independent variable	***F***	***df***	***p***	***f***
Type of instrument	1.020	8; 136	0.424	-
Gender	4.606	8; 135	0.000	0.46

* p <= 0.01

As shown in Table 5-48, there are no significant differences in the average functional problem scores for keyboard musicians whether playing piano or organ. In this case, the null hypothesis can be retained. In terms of gender, the result ($F_{8;135}$ = 4.606; p = 0.000; f = 0.46) indicates that at the 1% level, significant differences occur between the variables and thus the null hypothesis can be rejected. Furthermore, the result produces a large effect size which indicates that the finding is of great practical importance. In order to determine for which of the dependent variables there are significant differences in means for the two genders, one-way variance analyses (ANOVA) were done. The results are indicated in Table 5-49.

Table 5-49: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding functional problem variables for gender in the keyboard group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Sensory over-responsivity						
Gravitational insecurity	457.91	1	457.91	9.621*	0.002	0.25
Tactile-related hygiene	39.94	1	39.94	4.565	0.034	-
Discomfort with imposed touch	3.06	1	3.06	0.152	0.697	-
Atypical pain response	0.91	1	0.91	0.273	0.602	-
Discomfort with water	0.34	1	0.34	0.024	0.877	-
Sensory seeking						
Movement	3.69	1	3.69	0.503	0.479	-
Visual seeking/oculo-motor	179.32	1	179.32	19.099*	0.000	0.35
Touch	.79	1	.79	0.121	0.728	-

* $p \leq = 0.01$

F-values that are significant at the 1% level have been found for gravitational insecurity and visual seeking/oculo-motor (two of the functional problem variables). The null hypothesis can therefore be rejected in these cases. The corresponding effect sizes of these statistically significant results indicate that in terms of gravitational insecurity the results are of moderate practical importance, while for visual seeking/oculo-motor it is of great practical importance. These results are further discussed in Table 5-50.

Table 5-50: Means and standard deviations for gender in the keyboard group regarding the gravitational insecurity and visual seeking/oculo-motor variables

Variables	Male			Female		
	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Gravitational insecurity	68	20.94	6.85	76	24.51	6.95
Visual seeking/oculo-motor	68	12.49	3.36	76	10.25	2.77

The results in Table 5-50 show that in terms of the variable gravitational insecurity, the female keyboard players achieved a significantly higher mean score than the male keyboard players. While their score is slightly above the ASH's typical range, the males' score is at the high end of the typical range. However, as far as the visual seeking/oculo-motor variable is concerned, the opposite was found. In this case, the male keyboard players achieved a significantly higher average score than the females. The males' score is in the middle of the mild difficulties range, whilst the female's scores are only slightly above the norm.

This concluded the testing of hypothesis 2 and consequent data presentation. In the following section, attention is given to research hypothesis 3.

5.4 Motor/social components

This section examines research hypothesis 3 which involves the motor and social functioning of musicians. Variables in the motor/social components category are examined according to the 19 different instruments, different instrument groups, and then the type of instrument and gender within each particular instrument group.

5.4.1 Descriptive statistics

In Table 5-51, the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis for the motor/ social variables for the total group indicated. Columns 7 and 8 of Table 5-51 are provided to determine if the data complies with the assumption of extreme values which was discussed in Chapter 4. In the last column, the *p*-values of the Levene's Test are reported.

Table 5-51: Descriptive statistics regarding the functional problem variables for the total group

Variables	N	Min	Max	$\overline{X}$	SD	Skew-ness	Kurtosis	Levene's *p*-value
Postural control	1327	11	45	26.62	5.48	.168	.105	.633
Social/emotional								
Aggressive/impulsive	1326	7	29	16.31	3.99	.230	.247	.811
Anxious	1327	4	19	7.13	2.83	1.213	1.335	.293
Withdrawn/depressed	1325	7	30	18.30	3.60	.048	-.103	.216
Motor coordination								
Fine motor	1327	5	25	10.46	3.37	.604	.428	.903
Motor planning	1327	7	29	12.42	4.12	.781	.463	.681
Oral motor planning	1327	6	24	11.52	3.14	.450	.006	.570
Sequencing	1144	5	25	10.12	3.30	.650	.693	.299

From Table 5-51 it is clear that there are no unusual values. Both the skewness and kurtosis indices fall within the limits for all the variables involved. Thus, it can be assumed that the data relating to the motor/social variables for the entire group distributes normally. Furthermore, it is evident that in terms of the ASH's means, the postural control and social/emotional variables are at the high end of the typical range of the standard population. Concerning the motor coordination variables, all except the fine motor variable are at the high end of the typical range. The fine motor variable is slightly above the typical range of the ASH.

5.4.2 Comparison of 19 different instruments

Research hypothesis 3(a) was investigated by comparing the 19 groups' average motor/social scores by means of one-way multivariate variance analysis (MANOVA). For the multivariate test, Hotelling Trace was used and the following result, namely ($F_{144;8922}$ = 1.453; p = 0.000; f = 0.15) was obtained. This result indicates that the differences on the 1% level are significant and that the result has a small to medium effect size. In order to determine which dependent variables show significant differences in means for the 19 groups, one-way variance analyses (ANOVA) were done. The latter procedure firstly provides an indication as to which dependent variables demonstrate significant differences and secondly, for which groups these differences occur (using the Scheffé test). The sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size for the motor/social variables for the 19 different instruments are shown in Table 5-52.

Table 5-52: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size for the motor/social variables for the 19 different instruments

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Postural Control	412.66	18	22.93	0.768	0.740	
Social/Emotional						
Aggressive/impulsive	309.89	18	17.22	1.078	0.369	
Anxious	166.20	18	9.23	1.218	0.238	
Withdrawn/depressed	383.82	18	21.32	1.668	0.039	

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Motor Coordination						
Fine motor	246.23	18	13.68	1.269	0.199	
Motor planning	470.78	18	26.15	1.872	0.025	
Oral motor planning	290.21	18	16.12	1.734	0.015	
Sequencing	341.51	18	18.97	1.763	0.029	

* p ≤ = 0.001 (Bonferroni correction)

For none of the *F*-values have significant differences been found on the multiple 1% level for any of the dependent motor/social variables. Consequently, the null hypothesis can be retained in all cases. The results therefore indicate that there are no statistically significant differences in the means of the 19 different instruments.

5.4.3 Comparison of instrument groups

To investigate research hypothesis 3(b), the five instrument groups were compared according to the motor/social variables. As explained in Chapter 4, it is important to test the homogeneity of variances between the five instrument groups for the variables before executing a MANOVA. The Levene's Test has been used for this and the *p*-values of this test were shown in Table 5-51 under 5.4.1, descriptive statistics. For none of the variables, a significant Levene's Test value has been obtained and it can therefore be assumed that in this case the data also meets the assumption of homogeneity of variances for the five groups.

Research hypothesis 3(b) was then examined by comparing the five instrument groups (woodwinds, brass, percussion, strings and keyboards) average motor/social scores using a one-way multivariate variance analysis (MANOVA). The Hotelling Trace was used as multivariate test. Following this analysis, the following result was obtained: ($F_{32;5418}$ = 2.542; p = 0.000; f = 0.13). This result indicates that the differences on the 1% level are significant and that the result has a small effect size. Since the result does not deliver at least a medium effect size, it is not further investigated. Consequently, the null hypothesis can be maintained which indicates that there are no significant differences in means regarding the eight motor/social variables for the five instrument groups.

Following this presentation of data, musicians playing different instruments within each instrument can be compared in terms of the relevant motor/social variables. This is done in the next section.

5.4.4 Comparison of type of instrument and gender within the various instrument groups

Research hypothesis 3(c) and (d) was investigated by determining per instrument group whether significant differences in the average motor/social variables regarding the type of instrument and/or gender were found. As explained previously, the percussion group was omitted from the comparison as it is regarded as one instrument and as far as gender is concerned, only a very small group of females participated and it is therefore meaningful to analyse. The results of the other four groups are presented and discussed below.

5.4.4.1 Woodwinds

Table 5-53 shows the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the motor/social variables for the woodwinds group. The latter values are indicated separately for the two independent variables (type of instrument and gender).

Table 5-53: Descriptive statistics regarding the motor/social variables for the woodwind group

Variables	N	Min	Max	$\overline{X}$	SD	Skewness	Kurtosis	Levene's *p*-value	
								Gender	Instr
Postural control	350	13	45	27.07	5.44	.176	.220	.252	.798
Social/emotional									
Aggressive/impulsive	349	7	29	16.19	3.90	.259	.322	.686	.819
Anxious	350	4	18	7.30	2.82	1.170	1.413	.932	.300
Withdrawn/depressed	350	8	30	18.69	3.67	.108	.058	.505	.660
Motor coordination									
Fine motor	350	5	23	10.72	3.33	.517	.227	.837	.086
Motor planning	350	7	29	12.48	4.06	.785	.600	.433	.136
Oral motor planning	350	6	21	11.58	3.14	.327	-.187	.563	.520
Sequencing	298	5	21	10.31	3.25	.365	-.203	.235	.047

Considering the data in Table 5-53, it is clear that no unusual values are to be found. For the woodwind group, both the skewness and kurtosis values fall within the limits for all the variables involved. It can therefore be assumed that data relating to the Woodwind group's motor/social variables distributes normally and thus comply with the assumption that no extreme values occur. Additionally, it is evident that except for the withdrawn/depressed variable which is at the low end of mild difficulties, all other variables are at the high end of the typical range.

The homogeneity of variances between males and females (gender) and type of instrument (flute, oboe, clarinet, bassoon and saxophone) was also investigated by means of Levene's Test for the woodwind group. The *p*-values of this test are shown in the last two columns of Table 5-53. None of the motor/social variables have produced a significant Levene's Test value. Consequently, it can be assumed that there are no significant differences in variance for gender or type of instrument. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-54.

Table 5-54: MANOVA results with type of instrument and gender as independent variables for the woodwinds group

Independent variable	***F***	***df***	***p***	***f***
Type of instrument	0.802	32; 1134	0.777	-
Gender	1.583	8; 288	0.129	-

* p ≤ = 0.01

Table 5-54 shows that in terms of the woodwind group, there are no significant differences for the musicians playing different types of woodwind instruments or for the two genders regarding the motor/social variables. In both these cases, the null hypothesis is retained and the results are therefore not discussed further. Next, the possible differences in motor/social variables for the brass group regarding the type of instrument gender are investigated.

5.4.4.2 Brass

In Table 5-55, the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis as well as the Levene's Test probability values (*p*) for the motor/social variables for the brass group are indicated. The latter values are shown separately for the two independent variables (type of instrument and gender).

Table 5-55: Descriptive statistics regarding the motor/social variables for the brass group

Variables	N	Min	Max	$\overline{X}$	SD	Skewness	Kurtosis	Levene's *p*-value	
								Gender	Instr
Postural control	293	11	43	27.04	5.81	.114	.099	.934	.896
Social/emotional									
Aggressive/impulsive	293	7	29	16.09	4.08	.302	.162	.147	.812
Anxious	293	4	16	6.71	2.71	1.236	1.028	.057	.267
Withdrawn/depressed	293	7	27	17.73	3.78	.042	-.016	.782	.314
Motor coordination									
Fine motor	293	5	23	10.68	3.52	.537	.358	.905	.038
Motor planning	293	7	26	12.49	4.16	.741	.124	.634	.343
Oral motor planning	293	6	24	11.87	3.22	.565	.650	.830	.987
Sequencing	247	5	20	9.60	3.30	.724	.633	.802	.892

It is evident from Table 5-55 that no unusual values occur. Furthermore, both the skewness and kurtosis values fall within the limits of all the variables. It can therefore be assumed that data relating to these specific variables for the brass group distribute normally and thus comply with the assumption that no extreme values occur. With reference to the ASH's mean scores, it is apparent that all variables in the table are at the high end of the typical range of the standard population.

The homogeneity of variances for type of brass instrument and gender was also investigated for the group. The *p*-values of the Levene's Test show that for none of the variables there are significant differences in variances for the different brass instruments or gender. In this case, the data thus complies with the assumption of homogeneity of variances. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-56.

Table 5-56: MANOVA results with type of instrument and gender as independent variables for the brass group

Independent variable	*F*	*df*	*p*	*f*
Type of instrument	1.008	24; 704	0.452	-
Gender	2.721	8; 238	0.007	0.29

* p ≤ = 0.01

For the independent variable type of instrument, Table 5-56 shows that there are no significant differences in motor/social variables that are at least significant at the 1% level. Consequently, the null hypothesis can be retained. Furthermore, Table 5-56 shows that for gender ($F_{8;238}$ = 2.721; p = 0.007; f = 0.29) significant differences occur which are significant at the 1% level so that null hypothesis can be rejected in this case. The corresponding effect size indicates that the result for gender is of medium size and that it is of moderate practical importance.

In order to determine for which of the dependent variables there are significant differences in means for the two genders within the brass group, one-way variance analyses (ANOVA) were performed. The results are indicated in Table 5-57.

Table 5-57: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding motor/social variables for gender in the brass group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Postural control	92.74	1	92.74	2.853	0.092	-
Social/emotional						
Aggressive/impulsive	75.55	1	75.55	4.637	0.032	-
Anxious	21.84	1	21.84	2.939	0.088	-
Withdrawn/depressed	28.88	1	28.88	1.977	0.161	-
Motor coordination						
Fine motor	1.72	1	1.72	0.147	0.701	-
Motor planning	0.29	1	0.29	0.022	0.883	-
Oral motor planning	27.32	1	27.32	2.908	0.089	-
Sequencing	24.68	1	24.68	2.284	0.132	-

* p ≤ = 0.01

Although the MANOVA technique found a significant difference for means regarding gender for the motor/social variables, the ANOVA results indicate that none of the differences is significant at the 1% level. Consequently, the results are not further analysed and thus the null hypothesis can be retained. Next, the possible differences in motor/social variables for the string group regarding the type of instrument they play, as well as their gender are investigated.

5.4.4.3 Strings

Table 5-58 shows the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the motor/social variables for the string group. The latter values are indicated separately for the two independent variables (type of instrument and gender).

Table 5-58: Descriptive statistics regarding the motor/social variables for the string group

Variables	N	Min	Max	$\overline{X}$	SD	Skewness	Kurtosis	Levene's *p*-value	
								Gender	Instr
Postural control	466	11	45	26.28	5.15	.206	.320	.635	.165
Social/emotional									
Aggressive/impulsive	466	7	29	16.46	3.94	.084	.037	.013	.773
Anxious	466	4	18	7.33	2.92	1.166	1.121	.753	.176
Withdrawn/depressed	466	8	27	18.31	3.37	-.035	-.216	.106	.016
Motor coordination									
Fine motor	466	5	25	10.21	3.30	.718	.859	.677	.118
Motor planning	466	7	27	12.35	4.03	.719	.277	.000	.033
Oral motor planning	466	6	20	11.49	3.10	.421	-.283	.074	.368
Sequencing	405	5	25	10.05	3.15	.792	1.494	.168	.033

From Table 5-58 it is evident that no unusual values emerged. For the string group, both the skewness and kurtosis values fall within the limits for all the variables. Thus, it can be assumed that the data relating to these specific variables distributes normally for the string group. Additionally, it is apparent that the postural control and social/emotional variables are at the high end of the ASH's typical range. Concerning motor coordination, the oral motor planning variable is at the bottom end of the mild difficulties range, whereas the other motor planning are at the high end of the typical range.

The homogeneity of variances for type of instrument and gender groups has also been investigated for the string group. The *p*-values of the Levene's Test show that for one of the variables, namely Motor Planning, at the 1% level a significant Levene's Test value for gender has been obtained. With the exception of this variable, it can be assumed that equal variations in respect of the two genders occur for the other motor/social variables. As for the type of instrument group, no significant Levene's Test values were found. It can therefore be assumed that it complies with the assumption of homogeneity of variances. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-59.

Table 5-59: MANOVA results with type of instrument and gender as independent variables for the string group

Independent variable	*F*	*df*	*p*	*f*
Type of instrument	1.525	48; 2336	0.012	-
Gender	4.745	8; 396	0.000	0.29

*   p ≤ = 0.01

Table 5-59 shows that for the strings group at the 1% level ($F_{8;396}$ = 4.745; *p* = 0.000; *f* = 0.29) there were statistically significant differences regarding the motor/social variables. The corresponding effect size of 0.29 indicates that the result is of average practical importance and will be discussed further. In order to determine for which of the dependent variables there are significant differences in means for the two genders, one-way variance analyses (ANOVA) were performed. These results appear in Table 5-60.

Table 5-60: Sum of squares, degrees of freedom, mean squares, *F*-value, significance level and effect size regarding motor/social variables for gender in the string group

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Postural control	0.96	1	0.96	0.035	0.851	-
Social/emotional						
Aggressive/impulsive	49.36	1	49.36	3.089	0.080	-
Anxious	0.35	1	0.35	0.041	0.839	-
Withdrawn/depressed	0.28	1	0.28	0.025	0.875	-

Variables	Sum of squares	df	Mean square	*F*	*p*	*f*
Motor coordination						
Fine motor	62.29	1	62.29	5.979	0.015	-
Motor planning	204.65	1	204.65	14.897*	0.000	.20
Oral motor planning	59.52	1	59.52	6.145	0.014	-
Sequencing	0.01	1	0.01	0.000	0.988	-

* $p \leq = 0.01$

F-values that are significant at the 1% level have been found for one of the motor/social variables (motor planning) so that null hypothesis can be rejected in this case. This *F*-value has a medium effect size. It can therefore be assumed that the result is of moderate practical importance. The result of this variable is therefore further investigated and the averages of the two strings genders are provided in Table 5-61.

Table 5-61: Average, standard deviations for the two genders in the string group regarding motor planning

Variables	Male			Female		
	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Motor planning	184	12.61	4.21	221	11.18	3.23

The results in Table 5-61 indicate that in comparison to the female string players, the males achieved a significantly higher average motor planning score. Despite this finding, both genders' scores are within the typical range of the ASH. While the males' score is at the high end, demonstrating slightly more sensitivity, the females' score is firmly within the typical motor planning range. Next, the possible differences in motor/social variables for the keyboard group regarding the type of instrument they play as well as their gender are investigated.

5.4.4.4 Keyboards

Table 5-62 indicates the means ($\overline{X}$); standard deviations (SD); skewness and kurtosis, as well as the Levene's Test probability values (*p*) for the motor/social variables for the keyboards group. The latter values are indicated separately for the two independent variables (type of instrument and gender).

Table 5-62: Descriptive statistics regarding the motor/social variables for the keyboards group

Variables	N	Min	Max	$\overline{X}$	SD	Skewness	Kurtosis	Levene's *p*-value	
								Gender	Instr
Postural control	145	12	40	25.86	5.65	.184	-.322	.558	.503
Social/emotional									
Aggressive/impulsive	145	7	28	16.19	4.09	.303	.827	.064	.519
Anxious	145	4	19	7.19	2.80	1.337	1.379	.474	.427
Withdrawn/depressed	145	10	28	18.76	3.75	.183	-.460	.007	.000
Motor coordination									
Fine motor	145	5	21	10.10	3.33	.599	.420	.538	.638
Motor planning	145	7	28	12.42	4.33	.797	.614	.795	.839
Oral motor planning	145	6	20	10.88	3.11	.729	.141	.129	.468
Sequencing	129	5	24	11.20	3.66	.733	.755	.295	.127

It is evident from Table 5-62 that no unusual values occur and the assumption that the data is normally distributed can be accepted. Regarding the ASH's mean scores, it is clear that all variables in the table are at the high end of the typical range.

The homogeneity of variances for type of instrument and gender has also been investigated for the keyboard group. The *p*-values of the Levene's Test show that for the withdrawn/depressed variable at the 1% level, a significant Levene's Test value was obtained for both gender and type instrument. With the exception of this variable, homogeneity of variances can be assumed for the motor/social variables in terms of type of instrument and gender. A multivariate variance analysis (MANOVA) was performed and the Hotelling Trace was used as multivariate test. The results are shown in Table 5-63.

Table 5-63: MANOVA results with type of instrument and gender as independent variables for the keyboards group

Independent variable	*F*	*df*	*p*	*f*
Type of instrument	1.001	8; 120	0.439	-
Gender	0.924	8; 119	0.499	-

* p <= 0.01

Table 5-63 shows that for the keyboard group, there are no prominent differences regarding musicians playing different instruments or for the two genders regarding the motor/social variables. In both these cases, the null hypothesis is retained and the results are not discussed further.

5.5 Summary

Data that was gathered during the course of the present study was presented and analysed in this chapter. This was done by testing the three hypotheses. Research hypothesis 1 examined the average modulation and discrimination variable scores for significant differences. Hypothesis 2 investigated whether there are any significant differences concerning the average functional problem variable scores. The aim of the third hypothesis was to determine if there are any significant differences in the average motor/social components variable scores. Each of the hypotheses were considered in terms of (a) the 19 different instruments; (b) different instrument groups; (c) musicians playing different instruments within each particular instrument group; and (d) gender within each of the instrument groups.

It was determined that in comparison to the norm, musicians generally demonstrate enhanced sensory sensitivity. As far as the 19 different instruments are concerned, the majority (15) demonstrated auditory modulation sensitivity, whereas all 19 instruments scored in the mild difficulties range with regard to visual modulation. In terms of vestibular modulation, it became evident that French horn players are slightly more sensitive. A surprising result which emerged within the brass section, is that all the females obtained slightly higher proprioceptive discrimination, vestibular discrimination and tactile modulation scores than the males and the norm, indicating greater sensitivity in these areas. In terms of the motor/social variables, it was established that musicians in general have greater sensitivity.

At an emotional level, string, woodwind, brass and keyboard players show elevated levels of aggression/impulsivity, anxiety and introversion/depression[51]. At the same time, it is noticeable that the woodwind group achieved the highest score (at the low

[51] The ASH refers to aggressive/impulsive, anxious and withdrawn/depressed. However, for the sake of grammar, these terms were adapted to aggression/impulsivity, anxiety and introversion/depression.

end of the mild difficulties range) concerning the introversion/depression variable. Regarding motor coordination, the string players emerged with greater sensitivity and were found to be at the bottom end of the mild difficulties range for three of the variables.

In the next and final chapter of this study, results which emerged from the data analysis in this chapter are considered in light of the literature that was reviewed in Chapter 2 and 3.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The relation between musicians and their instruments has been the topic of much literature. While some scholars have examined it from a person's initial choice of instrument, others have set out to determine the link between musicians and their instruments exclusively from a personality and sensory processing perspective. Adding to these stances is an enquiry into musicians' sensory patterns – the focus of the present study. This concluding chapter provides an overview of the research process that was involved. It addresses the research questions and hypotheses, discusses contributions and limitations, and makes recommendations, including for further research.

6.2 Overview of the study

The study commenced by providing a background of previous scholarly contributions concerning the connection between musicians and their instruments. This included a short account of literary contributions regarding choice of instrument and the relation between musicians and their instruments. Contributing aspects to these connections include intelligence; personality, personal background and physique of musicians; the influence of music teachers, family, friends and peers; the instrument's timbre, size, weight, availability, cost and level of difficulty; as well as gender stereotyping. Apart from initial choice of instrument, researchers have examined differences which exist among music learners, music students and professional performers who play a particular musical instrument and/or one belonging to a specific instrument group. Additionally, the effects of musical training and playing a particular instrument on the brain's plasticity have been studied from both a neurological and neuroscience perspective.

Taking into account the various perspectives from which the connection between musicians and their instruments have been examined, I noticed that only a few isolated aspects involving musicians' processing of sensory information have been studied. For this reason, I decided to investigate musicians' sensory patterns in relation to their primary instruments. As far as I could determine, no research has been done on this topic by means of a sensory profile test. This prompted me to formulate the research questions and hypotheses that have driven the current research.

While the aim was to answer the research questions and test the hypotheses, I intended to include a large number of musical instruments to establish wider trends. Furthermore, researching musicians' sensory patterns would allow me to add a new dimension to what is already known about the link between musicians and their instruments – in the fields of both music and occupational therapy.

Two chapters were devoted to discussing relevant literature. The purpose of Chapter 2 was to provide an overall understanding of the human nervous system with reference to different parts of the brain, senses and sensory processing. Relating to the ASH data collection tool that was used, seven of the human senses as well as sensory processing elements and the assessment of sensory processing in adolescents and adults were discussed (refer to Table 6-1). Also linked to the ASH, Chapter 2 concluded with a discussion of the assessment of sensory processing in adolescents and adults.

Table 6-1: The human senses and sensory processing elements

Human senses
Auditory; olfactory; oral; proprioceptive; tactile; vestibular; visual
Sensory processing elements
Sensory integration; sensory modulation; sensory discrimination; praxis (motor coordination); postural-ocular skills; visual spatial processing; auditory and language processing; vestibular processing; tactile processing; sensory processing sensitivity; social-emotional functioning; functional problems; sensory processing disorder

Chapter 3 provided a detailed account of what is already known about the connection between musicians, their personality traits and their senses. It became apparent that, depending on the type of personality, anxiety and/or depression are often associated with musicians. In addition, personality traits relating to specific instrument groups and instruments were also discussed. A summary of these characteristics is presented in Table 6-2.

Table 6-2: Personality traits that are linked to instruments and instrument group

Instrument group and personality traits	Instrument
Orchestral string players: aloof, introverted, conscientious and show higher levels of self-sentiment.	**Violinists**: particularly intelligent and sensitive; high level of conscientiousness. **Violists**: emotionally more stable. **Cellists**: the most introverted and aloof of the group. **Bassists**: the most agreeable of the group.
Non-orchestral string players (no particular traits).	**Guitarists**: more imaginative, neurotic and psychotic (based on little research and not type of guitar/style specific).
Woodwind players: aloof and conscientious (but not as much as string players), as well as nervous, radical and self-sufficient.	**Flautists**: particularly imaginative. **Oboists**: low ergic tension; no anxiety. **Bassoonists**: lower levels of intelligence; elevated apprehensiveness; greater self-sufficiency.
Brass players: extraverted, expedient, group dependent and lower levels of intelligence.	**Trumpeters**: extroverted; individualistic; take the lead; least neurotic of all musicians. **Hornists**: more arrogant and introverted; sometimes prima donnas; prefer to interact with horn players.
Percussionists (no particular traits).	**Drummers**: more extroverted, but less intelligent and imaginative than other musicians (based on one study).
Keyboard players: extroverted; adjusts easily; warm hearted; emotionally stable; shrewd conservative; submissive; not being overly sensitive.	**Pianists**: particularly submissive, conscientious and conservative; high self-sentiment. Performance pianists are more extroverted. **Organists**: similar to pianists, but significantly shrewder.

Apart from personality traits, scholarly contributions involving various sensory aspects and processing faculties were examined. Dynamics, pitch, timbre, vibrato, and the different combinations thereof have been found to influence listeners' perception of audio-tactile metaphors. In addition, several neurology/neuroscience studies have determined that musicians' neuro-activity in different areas of the brain is dissimilar to that of non-musicians. This has also been established among musicians who specialise in different instruments. Throughout my research, it became evident that there are trends concerning certain personality traits and sensory attributes which are unique to musicians or certain groups of musicians.

Chapter 4 provided a framework for exploring the connection between musicians and their instruments from a sensory pattern point of view. In order to achieve this, different research designs were explored in light of the research questions and hypotheses. I concluded that a quantitative non-experimental criterion group research design would be most the most suitable approach in this context. This was followed by a detailed delineation of the method of data collection. This involved an explanation of the method of sampling, participants, procedures, measuring instrument (the ASH), as well as the ASH Scoring Program© which was used for scoring purposes. Following this account, validity, ethical considerations and statistical procedures which were followed for data analysis were explained. All data was analysed in Chapter 5. This was done by testing the four hypotheses. A number of deductive analyses of the different variables (as indicated in Table 4.1) resulted in several significant findings.

6.3 Discussion of important findings from this study

The aim of this section is to discuss significant trends which emerged from the data that was analysed. Apart from answering the research questions, these trends are further viewed in terms of previous literary contributions. While limited research is available on the sensory patterns of musicians, a connection between various sensory patterns and personality traits among the norm (standard population) has previously been established. This, together with differences among musicians (as well as musicians and non-musicians) from the perspective of personality traits, sensory processing and gender differences makes it possible to link this study's results with existing literature. It allows me to add greater depth in terms of understanding, explaining and adding meaning to the results.

Before discussing these results, it is important to understand that although musicians are generally more sensorily sensitive than the average person, their daily functioning needs to be taken into account, as this tends to mediate their sensitivity. As long as a person is capable of possible counterbalance difficulty through adaptive sensory strategies, mild or even definite difficulties can be effectively managed (May-Benson, 2015:39). However, the further away a person's score is from the ASH's typical functioning range[52], the more likely that person is to experience sensory processing challenges. Conversely, where a higher score normally points towards sensory processing difficulties or problems as far as the standard population is concerned, it is perhaps more accurate to view higher scores among musicians in light of their sensitivity and alertness which are fundamental to being able to function as a musician.

In the subsections that follow, the research questions are thematically answered according to each of the three hypotheses which involved the following respective variables: modulation and discrimination (hypothesis 1), functional problems (hypothesis 2), and motor/social components (hypothesis 3). In terms of all the hypotheses, (a) involves the main research question, while hypotheses (b), (c) and (d) involve sub-questions 1-3 respectively.

6.3.1 Hypothesis 1: significant modulation and discrimination findings

As a result of the data analysis that was done in Chapter 5, several noteworthy patterns emerged in terms of musicians' sensory modulation and discrimination. In comparison to the standard population, it has been found that for most modulation and discrimination variables, musicians are at the high end of the typical range or slightly above it, in other words at the low end of the mild difficulties range of the ASH (refer to Table 6-3). In cases where musicians' average score is at the high end of the typical range, enhanced sensitivity is indicated in the particular area in comparison to the norm. However, since such scores fall within the typical range, these patterns are in most cases not discussed in further detail.

[52] Whenever reference is made to typical range, mild difficulty range or definite difficulty range in this chapter, it refers to the ASH's ranges.

Table 6-3: Musicians' sensory modulation and discrimination in comparison to the norm

Modulation and discrimination	Musicians in general in comparison to the standard population
Modulation	
Auditory	**Low end** of the **mild difficulties** range
Visual	**Firmly within** the **mild difficulties** range
Tactile	"
Vestibular	"
Taste and smell	**High end** of the **typical** range
Discrimination	
Proprioceptive	**High end** of the **typical** range
Visual	"
Vestibular	"
Auditory	"
Tactile	**Low end** of the **mild difficulties** range
Taste and smell	**High end** of the **typical** range

6.3.1.1 Auditory modulation

In answering this component of the main research question, it was determined that except for percussion, trombone, trumpet and tuba players, all musicians' auditory modulation is above the typical range of the standard population and falls within the mild difficulties range of the ASH. It is noteworthy that except for French horn, all brass players fall within the typical auditory modulation range. These auditory modulation patterns which emerged from the data analysis are shown below in Figure 6-1. This clearly indicates the spread of data with regard to the various instruments across the different sensory functioning levels.

Violin	Piano	Cello	Double bass	Organ	Clarinet	Flute	Oboe	Bassoon	Harp	Viola	Electric/steel string guitar	French horn	Classical/nylon string guitar	Saxophone	Trumpet	Tuba	Percussion	Trombone
24.18	24.16	23.29	22.98	22.87	22.83	22.72	22.71	22.70	22.65	22.63	22.53	22.49	22.42	21.41	20.65	20.64	20.27	19.63
Mild difficulties															**Typical functioning**			

Figure 6-1: Spread of auditory modulation according to the different instrument groups' mean scores

As far as pitch and frequency are concerned, this is interesting since the violin, clarinet, flute, and oboe are midrange to high midrange frequency/pitch[53] instruments. The piano, organ and harp on the other hand cover most of the frequency/pitch spectrum – unlike brass instruments and some tuned percussion which are loud but low to midrange frequency instruments (SINE, 2017:1). (For musical instrument frequencies, refer to Appendix 9.) On the other hand, the finding correlates with some aspects of previous findings which show that musicians are more attentive to music stimuli than non-musicians (Virtala et al., 2018); exhibit superior ability to distinguish frequency changes (Liang et al., 2016); and as a result of a lower auditory threshold, respond more quickly to auditory input (Van Vugt & Tillmann, 2014).

Considering auditory sensitivity, sensory thresholds and low volume, it is fascinating that the classical/nylon string guitar for example did not surface in the definite difficulties range – on the contrary, it is closer to the typical range. Another question that needs to be considered here is if the level of auditory modulation among musicians was part of their sensory profile before playing a particular instrument and whether it is something that developed as a result of playing the instrument. The

[53] Pitch refers to the "perceived quality of sound that is chiefly a function of its fundamental frequency" (Randel, 2003). Pitch, together with loudness and quality (timbre) are the core elements of sound (VanCleave, 2018:1; LoPresto, 2009:145).

exact reason for these findings regarding musicians' auditory modulation patterns therefore remains unknown at this stage.

It was established that in terms of hypothesis 1(b), and thus sub-question 1, the percussion group was the only group within the typical range (high end of this range) regarding auditory modulation. The other groups were in the mild difficulties range of the ASH. However, considering the fact that the mild difficulties range is between -1.00 to -2.00 standard deviations below the typical mean (20.81) for auditory modulation and that definite difficulties are experienced below -2.00, the brass group was very close to the ASH's typical range. As can be seen in Figure 6-2, the percussion and brass players achieved a significantly lower average score than the other three groups (woodwinds, strings and keyboards). The latter three groups' auditory modulation was slightly above the norm which indicates that these groups of musicians are more sensitive to sound than the other two groups and the average person.

Keyboards	Strings	Woodwinds	Brass	Percussion
23.59	22.96	22.54	20.87	20.27
Mild difficulties				**Typical functioning**

Figure 6-2: Spread of auditory modulation according to the different instrument groups' mean scores

It is likely that woodwind and string players in particular are more sound-sensitive to accurately perceiving the higher frequencies of their respective instruments. On the other hand, it is unclear why the same finding emerged among the keyboard players. Furthermore, since auditory modulation involves the ability to integrate auditory information with previous knowledge to carry out meaningful responses (May-Benson, 2015:12; North Shore Pediatric Therapy, 2018a:1), it might correlate with the level of intonation that is required for woodwind and string playing. Conversely, this argument is invalid considering brass players' significantly lower average score (although within the norm’s typical range) and the fact that they are also responsible for accurate intonation.

6.3.1.2 Visual modulation

All 19 instruments’ results were above those of the typical range of the standard population (hypothesis 1(a)) as far as visual modulation is concerned (refer to Figure 6-3). The same was true for hypothesis 1(b) and (c). While harp is at the low end of mild difficulties, in other words closer to typical functioning (31.35), the guitars are closer to definite difficulties (43.66 and higher). This finding suggests that all 19 groups are more sensitive to visual stimuli than the average person. This finding correlates with Landry and Champoux’s (2018) results which indicate that musicians have superior multisensory processing and integration of tactile and visual information which allow them to react significantly more quickly to such stimuli than non-musicians. A surprising finding is that the visual modulation of organists and pianists differs quite a bit. One would think that this has to do with the fact that organists read three staves. However, this would not explain why other instruments reading single-staff notation scored higher than the organists. Except for the fact that all 19 instruments have higher visual modulation scores than the standard population, the relation between each of the instrument groups, as well as the difference between the groups, cannot be explained.

Classical/nylon string guitar	Electric/steel string guitar	Percussion	Trumpet	Saxophone	Bassoon	Double bass	Tuba	Organ	Clarinet	Cello	Viola	Trombone	Oboe	French horn	Violin	Flute	Piano	Harp
37.51	37.24	37.07	36.51	35.91	35.85	35.74	35.61	35.47	35.43	35.26	34.99	34.86	34.58	34.36	34.25	34.16	34.11	32.94

Mild difficulties

Figure 6-3: Spread of visual modulation according to the different instrument groups’ mean scores

While musicians generally seem to have somewhat higher sensory sensitivity than the typical person, I surmise that in the case of keyboard players, it is possible that due to the extreme width of the keyboard, these musicians develop a wider periphery which requires finer visual modulation. However, this does not explain string players' higher visual modulation score. It is possible that over time, musicians develop greater visual sensitivity which allows them to quickly and accurately read and respond to information contained in sheet music. If this is indeed the case, the questions remain why this was found specifically among string and keyboard players, and why the males in both groups achieved significantly higher scores than the female players.

With regard to hypothesis 1(d), a significant difference in the means of visual modulation has been obtained for the two genders among the string and keyboard groups. (Both groups' gender distribution was fairly equal.) For both these groups it was found that male and female visual modulation scores are above the norm indicating greater visual modulation sensitivity/challenges. Furthermore, the males' scores are significantly higher (middle of the mild difficulties range) than those of the females who are at the low end of the mild difficulties range. Despite the fact that this is a fascinating occurrence, the reason for this result is unclear.

6.3.1.3 Tactile modulation

Only two significant findings occurred with regard to this variable. As for hypothesis 1(b), all groups except percussion scored at the low end of mild difficulties, indicating a degree of tactile sensitivity. Unfortunately, the percussion group emerged with a significantly higher standard deviation than the other four groups and they were therefore not further investigated. As pointed out in Chapter 2, modulation dysfunction (or in this case, sensitivity) is often accompanied by sensitivity in multiple sensory systems' registration and processing (May-Benson, 2015:12). Since it has been established that musicians demonstrate higher auditory and visual modulation sensitivity than the standard population, it seems likely that there is a connection between these aspects and musicians' tactile modulation sensitivity. This presumption is based on musicians' extensive use of their auditory, visual and tactile senses. The second finding worth mentioning is the difference between the two genders in the brass group (hypothesis 1(d)). While the males scored within the typical range, the females were in the mild difficulties range. Although this is an interesting finding, there is no specific explanation that can be put forward at this point in time for this outcome. Regarding hypothesis 1(a) and (c), no unusual patterns emerged.

6.3.1.4 Vestibular modulation

Since all vestibular modulation scores fell within the typical range for the various sub-sections of hypothesis 1, no patterns could be established which deviate significantly from the standard population. However, as far as hypothesis 1(c) is concerned, the brass group obtained significant differences in means for the type of instrument. It was found that the French horn players achieved a significantly higher average (in other words closer to the "mild difficulties" range) for the vestibular modulation variable in comparison to the trumpeters and trombonists. It is possible that this is linked to a greater need for tactile vibration and/or proprioception so as to counteract their slight sensitivity to vestibular modulation. It might also explain their choice of instrument. Supporting this supposition, tuba players' vestibular modulation results were similar to the French horn players.

With regard to hypothesis 1(d), significant differences in means for the two genders have been identified in terms of woodwind, string and keyboard players. It was established that, within all these groups, the male musicians achieved significantly lower average scores in comparison to the female musicians who are at the high end of the norm. This indicates that the females might have somewhat more vestibular modulation sensitivity. Consequently, it is possible that this might have some influence on these individuals' self-regulation and emotions (Wilson & May-Benson, 2014). Similarly, both Mihajlovski's (2016) and Kemp's (1981a) sample of professional female woodwind, string and keyboard players was found to be more tense, frustrated, driven and overwrought. Although there were significantly more female woodwind players (male 35.1%; female 64.9%), in light of the findings of

Mihajlovski (2016), Wilson and May-Benson (2014) and Kemp (1981a), it seems unlikely that unequal gender distribution could have influenced the results.

6.3.1.5 Taste and smell modulation

The taste and smell modulation variable produced only two sensory patterns worth mentioning. Both these patterns emerged in terms of hypothesis 1(b). Firstly, while musicians are generally more sensitive to taste and smell (refer to Table 6-3), it is worth mentioning that, secondly, woodwind players' modulation of taste and smell is more sensitive than other musicians. On average, their taste and smell modulation is at the low end of mild difficulties. I am unaware of a specific reason for this divergence and strongly doubt that higher sensitivity in this regard influences the functioning of musicians per se. It should rather be viewed in view of the fact that it confirms that modulation difficulties (or in this case, sensitivity) are often found in more than one sensory system (May-Benson, 2015:12) which is evident in the case of musicians.

6.3.1.6 Overall discrimination

In terms of hypothesis 1(a) to (c), musicians in general have been found to be at the high end of the typical range for all the discrimination variables, except tactile discrimination. Brass players were slightly above the norm. Similar to higher modulation scores, elevated discrimination scores point toward greater sensitivity or awareness of discrimination differences. It is possible that this heightened sensitivity developed as a result of being a musician, but no research to the best of my knowledge is available at this point to confirm this supposition.

6.3.1.7 Proprioceptive discrimination

Only two patterns emerged that are worth mentioning in this regard and that is in connection with hypothesis 1(b) and (d). It has been established that musicians demonstrate greater proprioceptive discrimination sensitivity than the average person. This is in alignment with the results of Clark et al. (2013) and Kolodziej et al.

(2007). Adding to this phenomenon is the fact that this study investigated overall proprioception, while Clark et al. (2013) investigated musicians' right-hand proprioception and Kolodziej et al. (2007) musicians' left-hand proprioception. Nonetheless, I find this very interesting in terms of string players and agree with Kolodziej et al. (2007) that, despite the lack of significance, string players' left hands depend on superior proprioception and sensorimotor integration. These skills are vital, especially in terms of the amount of proprioceptive awareness which is required to apply adequate pressure when pressing strings (standard orchestral strings and guitar), bowing (standard orchestral strings) and plucking the strings (and harp).

The second pattern involves gender differences among the brass and woodwind players. Male woodwind players scored firmly in the typical range of this variable, while female woodwind players' scores were at the high end of the typical range. A similar pattern presented itself concerning the brass players. In this case however, the males were at the high end of the typical range, whilst the females slightly above the typical range. Although this is an interesting occurrence, the cause is unknown.

6.3.1.8 Visual discrimination

An unexpected result of my research is that no significant differences occurred between musicians and the standard population regarding visual discrimination. Although higher scores were obtained by all musician groups, these scores were still within the typical range of the norm. I anticipated superior ability in this aspect considering musicians' enhanced capacity to deduce meaning from visual data (notation) in a short period of time and act on it, as well as their ability to discriminate between auditory stimuli. This is especially in light of research by Penttinen et al. (2015) and Güçlü et al. (2011). Penttinen et al. (2015) determined that pianists have shorter fixations, longer eye-hand span and greater gaze activity. Güçlü et al. (2011) on the other hand found that musicians exhibit better auditory stimuli discrimination than the norm.

6.3.1.9 Vestibular discrimination

Concerning hypothesis 1(d), significant differences in averages for the vestibular discrimination variable between the two genders have been identified for the woodwind and brass players. It was determined that both groups of male participants achieved significantly lower average scores compared to the females. Both groups of males' scores were within the typical range of the norm, while the female woodwind players lean towards mild difficulties. The female brass players on the other hand are at the low end of mild difficulties. In comparison to the norm, female brass players obtained a slightly higher vestibular discrimination score. Although there is not a significant difference between the female brass players and the standard population, it is worthwhile viewing this finding in conjunction with their higher than average proprioceptive discrimination and overall modulation scores, as well as a greater sensitivity in terms of tactile modulation, since challenges in one of these areas are often reflected in other areas (May-Benson, 2015:36).

It is possible that female brass players are attracted to this group of instruments because of the amount of effort which is required by the embouchure-related facial muscles, the weight of the instrument and the high level of vibration to compensate for or counterbalance their slight difficulty in modulation. This is one of the most important findings of this study and may serve as an indication of the influence of sensory state on instrument selection.

Bearing in mind female brass players' personality, it is notable that there is also not a significant difference between them and the normative females. At the same time it is notable that higher vestibular discrimination can be accompanied by some degree of fear/anxiety/avoidance in terms of heights, elevators/escalators and confined spaces (North Shore Pediatric Therapy, 2018b:1; May-Benson, 2015:71-72). This correlates with Kemp's (1982a:56) personality trait finding regarding a higher level of anxiety among female brass players than their normative counterparts. Conversely, male woodwind and brass players' scores are solidly within the typical range of the norm; they differ significantly from the norm in terms of personality traits (Kemp, 1996, 1982a).

Furthermore, although there is not a significant difference between the female brass players and the standard population females, a similar sensory pattern (slight difficulty) trend exists for proprioceptive discrimination, tactile modulation, as well as overall modulation scores. As explained in Chapter 2 under “Functional problems”, a higher proprioceptive discrimination score can point towards sensory seeking and/or sensory over-responsivity. However, this needs to be viewed taking into account effective daily functioning. As pointed out under “The ASH *Scoring Program©*” in Chapter 4, sensory processing difficulty is not necessarily problematic as long as a person is able to compensate for it through adaptive behaviour.

It needs to be kept in mind that despite the significant gender differences between the woodwind players, both genders’ scores fall within the typical range of the standard population. At the same time, the group’s gender distribution was notably uneven. As mentioned earlier, 35.1% of the woodwind players were male and 64.9% female, while the brass sample consisted of 73.7% male and 26.3% female participants. It is unknown if the unequal gender distribution had an effect on the outcome.

6.3.2 Hypothesis 2: significant functional problem findings

Each of the research questions was considered in terms of the functional problem variable. Several sensory patterns became apparent concerning hypotheses 2(a), (b) and (d). On the other hand no significant differences occurred within the various instrument groups (hypotheses 2(c)). Before these patterns are discussed in more detail, Table 6-4 provides an overview of trends which were established among musicians. Similar to sensory modulation and discrimination, it is apparent that musicians are generally more sensitive than the standard population in respect of the functional problem variables.

Table 6-4: Functional problem trends among musicians

Functional problem variable	Musicians in general in comparison to the standard population
Sensory over-responsivity	
Gravitational insecurity	**High end** of the **typical** range
Tactile-related hygiene	"
Discomfort with imposed touch	"
Atypical pain response	**Low end** of the **mild difficulties** range
Discomfort with water	"
Sensory seeking	
Movement	**High end** of the **typical** range
Visual seeking/oculo-motor	**Low end** of the **mild difficulties** range
Touch	**High end** of the **typical** range

As pointed out by May-Benson (2015:36), sensory modulation and/or discrimination difficulties (and/or sensitivity in the case of musicians), might point towards functional problems. On the other hand, sensory seeking behaviours can either reflect modulation or discrimination difficulties/sensitivity. Both these modulation and discrimination patterns are evident in the findings of this study.

6.3.2.1 Sensory over-responsivity behaviours

Regarding sensory over-responsivity, noteworthy results occurred for hypothesis 2(b) and (d) regarding gravitational insecurity. Before the gravitational insecurity variable is discussed in more detail, the other sensory over-responsivity variables are briefly mentioned since significant patterns could be established only for hypothesis 2(b).

Sensory over-responsivity in terms of discomfort with imposed touch, tactile related hygiene, discomfort with water, and atypical pain response frequently coincides with modulation difficulties/sensitivity, particularly mild tactile and vestibular processing difficulties (May-Benson, 2015:31). This sensory pattern emerged for all instrument groups. Table 6-5 provides a summary of these results. While these groups' sensory over-responsivity was either at the high end of typical functioning or slightly above it, higher sensitivity also occurred in terms of their tactile and vestibular modulation.

Table 6-5: Summary of instrument groups regarding sensory over-responsivity

Sensory over-responsivity	ASH range	Instrument group
Gravitational insecurity	**High end** of **typical** functioning	All groups
Tactile-related hygiene	**Low end** of **mild** difficulties	Woodwind; brass; strings; keyboard
	High end of **typical** functioning	Percussion
Discomfort with imposed touch	**Low end** of **mild** difficulties	Woodwind; strings; keyboard
	High end of **typical** functioning	Brass; percussion
Atypical pain response	**Low end** of **mild** difficulties	All groups
Discomfort with water	**Low end** of **mild** difficulties	Woodwind; keyboard
	High end of **typical** functioning	Brass; strings; percussion

Gravitational insecurity as explained in Chapter 2 under "Functional problems" often coincides with vestibular modulation difficulties. Following the analyses in Chapter 5, it was established that, regarding hypothesis 2(b), all instrument groups scored at the high end of the typical range of the norm, indicating possible gravitational insecurity sensitivity. However, as explained earlier, scores which fall within the typical range of the ASH should not be over-interpreted. This finding is therefore merely viewed in light of the fact that musicians are further away from the mean of the typical range.

Furthermore, significant differences in gravitational insecurity means for the two genders have been identified for the following groups: woodwinds, brass and keyboards (hypothesis 2(d)). It was determined that in all three instrument groups, the males achieved significantly lower mean scores than the female respondents. Woodwind and brass males scored firmly within the typical range, while their female counterparts were at the high end of typical gravitational insecurity and might therefore experience more sensitivity in this regard. As for the keyboard group, males were at the high end of the typical range, while the females were slightly above it, indicating a stronger possibility of gravitational insecurity challenges than the woodwind and brass females.

6.3.2.2 Sensory seeking behaviours

The sensory seeking behaviours that were established for the different instrument groups are shown in Table 6-5. It was found that while other instrument groups are at the high end of the typical range of the standard population, the woodwind group is at the low end of the mild difficulties range as regards seeking touch. As explained in Chapter 2, sensory seeking behaviours often go together with either modulation or discrimination challenges/sensitivity “as a way of providing organizing inputs to counteract other uncomfortable stimuli” or “to perceive the input or make the input meaningful” (May-Benson, 2015:36). This pattern which emerged concerning sensory seeking behaviour and modulation/discrimination difficulties is also evident in musicians’ seeking of movement behaviour and visual seeking/oculo-motor functioning. In fact, noteworthy results occurred for visual seeking/oculo-motor functioning in hypothesis 2(a), (b) and (d).

Table 6-6: Summary of instrument groups regarding sensory seeking behaviours

Sensory seeking behaviour	ASH range	Instrument group
Movement	**High end** of **typical** functioning	All groups
Visual seeking/oculo-motor	**Low end** of **mild** difficulties	All groups
Touch	**Low end** of **mild** difficulties	Brass; strings; percussion; keyboard
	High end of **typical** functioning	Woodwind

In terms of hypothesis 1(a), the scores of pianists and violinists are at the high end of typical functioning (refer to Figure 6-4). All the other intruments’ scores are above the typical range but at the low end of mild difficulties. This is intriguing since sensory visual seeking/oculo-motor functioning is linked to modulation. Considering musicians’ higher level of visual modulation which would typically allow them to respond efficiently to visual stimuli, it makes sense that they are visual seeking. This is consistent with Bundy et al.’s (2002:103) finding that modulation sensitivity reflects in either sensory seeking or sensory avoiding behaviours. Despite these findings regarding the different instruments, it was revealed that regarding hypothesis 1(b), all instrument groups were at the low end of mild difficulties.

Trumpet	Percussion	Tuba	Electric/steel string guitar	Double bass	Classical/nylon string guitar	Saxophone	Organ	Trombone	Clarinet	Cello	Flute	Bassoon	Oboe	Harp	French horn	Viola	Piano	Violin
12.86	12.70	12.68	12.53	12.48	12.19	12.09	11.82	11.82	11.68	11.58	11.55	11.54	11.40	11.20	11.01	11.00	10.91	10.69
Mild difficulties																	**Typical functioning**	

Figure 6-4: Spread of visual seeking/oculo-motor functioning according to the different instrument groups' mean scores

As for hypothesis 1(d), significant differences in means regarding gender for three of the groups, namely woodwinds, strings and keyboards, became apparent. It was determined that for all three instrument groups, the males achieved similar and significantly higher mean scores than the females. While all the males were closer to the middle of the mild difficulties range, the female string and woodwind players' visual seeking/oculo-motor scores were slightly higher than the typical population, while the female keyboard players were at the high end of the typical range. In terms of this finding, it is evident that there is a link between this finding and musicians' slight visual discrimination sensitivity. Even more interesting is the fact that similar patterns emerged for these group's gender scores regarding the visual discrimination variable. This points towards over-responsivity, in other words greater visual sensitivity which provides them with superior reflexes to visual input (Landry & Champoux, 2018; May-Benson, 2015:36). However, this does not explain the gender difference.

6.3.3 Hypothesis 3: significant motor/social findings

With regard to all motor/social variables, musicians scored at the high end of the typical range. While these scores still fall within the typical range of the ASH's standard population, it is intriguing that musicians lean towards the more sensitive side of the range. This section provides a discussion of findings relating to each of the three main variables which are contained in the motor/social components section. These are postural control, social/emotional functioning and motor coordination. No significant findings emerged for hypothesis 3(a) and (c). On the other hand, noteworthy results were obtained for hypothesis 3(b) and (d). The percussion group was also excluded from hypothesis 3's analyses due to its significantly higher standard deviation from the norm than the other groups.

6.3.3.1 Postural control

It was determined that all instrument groups were at the high end of the typical range of the ASH. Although these scores still fall within the typical range, challenges in this area often coincide with higher discrimination and motor coordination scores (May-Benson, 2015:37) – which is true in the case of the musicians who participated in this study. Taking into consideration postural-ocular skills which are required for reading, depth perception and eye-hand coordination (North Shore Pediatric Therapy, 2017c:1), it is probable that enhanced sensitivity among musicians might be linked to their superior eye-hand coordination. Furthermore, and as explained by May-Benson (2015:37), postural control difficulties often go together with motor coordination, proprioceptive processing and/or vestibular processing. It is therefore noteworthy that musicians obtained higher scores for all three of these aspects.

6.3.3.2 Social/emotional functioning

Noteworthy findings only emerged for hypothesis 3(b) and not for (a), (c) or (d). All instrument groups scored at the high end of the typical range for the aggressive/impulsive and anxious variables. While the strings, brass and keyboard players were in the high typical range for being withdrawn/depressed, the woodwind players scored at the low end of mild difficulties. As explained in Chapter 2, the social/emotional traits which are contained in the ASH often coincide with sensory processing difficulties. Although it is perhaps more accurate to refer to sensitivity than difficulties in the case of musicians, these patterns were evident among the musicians in this study.

Furthermore, except for aggressiveness, many scholars, for example Kenny and Halls (2018), Bandi et al. (2017) and Kemp (1996), have observed trends and differences among musicians regarding the personality traits which are contained in the ASH. As indicated in the research of these scholars, string players (particularly cellists) and woodwind players are more withdrawn/aloof/introverted than other musicians and non-musicians. The findings of this study therefore partially support this in terms of its woodwind sample. The findings of this study also support those of previous studies pertaining to anxiety and depression which are often found among musicians (Kenny & Halls, 2018; Bandi et al., 2017). As far as I am aware, the personality traits which are contained in the ASH and have been studied from a personality perspective among musicians, are now for the first time connected to sensory processing difficulties/sensitivity. In addition to isolated sensory patterns which have previously been identified among musicians, past personality trait research identified depression, impulsivity introversion, and anxiety as mere traits commonly found among musicians without being able to connect these to higher levels of sensory sensitivity than the average person.

6.3.3.3 Motor coordination

It was found that musicians overall scored at the high end of the typical range of the standard population in terms of all four motor coordination variables. As far as the comparison of instrument groups is concerned (hypothesis 3(b)), several patterns emerged which can be viewed in Table 6-7. It is fascinating that the same motor coordination patterns emerged regarding the fine motor, motor planning and sequencing variables. This correlates with Krause et al.'s (2010) research which indicates superior coordination among musicians. In addition, Krause et al. (2010) found that drummers (who have been excluded from further analysis in this study) have superior coordination in comparison to other musicians and non-musicians. However, it needs to be taken into account that apart from drummers, their musician sample consisted of pianists and singers only and was significantly smaller than this study. No significant findings arose as far as hypothesis 3(a) and (c) are concerned.

Table 6-7: Summary of instrument groups regarding motor coordination

Motor coordination variable	ASH range	Instrument group
Fine motor	**High end** of **typical** functioning	Woodwind; brass; keyboard
	Low end of **mild** difficulties	Strings
Motor planning	**High end** of **typical** functioning	Woodwind; brass; keyboard
	Low end of **mild** difficulties	Strings
Oral motor planning	**High end** of **typical** functioning	All groups
Sequencing	**Low end** of **mild** difficulties	Woodwind; brass; keyboard
	High end of **typical** functioning	Strings

As far as gender is concerned (hypothesis 3(d)), it was found that significant differences emerged only for the string group. The males in the group achieved significantly higher average scores than the female musicians, yet still within the typical range of the norm. This is interesting since one would rather have anticipated either lower scores or superior motor planning skills for the group as a whole. At the same time, this finding correlates with the fact that, in comparison to the other groups, the string players did not emerge with any extreme sensory discrimination sensitivity pattern.

6.4 Significance of contributions

This pioneering study contributes a new dimension according to which the relation between musicians and their instruments can be explored. It was established that musicians are generally more sensitive in terms of all the variables contained in the ASH. At the same time, I anticipated more significant differences between musicians' sensory patterns and those of the standard population. Nevertheless, the findings provide a better understanding of these differences. Importantly, the results give rise to further questions and hypotheses for future research.

This was the first study employing the ASH to determine sensory patterns among musicians; it was also the first thorough inquiry into these patterns using a reliable and validated occupational therapy assessment. Previous research focused on isolated sensory patterns and personality traits: for the first time with this research a correlation was drawn between musicians' sensory patterns and their personality traits. This provides a deeper and more holistic understanding of the musician profile. Furthermore, in addition to the variables which influence musicians' choice of instrument (refer to Chapter 1), the sensory patterns' research that was done in this study provides a far greater understanding of the intricacies which are involved in achieving this goal.

Apart from this, new light is shed on variables that influence choice of instrument and, for this reason, 19 instruments have been included. This was done in view of the fact that since this is a groundbreaking study, the aim was to provide other researchers with a thorough basis for further investigation. In addition, the large number of 1327 participants from more than 60 countries makes it possible to generalise the findings to especially the Western population of musicians[54]. Most of these musicians were recruited via Facebook by posting advertisements on a 107 musician groups/pages. I concur with Carter-Harris (2016), as well as Grieve, Witteveen and Tolan (2014) that Facebook can be used as a viable and reliable platform for social research if such data is managed well.

Lastly, the present study provides occupational therapy researchers with a new population of participants in terms of sensory patterns – musicians. As pointed out in Chapter 1, this is particularly valuable in terms of comparing musicians' sensory patterns/profile to the general population. Apart from this, the data from this study provides the Spiral Foundation with a normative South African musician sample.

6.5 Limitations

The reliance on self-reported data could have influenced the findings. However, participants were requested to truthfully answer all questions in the ASH. At the same time, most participants requested the results of their sensory assessment which, in my opinion, increased the likelihood of reliability.

No preference was given to musical style or number of years/hours of practice these participants have invested in playing and studying their instruments. As a result of

[54] As mentioned in Chapter 4, the majority of participants were from the United States of America (approximately 510 participants), South Africa (approximately 350 participants) and England/UK (approximately 185 participants).

literature (Proverbio & Bellini, 2018; Vuust et al., 2012) that was consulted, it is possible that these aspects could have influenced the results. Likewise, the effect of the amount of time professional performers and music teachers spend playing their instruments was not taken into account and the influence thereof is thus unknown.

Following the results, it would have been worth determining if gender is in fact an influencing factor. In retrospect, I would therefore have liked to have recruited more male woodwind players and more female brass and percussion players to even out the unequal gender representation.

6.6 Recommendations

As a result of this first-of-its-kind study there are a vast number of possibilities to further explore the connection between musicians, their primary instruments and their sensory patterns. Ultimately, the contribution of this study is part of a larger pursuit to compile musician-instrument profiles and a tool for choosing a musical instrument. In order to achieve this, a longitudinal inquiry is necessary to record the character traits/personality, mental, physical, emotional and sensory development of musicians. If this as well as the instrument/s they pursue are monitored during their journey of mastering their instrument/s and becoming professional musicians, it might be possible to determine the typical profile of a musician based on how it changes over time. Once this has been confirmed, it could be feasible to design a reliable assessment tool in order to establish which instrument is the “most suitable” for a particular individual. This study brings researchers a step closer to achieving this, both in terms of its findings, as well as the following areas that were consequently exposed as opportunities for further research:

- Changes in musicians’ sensory patterns as a result of aging
- Reasons for divergent sensory patterns among musicians playing the same instrument
- A study similar to this one, but including a personality inventory in order to draw a quantitative parallel between the same group of musicians’ sensory patterns and their personality traits

- The link between proprioceptive discrimination and focal hand dystonia among musicians, especially string players (standard orchestral strings and guitar)
- The influence of playing an (any particular) instrument on a person's sensory profile
- Reasons for gender differences among musicians' sensory patterns
- The influence of gender distribution among woodwind and brass players; and to what degree equal gender distribution would influence the results
- The influence of musicians' personal background, work conditions, living in a specific country or place in a country, socio-economic factors, intelligence, musicality, medical history/conditions, and physical/ mental disabilities
- Drummers and orchestral percussionists' sensory patterns
- The effect of a person's cultural background on their choice of instrument and sensory patterns.

6.7 Conclusion

The foremost aim of this study was to examine the relation between musicians' sensory patterns and their primary musical instrument. In addition, the connection between the sensory patterns of musicians from different instrument groups, musicians within the various instrument groups, as well as gender within these groups was investigated. Not only could these relations be determined and the research questions be answered, but by employing the ASH, a fresh understanding of the connection between musicians and their instruments could be established. For the first time, extensive research was done concerning the sensory patterns of musicians, providing clear direction for future research.

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APPENDIX 1

Example of informal invitation to participate (LinkedIn)

Dear …

Thanks for accepting my request to connect! I'm busy with my PhD and want to establish if musicians playing a particular instrument share similar sensory characteristics. Would you be willing to participate? It involves a 30-minute online questionnaire (link below). In exchange, you'll receive the results of your sensory test free of charge.

https://www.surveymonkey.com/r/MusicSen

Kind regards

Tronél Hellberg
tronelhellberg@mweb.co.za

APPENDIX 2

Example of informal invitation to participate (Facebook)

Dear fellow musicians!

I'm busy with my PhD on the sensory characteristics of musicians and am looking for participants playing one/more of the following instruments:

Woodwinds: flute, oboe, clarinet, bassoon or saxophone

Brass: French horn, trumpet, trombone or tuba

Percussion: orchestral percussion or drum kit

Keyboards: piano or pipe organ

Strings: violin, viola, cello, double bass, harp, classical/nylon string guitar or electric/steel string guitar

It involves a 30-minute online questionnaire. In exchange, you'll receive the results of your sensory test free of charge. :) Participants must be a music lecturer, qualified music teacher, professional performer or final year/postgraduate student specialising in one of the instruments listed above. Should you be interested, please reply/send me a message.

Thanks!

Tronél Hellberg

APPENDIX 3

Example of formal invitation to participate (orchestras)

Dear Directors and Members of … Orchestra

I am a PhD student at the University of the Free State, South Africa and I would like to invite … Orchestra to participate in my study.

The title of my thesis is "Musicians' sensory patterns in relation to their primary musical instrument". This is a groundbreaking study in that it is the first study in the world that uses a validated sensory test (used in occupational therapy) to establish a possible link between musicians, their instruments and sensory patterns.

The instruments that I include in my study are as follows:

Instrument group	Instruments
Woodwinds	Flute, oboe, clarinet, bassoon and saxophone
Brass	French horn, trumpet, trombone and tuba
Percussion	Orchestral percussion and drum kit
Keyboards	Piano and pipe organ
Strings	Violin, viola, cello, double bass, harp classical/nylon string guitar and electric/steel string guitar

In order to reach statistical significance, my aim is to recruit 1 330 participants (70 per instrument) involving professional musicians, music teachers, music lecturers and final year/postgraduate music students specialising in one of the instruments listed above. I would sincerely value it if orchestra members who meet one/more of these criteria, can complete a 30-minute questionnaire. The questionnaire can be accessed via the link below. (It is important not to exit the questionnaire before completing it, otherwise one has to start all over.)

https://www.surveymonkey.com/r/MusicSen

Yours sincerely

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APPENDIX 4

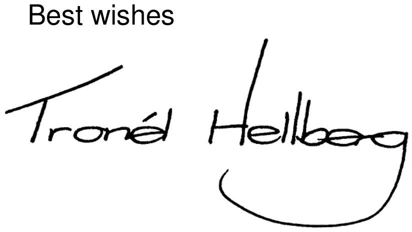
Explanation of Adult/Adolescent Sensory History results

For my study, I use the *Adult/Adolescent Sensory History* self-report questionnaire to determine if there is a connection between musicians playing a specific musical instrument and their sensory characteristics. However, the main purpose of this questionnaire is for occupational therapists to establish if an individual experiences difficulty with processing and integrating sensory information.

The *Adult/Adolescent Sensory History* is a validated and standardised test which is used by occupational therapists for clinical assessment and to create an intervention plan if necessary. Although this test has aspects in common with Winnie Brown and Dunn's *Adolescent/Adult Sensory Profile* test, it provides thorough insight into each sense and therefore my reason for using it. The table below explains the interpretation of the test results. **Please do not be alarmed if your results show some mild or even definite difficulties!** In the case of "definite difficulties", it does not necessarily mean you should be worried or need intervention – it depends on the severity! If you are already aware of a specific difficulty which the test confirmed and it has a negative impact on your functioning, you are encouraged to discuss it with an occupational therapist. If the result shows "mild difficulties" and it does not impact your ability to function effectively, there is no need to be concerned. Having a better understanding of one's sensory processing, has been shown to have a positive impact on these scores without any intervention. Should you require further assistance, detail, or clarification, please do not hesitate to contact me!

Interpretation	Explanation	Score
Typical	Typical of most people	Above -1.0
Mild	Mild difficulties	From -1.0 to -2.0
Definite	Definite difficulties	Below -2.0

Best wishes



APPENDIX 5

Glossary of occupational therapy terms

Glossary of Occupational Therapy Terms

Gravitational insecurity: Extreme fear and anxiety that one will fall when one's head position changes.[1]

Motor Coordination: The ability of several muscles or muscle groups to work together harmoniously to perform movements.[1]

Proprioception: The unconscious awareness of sensations coming from one's joints, muscles, tendons and ligaments; the "position sense".[1]

Sensory discrimination: Ability to efficiently recognise "the details both within the sensory input, and between different sensations (such as smell, taste, vision and hearing) and to organise the information. This is the 'what is it' sense."[2]

Sensory modulation: Sensory modulation is a neurological function which regulates sensory information for ongoing use.[3] Efficient sensory modulation involves the ability to regulate the reaction to sensory input in a graded manner (jumping when you hear a loud bang, but not when the air conditioner cycles on). The balancing of excitatory and inhibitory inputs, and adapting to environmental changes (not jumping at every bang when your office is next to a large construction job).[4]

Sensory over-responsiveness: Avoids sensory input.

Sensory seeking: Seeks sensory input.

Tactile: Refers to the sense of touch and various qualities attributed to touch: to include detecting pressure, temperature, light touch, pain, discriminative touch.[1]

Vestibular: Refers to our sense of movement and the pull of gravity, related to our body.[1]

Visual-spatial processing skills: Perceptions based on sensory information received through the eyes and body as one interacts with the environment and moves one's body through space. Including: Depth perception, directionality, form constancy, position in space, spatial awareness, visual discrimination, visual figure-ground.[1]

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[1] Alternatives for Children. n.d. *Glossary of commonly used Occupational Therapy terms.* http://www.alternatives4children.org/glossary/occupational-therapy-glossary.pdf [accessed 8 July 2015].
[2] Pediatric Therapy and Learning Center. 2016. *Sensory discrimination.* http://pediatrictlc.com/sensory-discrimination/ [accessed 22 July 2016].
[3] North Shore Pediatric Therapy. 2014. *What is Sensory Modulation?* http://nspt4kids.com/healthtopics-and-conditions-database/sensory-modulation/ [accessed 22 July 2016].
[4] School-OT.com. n.d. *Sensory integration 101.* http://www.school-ot.com/Sensory%20101.html [accessed 10 February 2017].

APPENDIX 6

Adult/Adolescent Sensory History (questionnaire)

Spiral foundation — Sensory Processing Institute for Research and Learning

The Koomar Center — OTA — Collaborative Therapists • Sensory Integration

Adult/Adolescent Sensory History
Self-Report Questionnaire

Jane Koomar, PhD, OTR/L, FAOTA & Teresa May-Benson, ScD, OTR/L, FAOTA
(Contributions by Mandy Hurwitz, Rebecca Kahler-Reis, Stacey Szklut)

GENERAL INFORMATION **Date:** ________________

Name: ______________________________ **Birth Date:** ____________
(First) (Last) (Nickname)

Address: ______________________________ **Phone:** ____________

Gender: ☐ Male ☐ Female

Race/Ethnicity: ☐ Caucasian/White ☐ Hispanic ☐ African-American/Black ☐ Native-American ☐ Asian ☐ Other *(specify)* ________

Marital Status: ☐ Married ☐ Separated ☐ Divorced ☐ Widowed ☐ Single ☐ Other *(specify)*: ______________________

Highest Education Completed:
☐ Less than high school ☐ High school ☐ Some college/Associate's
☐ Bachelor's ☐ Post-graduate ☐ Doctorate/Post-doctorate

Occupation: ______________________________

Reason for referral: ______________________________

____

____

What do you hope to gain from this evaluation and/or treatment? ______________________________

____

____

____

____

Scoring Key:

5 = You almost **Always** respond this way (e.g., more than 95% of the time)
4 = You **Often** respond this way (e.g., about 70 - 95% of the time)
3 = You **Sometimes** respond this way (e.g., about 30 - 69% of the time)
2 = You **Rarely** respond this way (e.g., about 5 - 29% of the time)
1 = You **Never** respond this way (e.g., less than 5% of the time)

INSTRUCTIONS: Please check the box that best describes how frequently you routinely have a response. Refer to the scale when answering. If you are unsure about a response, answer to the best of your ability and clarify in the comments section. If you have not experienced a response, score as Never and indicate this in the comment section. ***You must provide a response to all questions.***

Scale: 5-Always 4-Often 3-Sometimes 2-Rarely 1-Never

VISUAL AND SPATIAL PROCESSING						
Do you…	**5**	**4**	**3**	**2**	**1**	**Comments**
1. Blink at bright lights or seem irritated by them?						
2. Become easily distracted by visual stimulation?						
3. Avoid or have difficulty with eye contact?						
4. Keep lights very low or off in house or prefer to use low watt bulbs?						
5. Keep shades pulled down?						
6. Prefer to have a limited number of items in the house or on the walls?						
7. Dislike bright colored clothing?						
8. Dislike furniture or rugs with patterns or flowers?						
9. Overly attend to small visual details?						
10. See people in two dimensions?						
11. Prefer to look from the side?						
12. Like to stare at lights or oncoming headlights?						
13. Prefer wall and/or ceilings painted dark colors?						
14. Like to watch fast-changing TV segments or often "channel surf"?						
15. See only parts of a room at a time?						
16. See through a haze or fog?						
17. See double?						
18. Have difficulty finding your way from a map?						
19. Have difficulty focusing to thread a needle?						
20. Have difficulty looking for items on a grocery shelf?						
21. Tend to draw some numbers or letters backwards?						
22. Have difficulty doing puzzles?						

Scale: 5-Always 4-Often 3-Sometimes 2-Rarely 1-Never						
Do you…	**5**	**4**	**3**	**2**	**1**	**Comments**
23. Have difficulty interpreting drawings in comics or cartoons?						
24. Have difficulty matching socks?						
25. Have difficulty finding a familiar face in a crowd?						
26. Have difficulty figuring out how to arrange furniture in a room?						
27. Have difficulty following traffic signs while driving?						
28. Have trouble following objects with your eyes?						
29. Have difficulty locating the appropriate aisle in a store?						
AUDITORY AND LANGUAGE PROCESSING						
1. Seem overly sensitive to sounds?						
2. Become distracted by lots of noise?						
3. Become distracted by background noises such as refrigerators?						
4. Avoid going places that may be too loud?						
5. Feel angry when there is too much noise?						
6. Become bothered by the hum of a fan or light?						
7. Attend to intruding noises like mowers, planes going overhead or sirens more than most people?						
8. Have difficulty understanding the words to a song when listening to music?						
9. Have difficulty attending to a conversation when there is background noise?						
10. Seem to have trouble remembering or understanding what is said?						
11. Have trouble finding the language to express what you want?						
12. Have trouble following two or three verbal directions given at once?						
MOVEMENT (VESTIBULAR PROCESSING)						
1. Avoid fast carnival rides that spin or go up and down?						
2. Avoid roller coasters?						
3. Dislike flying in airplanes?						

Scale: 5-Always 4-Often 3-Sometimes 2-Rarely 1-Never

Do you…	5	4	3	2	1	Comments
4. Become carsick easily?						
5. Become upset when head is tilted backwards (e.g., as in hair washing or showering)?						
6. Have difficulty if not in the front seat while riding in a car?						
7. Seek fast movement activities (e.g., biking, skiing, carnival rides)?						
8. Dislike roughhousing?						
9. Rock in your seat?						
10. Enjoy jumping a lot?						
11. Shake/rock/bang your head?						
12. Seem fearful of heights?						
13. Dislike elevators or escalators?						
14. Hesitate or avoid climbing ladders?						
15. Seem fearful of catching balls?						
16. Hesitate going up or down stairs?						
17. Have difficulty riding a bike?						
18. Have difficulty merging while driving onto a freeway?						
19. Have difficulties with balance?						
20. Fall when on a bus, car or subway that stops quickly?						
21. Have difficulty driving a car?						
22. Dislike having your eyes covered?						
23. Experience things as moving which are not moving?						
24. Have difficulty traveling through a tunnel without feeling uncomfortable?						
25. Have difficulty finding a seat in a dark movie theater?						
26. Get disoriented in space easily?						
27. Have trouble discriminating fast and slow motion?						
28. Have difficulty when crossing over bridges?						

Scale: 5-Always 4-Often 3-Sometimes 2-Rarely 1-Never						
Do you…	**5**	**4**	**3**	**2**	**1**	**Comments**
TASTE AND SMELL						
1. React negatively or seem overly sensitive to odors (e.g., perfume, foods, cleaners)?						
2. React negatively to the taste of foods?						
3. React negatively to the texture of foods?						
4. Find it uncomfortable to eat at restaurants because of food or smells?						
5. Have more difficulty eating textured than smooth foods?						
6. Have difficulty eating smooth foods with a few lumps (e.g., soup)?						
7. Lick, suck or chew on non-food items (e.g., hair, pencils)?						
8. Tend to explore with smells, or deliberately smell objects?						
9. Like drinks/food that are only room temperature, not hot or cold?						
10. Feel as though all foods taste the same?						
11. Seek out crunchy or chewy foods?						
TOUCH (TACTILE PROCESSING)						
1. Become irritated by tags in the back of your shirts?						
2. Become bothered by clothing or socks?						
3. Avoid getting your hands into messy things?						
4. Tend to be more sensitive to pain than others?						
5. Become especially bothered by small cuts?						
6. Notice irritating bumps on your bed sheets?						
7. Over or under dress for the temperature?						
8. Seem overly sensitive to food or water temperature?						
9. Crave being held or cuddled?						
10. Prefer tight exercise-type clothing?						
11. Seem excessively ticklish?						
12. Prefer to touch rather than be touched?						

Scale: 5-Always 4-Often 3-Sometimes 2-Rarely 1-Never						
Do you…	**5**	**4**	**3**	**2**	**1**	**Comments**
13. Dislike light touch in intimate relationships?						
14. Become very angry/annoyed when bumped or pushed unexpectedly?						
15. Dislike having your arms or back stroked?						
16. Become bothered by people sitting/standing too close to you?						
17. Dislike haircutting or shampooing?						
18. Dislike fingernail or toenail cutting?						
19. Have difficulty petting animals due to feeling of fur?						
20. Tend to prefer long sleeves and pants regardless of weather?						
21. Dislike water running onto your face in the shower?						
22. Dislike going barefoot?						
23. Strongly dislike showers?						
24. Become extremely irritated when splashed with water?						
25. Dislike shaving?						
26. Mouth objects or clothing frequently?						
27. Tend not to feel pain as much as others?						
28. Seem oblivious to bruises and heavy falls?						
29. Tend to examine objects by touching them thoroughly with your hands?						
30. Have difficulty finding objects in your pockets or purse without looking?						
31. Have difficulty applying shaving cream thoroughly to your face or legs?						
32. Have difficulty recognizing food stuck on your face or the need to blow your nose?						
33. Need to have coarse textures next to your skin?						
PROPRIOCEPTION						
1. Tend to bump into things?						
2. Over or underestimate amount of force needed for a task?						

Scale: 5-Always 4-Often 3-Sometimes 2-Rarely 1-Never

Do you…	5	4	3	2	1	Comments
3. Seem shaky when doing fine motor tasks?						
4. Tend to grasp objects very tightly?						
5. Tend to break many objects?						
6. Tend to drop things easily?						
7. Tend to eat in a sloppy manner?						
8. Tend to spill liquids?						
9. Have trouble chewing?						
10. Think of yourself as clumsy?						
POSTURAL CONTROL						
1. Tend to move in and out of your chair while eating or doing work?						
2. Prefer to stand while working?						
3. Find physical activity organizing when overloaded or irritated?						
4. Grimace or move tongue while doing fine motor tasks?						
5. Tire easily with physical activity?						
6. Slump while sitting?						
7. Keep your mouth open?						
8. Chew with your mouth open?						
9. Hold a pencil differently than most people?						
10. Experience fatigue in your hand with writing?						
11. Tend to be slow in eating?						
MOTOR COORDINATION (PRAXIS SKILLS)						
1. Find small manipulative activities difficult?						
2. Avoid fine motor activities?						
3. Have difficulty following the steps of a recipe?						
4. Take a long time to do most motor tasks?						
5. Have difficulty planning a dinner, including setting the table, organizing timing of meals, etc.?						

Scale: 5-Always 4-Often 3-Sometimes 2-Rarely 1-Never

Do you…	5	4	3	2	1	Comments
6. Tend to be slow in dressing?						
7. Misunderstand meaning of words in relation to movement or body position (e.g., up, down, behind)?						
8. Have difficulty with motor tasks that have several steps?						
9. Dislike participating in sports or games?						
10. Have difficulty learning exercise steps or routines?						
11. Have difficulty reproducing a rhythm with your hands?						
12. Lose track of the sequence of an activity?						
SOCIAL/EMOTIONAL						
1. Tend to prefer to be alone?						
2. Have a strong desire for sameness and routine?						
3. Seem sensitive to criticism?						
4. Lack self confidence?						
5. Tend to be quiet and withdrawn?						
6. Feel discouraged or depressed?						
7. Tend to crave attention?						
8. Have strong outbursts of anger?						
9. Have trouble getting along with others?						
10. Tend to be active and aggressive?						
11. Tend to lack carefulness?						
12. Tend to be impulsive?						
13. Tend to be easily frustrated?						
14. Have difficulty separating from parents or other loved ones?						
15. Have fears of leaving your home on a daily basis?						
16. Have panic attacks?						
17. Have anxiety attacks?						

APPENDIX 7

Letter of informed consent

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
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Co-supervisor:
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15 February 2016

Dear Participant

Re: Informed consent

I would like to invite you to participate in a research project titled *Musicians' sensory patterns in relation to their primary musical instrument*. The study investigates the link between a musician's sensory preferences and instrument of specialisation, in order to gain a better understanding of musicians playing a particular instrument. Since you are a professional performer, music lecturer/teacher or a final year/postgraduate music student specialising in a particular instrument, you are invited to participate in the study.

No risks are involved and no remuneration is offered. Participants are required to complete two questionnaires. The first questionnaire concerns your sensory history using a standard occupational therapy test while the second questionnaire is linked to your musical profile. It will take approximately 40 minutes to complete both questionnaires. In return and if you so prefer, you will receive a report of your sensory history results, providing you with a better understanding of your sensory preferences. I will also provide you with the findings of the study if you are interested.

While I greatly appreciate your willingness to participate in this important study and the valuable contribution you can make, participation is entirely voluntary and you are under no obligation to take part in the study. Your identity and information will be treated with great care and confidentiality. As participant, you are free to withdraw at any point without further obligations. Should you be unhappy or have any concern regarding the way in which the research is being conducted, do not hesitate to contact me or my supervisors. If you have questions about your rights as participant, you may contact Charné Vercueil on +27 (0)51 4017083 or send her an email at VercueilCC@ufs.ac.za.

Yours sincerely

Tronél Hellberg

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INFORMED CONSENT

Please complete and return this page. Keep the letter above for future reference.

Study: Musicians' sensory patterns in relation to their primary musical instrument

Researcher: Tronél Hellberg

I hereby give free and informed consent to participate in the above mentioned research study. I understand that participation is voluntary and that I may withdraw at any point without further obligations.

Name: ____

Surname: ____

Contact number: ______________________________________

Email address: ____

I would like to have the results of my sensory test. | Yes | No |

Should you wish to have the results of your sensory test and choose to complete the questionnaires anonymously, please provide your pseudonym in order for me to process your request. ______________________________

I am interested in the results of the study. | Yes | No |

______________________________ ______________________

Signature of participant Date

APPENDIX 8

Adult/Adolescent Sensory History means and standard deviations

Variable	Mean	SD	Typical range	
Discrimination	**110**	**24.57**	**85.43**	**134.57**
Auditory	10.5	3.56	6.94	14.06
Proprioceptive	21.6	6.77	14.83	28.37
Tactile	13.1	3.78	9.32	16.88
Taste and smell	9	2.84	6.16	11.84
Vestibular	34	8.56	25.44	42.56
Visual	22	6.23	15.77	28.23
Modulation	**109**	**23.66**	**85.34**	**132.66**
Auditory	15.5	5.31	10.19	20.81
Tactile	42	10.98	31.02	52.98
Taste and smell	10.9	3.55	7.35	14.45
Vestibular	15.5	5.49	10.01	20.99
Visual	25.2	6.15	19.05	31.35
Sensory over-responsivity				
Gravitational insecurity	18.1	6.07	12.03	24.17
Tactile-related hygiene	6	1.7	4.3	7.7
Discomfort with imposed touch	11.9	4.14	7.76	16.04
Atypical pain response	5	1.84	3.16	6.84
Discomfort with water	7.6	2.57	5.03	10.17
Sensory seeking				
Movement	10.1	2.77	7.33	12.87
Visual seeking/oculo-motor	8.4	2.56	5.84	10.96
Touch	7.2	2.36	4.84	9.56
Postural control	22.9	6.18	16.72	29.08
Social/emotional				
Aggressive/impulsive	13.2	3.91	9.29	17.11
Anxious	5.8	1.86	3.94	7.66
Withdrawn/depressed	15.4	3.98	11.42	19.38
Motor coordination				
Fine motor	8.6	3.07	5.53	11.67
Motor planning	10	3.55	6.45	13.55
Oral motor planning	9.7	3.12	6.58	12.82
Sequencing	8.8	3.71	5.09	12.51

APPENDIX 9

Musical instrument frequency chart