# THE ROLE OF INCIDENTAL PROCESSES IN MUSICAL SKILL ACQUISITION:

A MIXED ETHNOGRAPHIC AND EXPERIMENTAL APPROACH

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## Declaration of Authorship

I, Micka Clayton, hereby declare that this thesis, and the work presented in it, is entirely my own. Where I have consulted the work of others, this is always clearly stated.

Signed: ______________________

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# ABSTRACT

Explicit instruction and demonstration are standard pedagogical tools for learner acquisition of subject-specific knowledge and specialised motor skills. However, research in diverse fields such as memory and retention, language learning, and sport, has found intrinsic benefits when acquisition occurs incidentally. These include faster learning and automation of motor skill, more accurate retrieval of information, lessening the burden on working memory, and reliability of skills under pressure. Applications for inducing incidental learning to exploit these benefits have been established, and ongoing research continues to inform new developments in these fields. Despite clear parallels with the acquisition of specialised knowledge and motor skill in musical performance, little research has been undertaken or applications developed in music-specific contexts. This thesis draws on theory and examples of incidental learning from existing literature, considers potential applications for music performance, and adopts a mixed-method approach to practical research assessing this potential. This includes a.) ethnographic observations of real-life music lessons, and a survey of instrumental music teachers indicating widespread use of pedagogical practices that facilitate incidental skill acquisition in students, b.) a sight-reading experiment with skilled musicians, employing standard protocols of implicit sequence learning, demonstrating improved reaction times and note accuracy of an undetected, repeated musical sequence versus random notes, and c.) a proof-of-concept study, delivering an experiment-driven curriculum to a group of young novice musicians enrolled in a week-long music programme, who acquire musical skills incidentally through games, with significant before-and-after test results. The successful use of music with existing experimental protocols confirms both the transferability of learning research findings to a music context and, in turn, the viability of music as multi-sensory modality for learning research. Furthermore, the high prevalence of incidental skill acquisition in existing teaching conditions paves the way for the development of targeted applications, with a preliminary test of this concept providing promising results.

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# INTRODUCTION

As a young professional musician and teacher in South Africa, I entered into my first orchestral outreach programme with slight apprehension. It seemed surreal to approach children in abject poverty with a violin or a clarinet and offer to teach them how to play, as if that would make any difference to their plight. What I soon found out, was that even in the direst of circumstances, music has the power to bring light and joy, hope and purpose. For many, it did make all the difference.

Following this and subsequent experiences, I acquired the strong conviction that every child deserves a music education, but more than this, that our teaching methods needed to be adjusted and adapted to ensure that such an education would be accessible, flexible, and effective for all children – a cause for which I advocated throughout my career. It became evident, however, that lasting, meaningful change would need more than this. If I wanted to be heard, I needed a louder voice, an erudite and persuasive one.

In 2015, I therefore embarked upon my journey in the United Kingdom, enrolling for a post-graduate diploma in music pedagogy at the Trinity Laban Conservatoire for Music and Dance. It was there, in conversation about the need for science-based evidence of the efficacy of musical interventions to procure music education funding, that I first took genuine cognisance of the collaboration of music and science for improved knowledge and outcomes. I instantly knew that I needed to contribute to this field, and my path was set.

As part of my studies at Trinity, I attended a piano master class with renowned pianist Martino Tirimo, for an assignment to evaluate advanced teaching practices in music. One of the undergraduate students asked maestro Tirimo whether he knew of any "tricks" to memorise a piece of music quickly. His initial response was short and to the point – "in music, there are no shortcuts". He then went on to explain that, in his experience, by the time he had engaged with the music in all the ways necessary for gaining a deep knowledge and understanding of the melodic phrases, the harmonic progression, the rhythmic patterns, the structure and character of the piece, memorisation was an *incidental* "side-effect". This idea of incidentally acquiring musical skills while pursuing different learning goals was intriguing, and I wanted to see if this could be tested in practice.

I subsequently devised an informal experiment for another assignment on the same course, providing a group of piano students with the same intricate musical phrase to play. Half of the group was instructed to deliberately memorise the phrase, while the other half was told to play the notes according to a set of rhythms, indicated by dashes for long notes and dots for short ones, similar to Morse code (see Appendix A). After a predetermined number of repetitions, the sheet music was removed, and the students were asked to play the phrase from memory. As hypothesised, the rhythm group, who never intentionally attempted memorisation, performed markedly better than the other. This conceptually replicated, in the music domain, word memorisation experiments that had shown that recall is better when participants are required to overtly organise the to-be-remembered material according to some novel spatial or class categories (like the Morse code rhythms) than when they are merely instructed to memorise it (Ornstein & Trabasso, 1974). In other words, the very process of organising material can result in the incidental learning of that material.

Galvanised by these initial observations of incidental musical learning, in the current thesis, Chapter 1 explores what is known about this phenomenon in various fields of study. As the name suggests, incidental learning can be defined as “a byproduct of some other activity” (Marsick & Watkins, 2001, p. 25). In other words, it is the acquisition of knowledge or a skill without the intention to learn that specific knowledge or skill, whilst engaging in a different action, or pursuing other knowledge or skills. It has been named as a significant type of learning in prominent works such as Bandura’s Social Learning Theory (1977), Schön’s Reflective Practice (1983), and Kolb’s Experiential Learning (1984a), which itself was inspired by pioneering learning theorists like Dewey, Lewin, and Piaget.

More than just being given a place of importance in seminal research on learning, incidental learning has been studied and documented in many diverse areas of research, including language acquisition (Hulstijn, 2013; Ramos & Dario, 2015; Saffran et al., 1997), memory and recall (Costanzi et al., 2019; Mandler, 1967; Ornstein & Trabasso, 1974; Wagnon et al., 2019), cognitive and/or physical disability (Brown et al., 2003; Cooley, 2012; Ledford et al., 2008), and motor learning (Lee et al., 2019; Maxwell et al., 2000; O'Reilly et al., 2008). Importantly, it has also been studied in music, where it has been found that musical knowledge and skills are acquired incidentally from a very young age through mere exposure to the musical practices, rules, and elements in our environment, in a process known as enculturation (Hannon & Trainor, 2007; Schellenberg et al., 2005; Tillmann, 2005; Trainor et al., 2012; Trehub, 2003). Furthermore, apart from our encultured knowledge, the incidental learning of music is a lifelong, ongoing process (Veblen, 2018), in which unfamiliar musical elements can also be acquired, without the need for specialist musical training (Rohrmeier et al., 2011). Essentially, research in the field of music has determined that “incidental learning constitutes a powerful mechanism that plays a fundamental role in musical acquisition” (Rohrmeier & Widdess, 2017, p. 1299).

It was, however, in the literature on a specific subtype of incidental learning, namely implicit learning, that true revelation surfaced. Implicit learning can be defined as "the non-episodic learning of complex information in an incidental manner, without awareness of what has been learned" (Seger, 1994). Thus, like incidental learning, it is unintentional, but in addition to that, the learner neither becomes aware of having acquired new knowledge or skills, nor can they verbalise the process of acquisition. Significantly, in multiple fields of study, several inherent benefits to this specific type of incidental learning have been identified, such as faster acquisition and automation of knowledge and skills (Choo et al., 2012; Magill, 1998), prevention of injury in sport (Benjaminse & Otten, 2011; Ciavarro et al., 2008), preserved learning ability in neurological impairment (Meulemans & Van der Linden, 2003; Roodenrys & Dunn, 2008; Schuchard & Thompson, 2014), enhanced memory and retention (Chun & Jiang, 2003; Vickery et al., 2010), reliability of motor skill under pressure (Lam et al., 2009; Masters et al., 2008), and increased reaction speed and faster decision making (Milazzo et al., 2016; Raab et al., 2009), all of which is discussed in detail in the literature review of this thesis.

In addition, researchers have subsequently developed applications to employ these benefits in the learning environments of their various disciplines. In almost every case mentioned here, a corresponding advantage for musical learning and performance can be imagined. Whether it is faster learning and memorisation of musical repertoire, reliability of motor skill and technique under the pressure of being on stage, reducing the magnitude of performance-related injuries in professional musicians, or making music education more accessible by applying different learning pathways for students with different learning needs, the potential is far-reaching. However, no such applications exist currently for music. It is clear from these specific findings, as well as from those on incidental learning as a wider phenomenon, that there may be significant implications for music pedagogy, as discussed in Chapter 2. Yet, there is a void in the research necessary for meaningful future development of any such applications. This thesis aims to contribute new knowledge to the field of incidental learning of musical skills in an effort to start bridging the gap between theoretical potential and applied reality.

The view from personal experience and from speaking to other music teachers, was that methods that result in incidental learning by students are often employed, for example when we explain a difficult motor skill with a metaphor ("pretend you are shaking a bottle of juice" – for cello vibrato). The use of metaphor is not, in and of itself, an automatic indication of incidental learning. In many instances it is simply a cross-modal application of prior skill or knowledge to a novel situation, or the explicit embodiment of an abstract concept. It may also be an example of Piagetian adaptation (Boeree, 2006), although the latter may still occur outside of the learner's intention and awareness. This highlights the difficulty of categorising learning instances as incidental, or not, when dealing with real-life musical learning conditions, and the ways in which metaphor may possibly facilitate incidental learning need to be specifically addressed. However, whether teachers use metaphor in these ways, and other teaching methods that facilitate incidental learning, wittingly or not, any accompanying benefits of such learning would probably also be incidentally acquired. Without further investigation, this would be merely speculative, which led to the first practical research objective of this thesis in Chapter 3: to observe real life one-to-one music lessons to determine whether and how often incidental learning occurs, whether or not this is facilitated by teaching methods, and whether any advantages of such learning can be identified. These observations were followed by a survey of instrumental music teachers themselves, providing deeper insight into their awareness of using such methods, whether they do so deliberately, and if so, what motivates such use.

Building on observational findings, the next objective of the current project was to go beyond examining incidental music learning as it may occur spontaneously in everyday music lessons and seek to provide experimental evidence of incidental, and possibly implicit, learning in the context of a relatively ecologically valid musical task. Previous experimental research on incidental music learning has provided robust evidence of the incidental acquisition of a range of musical elements (Rohrmeier & Rebuschat, 2012; Rohrmeier et al., 2011). However, the aim here was to go beyond such findings to provide evidence of potential incidental/implicit learning advantages for music, comparable to those that were observed and developed in other fields. To this end, as discussed in Chapter 4, classic implicit learning paradigms were adapted for use with musical parameters. Sight-reading was chosen as an important musical skill, and 31 musicians of differing proficiency levels, on a wide range of instruments, participated in an experiment to pursue the above aim. This could also indicate the transferability of other advantages found in related experiments and paves the way for further research of this kind. It is important to note here that the focus on an implicit learning experiment specifically, as opposed to incidental learning in general, is merely for this purpose of transferability of reported benefits to musical contexts. The incidental/implicit distinction is further explored and discussed within the literature review.

After investigating the existence, frequency, and awareness of incidental learning in everyday music teaching practice, and determining the level of transferability of findings from existing research in other fields in a controlled experiment, the final question addressed in the present thesis was whether teaching methods can be designed that apply the potential advantages of incidental learning to real-life musical skill acquisition. In Chapter 5, therefore, a small-scale proof-of-concept study is reported, that set out to test the hypothesis that teaching methods that facilitate incidental learning can be deliberately designed and applied to attain beneficial learning outcomes for music students. A group of young learners who had never played orchestral instruments before, or read music notes, played custom-designed musical games with embedded skills to be incidentally acquired, in a four-day-long summer music programme. Before-and-after attainment scores were analysed to find whether significant incidental learning occurred. Finally, in Chapter 6, all of the above findings are reviewed, including a critical evaluation of the process, and projections of future possibilities.

It is important to remember that even the incidental acquisition of a skill still requires numerous repetitions. However, despite no literature providing evidence for it in a musical context, considering the available evidence from other fields, and from years of experience as professional musician and music teacher, it seems likely that skill automation, reliable memorisation, reading accuracy, fluency and expressivity, and even more skills necessary for musical performance, may be attained faster through incidental learning than through the rote repetition of traditional Western classical music training practices. It is therefore possible that maestro Tirimo might have been wrong all along – in music, there *may* be shortcuts.

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# THEORETICAL FRAMEWORK

## KEY TERMS AND DEFINITIONS

Several related concepts and learning phenomena came to light in the literature review of this thesis, and the terms describing them, as well as their relation to the musical context, were used frequently throughout. In the diverse study disciplines consulted, there are subtle but distinct variations in the definitions of these concepts, with specific implications for the appropriate use and subsequent meaning of their related terms. Where discussions were undertaken within any specific discipline, the differences in definition were pointed out, and the application of any descriptions or terms were meant to reflect the accepted use within that field. However, as pertaining to the original work presented in this thesis, and further discussions, all terms were used according to the definitions provided as follows, and as demonstrated in Figure 1:

**Incidental Learning:** *The unintentional acquisition of knowledge or skills as a byproduct of some other action.* Incidental learning is an umbrella term that may include other subcategories, such as **implicit** and **statistical** learning, amongst others. A musical example may be learning how to play a specific scale, because it appears within the melody of a piece of music, without the deliberate intention to learn that scale.

**Implicit learning:** *"The non-episodic learning of complex information in an **incidental** manner, without awareness of what has been learned"* (Seger, 1994, p. 163). Learning is defined as implicit when the learner acquires knowledge or skills incidentally, but does not know and cannot verbalise that they learnt something, what they learnt, or how they learnt it. In cognitive science, learning cannot be classified as implicit without conducting robust awareness measures. In practice, such as in language or music acquisition, and as used in this thesis, it refers to incidental learning instances of which the learner seems unaware. The above musical example would be implicit if the learner does not realise that they have acquired the ability to play the specific scale, nor could they, if questioned, explain when or how they learnt it.

**Statistical Learning:** *The (usually) **implicit** perception and extraction of statistical regularities in the environment, allowing for the acquisition of knowledge or skills pertaining to that environment.* Statistical learning may occasionally be **incidental**, but not **implicit**, when environmental regularities are explicitly pointed out, allowing for unintentional knowledge or skill acquisition, deriving from awareness of the regularities. A musical example of statistical learning would be the unintentional memorisation of music through the subconscious acquisition of patterns, relations, and structural regularities within the notation.

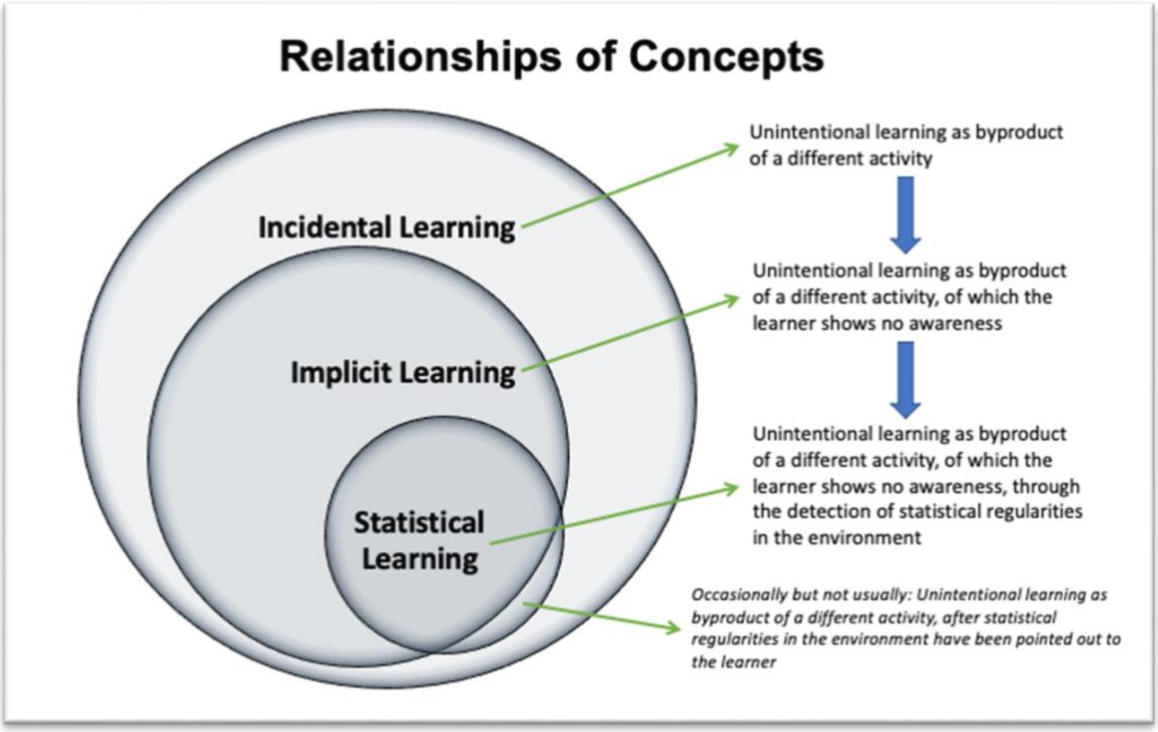


**FIGURE 1:** *Relationships Between Key Concepts and Terms*

## THEORETICAL FOUNDATION OF RESEARCH

As introduced briefly before, and as discussed in the literature review, the foundation for this thesis is based in the evidence that has emerged from incidental learning research, and implicit learning research specifically, from the fields of cognitive psychology, sport psychology, the study of language acquisition, neuroscience, and medicine. The particular research interest is seated in the findings of intrinsic benefits to this type of learning, namely improved memory and retention (Chun & Jiang, 2003), that is resistant to the interference of increased cognitive load (Vickery et al., 2010), better movement preparation (Raab et al., 2009), and faster decision-making (Milazzo et al., 2016), prevention of injury (Benjaminse & Otten, 2011), and reliability of motor skill under pressure (R. Masters, 1992), as well as preserved learning mechanisms in cognitive impairment (Meehan et al., 2011; Meulemans & Van der Linden, 2003).

Considering the parallels that can be drawn to the musical context for each of these fields, and the reliance of musical performance on both procedural and declarative aspects, across multiple modalities, the hypotheses of this thesis are that a.) the same overarching learning theory as applied to research foci in other fields should be applicable to music, b.) commensurate benefits should be available to musical learners, and c.) specific applications and/or teaching methods could be imagined and developed to induce such benefits in music education.

## ORIGINAL CONTRIBUTION TO KNOWLEDGE

In the music-focused literature review it was found that, in principle, the learning theory as referred to in the first hypothesis (a.) above, has been well-documented and researched within the music domain. The existence and mechanisms of implicit learning, and incidental learning in a broader sense, were reported and described in detail. However, the research has not thus far considered any specific benefits of these types of learning for music, nor postulated any potential targeted applications of such benefits for musical learners. It is therefore in this area that this thesis aims to contribute new and original knowledge to the fields of music science, cognitive psychology, and pedagogy.

A three-tiered approach will be taken to achieve this aim (Fig. 2):

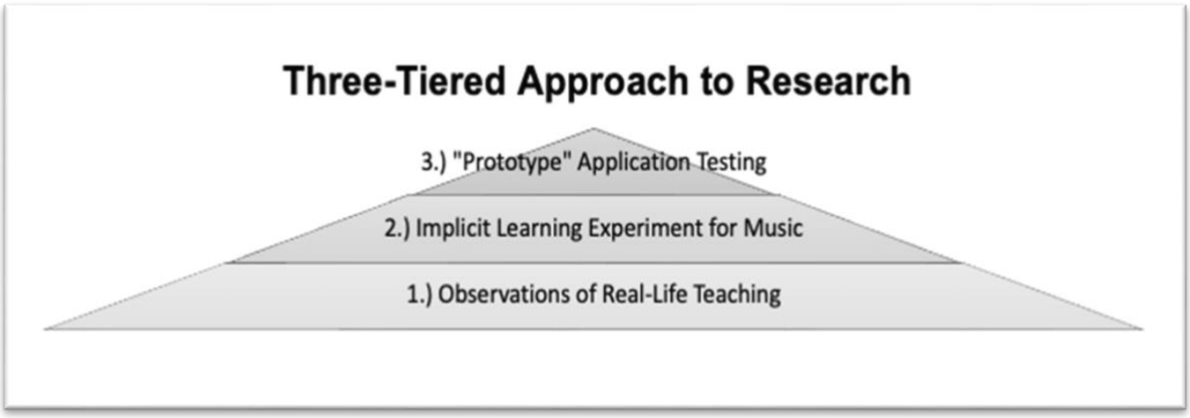


**FIGURE 2:** *The Order of Research to be Undertaken*

1.) The fact that no targeted focus on any benefits of incidental learning in music, or teaching methods that could facilitate it, have been explored, does not mean to say that incidental learning does not happen organically in existing music teaching environments, and that learners are not reaping the intrinsic benefits of such learning in the process. Situating any future formal theory and research of incidental learning within the music teaching context, would necessitate a thorough investigation and knowledge of the pre-existing prevalence and aspects of such learning. This would also provide a deeper understanding of how to build on teachers' existing skills and methods, rather than attempting to "reinvent the wheel".

2.) Once a clear view of existing teaching praxis has been established, the premise of equivalent benefits in the musical context as to those found in other domains, needs to be tested under controlled, experimental conditions. This would not only go towards ensuring that the theory is sound, but also that related aspects of incidental learning research in other fields may be transferrable to the music domain.

3.) Neither the knowledge of existing, informal occurrence of incidental learning in everyday teaching conditions, nor the credible empirical evidence of any advantages under experimental conditions, provide on their own the grounds or means for developing teaching methods that may benefit music learners in future. Thus, utilising the knowledge obtained in the first and second tiers of the research, as well as relevant literature, and real-life experience of structuring musical activities for learners, “prototype” applications can be designed and tested in real-life learning conditions.

Following this research strategy should provide a comprehensive view of the research topic, as well as allow for the presentation of the thesis as a coherent, complete body of work.

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# METHODOLOGY

Research in the field of music has traditionally favoured rich, descriptive, qualitative analyses, with an interpretive approach of constructing knowledge through observing events in the environment, as related to our interaction with these phenomena. Cognitive psychology, on the other hand, generally views research from a scientific perspective of observing, testing, and measuring phenomena objectively, and inferring the knowledge that already exists outside of our interaction with events. Although there may always be exceptions to the rule, whether exploring music through a cognitive science lens, or looking at cognitive learning processes from a music point of view, it seems that, for the most, researchers have attempted to conduct their investigations according to their preferred paradigms and to employ the associated methodology. Although this has led to valuable contributions to both disciplines, one cannot escape the impression that the findings often seem one-dimensional, and do not provide a comprehensive view.

It is not necessary for there to be a perceived dichotomy between music and science. Music is as innate to human beings as is language or any other form of communication, and music epitomizes important focal areas of research in cognitive psychology, such as creativity. At the same time, musical learning and performance do not have a metaphysical origin. They utilise the same neurobiology and collective cognitive processes as any other learning and performance. The design of this research project is thus to take a pragmatist approach, to employ the methodologies of both science and music, and combine them where necessary, in order to gain a panoptic view, and deeper understanding, of the role of incidental processes in musical skill acquisition.

## CONSIDERING THE FRAMEWORK

The primary consideration of any research design is the adoption of one or more methods to enable the investigation of the chosen subject and indicate the type of analysis to be employed to make sense of the collected data. In a brief overview of the foundations of the abovementioned traditional approaches of both music and cognitive science, and how they operate in practice, it is necessary to compare and consider the basic principles of these paradigms. This will allow for a critical evaluation of the adopted pragmatic approach, and the multi-strategy methods that were used to obtain, interpret, and present the data, analyses, and findings in this thesis.

### *PARADIGM*

Any research paradigm consists of four discernible components:

- *Ontology*, or “the study of being” (Crotty, 1998, p. 10), reflects the researchers’ beliefs about the nature of reality, in other words, how something *really* is, and how it *really* works.
- *Epistemology*, considering what it means to know something, what the nature of knowledge is, the different forms that knowledge may take, and the relationship between the knowledge and the person “knowing” it (Cohen et al., 2002).
- *Methodology*, the overarching research strategy, i.e., the “plan of action” for what data will be collected, when, how, and from where it will be collected, and why (Scotland, 2012).
- *Methods,* the tools, procedures, and techniques that are used to collect and analyse the required data as identified in the methodology. They can be either qualitative or quantitative, both of which can be used in any paradigm.

Every paradigm follows a particular set of philosophical foundations, which cannot be empirically (dis)proven, reflecting its ontological and epistemological views on reality and knowledge, which will be evident in the chosen methods of data collection and analyses. This way, it is possible for different researchers to consider the same phenomenon, utilising completely different research approaches (Grix, 2018), or as it may be in the current case, using more than just one.

THE SCIENTIFIC PARADIGM. This has also been known as positivism/post-positivism, where the ontological view is realism, believing that phenomena exist independent of our knowledge of them, and with an objective epistemology that allows researchers to impartially discover such pre-existing knowledge. The related methodology looks towards explaining relationships, such as correlations and causality between two variables, which should ideally form the basis for prediction and generalisation. According to the principle of falsification (Popper, 1934), unless all attempts to disprove a scientific fact/theory have failed and been exhausted, no fact/theory can ever be undeniably accepted as true. In other words, researchers may fail to reject hypotheses, but never *prove* them (Creswell, 2009).

Methods include empirical tools, such as standardised tests, experiments, closed-ended questionnaires and surveys, and observation of phenomena with standardised techniques, with the resulting quantitative data analysed by descriptive and inferential statistics. Ideal findings would be objective and resistant to contradiction or refutation, would demonstrate internal validity (the results were due to the independent variable as hypothesized), external validity (the results can be generalised to a wider population or other related subject areas), and they would be replicable and reliable (i.e. other researchers could perform equivalent research and obtain the same results).

THE INTERPRETIVE PARADIGM. Often referred to as constructivism/social constructionism, this paradigm moves from an ontological perspective of relativism, which asserts that reality is subjective or individually constructed (constructivism), and differs from person to person (Guba & Lincoln, 1994). The epistemology is subjective, believing that reality, and the phenomena therein, does not exist outside of our consciousness and knowledge of it. Different people may construct different meanings for the same phenomena, with truth being a consensus between them (social constructionism) (Pring, 2000). Knowledge is therefore historically situated, and culturally derived, and different ideologies are accepted, since the social world can only be understood from the perspectives of the participants in it (Scotland, 2012). The methodology of interpretivism looks to understand phenomena from this individual perspective, for example, through case studies (in-depth observation and study of specific people, events, or processes), phenomenology (the study of an experience of a phenomenon without introducing bias), hermeneutics (finding meaning in texts and language), and ethnography (the study of a specific cultural group).

Methods include interviews, observations, questionnaires and surveys (all open-ended), focus groups and role-playing, and the study of artefacts and texts. The resulting qualitative data are analysed through interpretation by the researcher. Ideal findings would be rich, descriptive, and would present justification and credibility (internal validity), can be used by other people in different circumstances (external validity), and the process and findings can be replicated by others (reliability).

THE PRAGMATIST PARADIGM. With pragmatism, a mixed-method, multi-strategy approach emerges, calling upon the tools involved in both the above approaches. The pragmatist realises that certain phenomena cannot be studied or explained using a single perspective, and adopts whichever methodology is suited for the circumstance. Both quantitative and qualitative methods are utilised, and both types of analyses are applied to the results of such research, which is usually presented in one of three formats (Williamon et al., 2021):

- *Sequential Explanatory Design*, where the quantitative element is the most important, and is subsequently explained by qualitative descriptions and interpretations.

- *Sequential Exploratory Design*, with the dominant element being qualitative findings, which are explored and substantiated through quantitative data.

- *Concurrent Triangulation*, where both qualitative and quantitative research is conducted concurrently, or combined, bearing equal weight, and datasets are consolidated through in-depth analysis.

The current thesis lends itself to a pragmatist approach, employing concurrent triangulation, as neither the cognitive science study of incidental musical skill acquisition, nor the musical understanding and description of it, is more significant than the other. It is only through studying the literature in both domains, observing the learning in situ, testing the premises through experimental means, and combining the two conditions, that a true comprehension of the phenomenon can be achieved. The different methods used in each part of this project will therefore be discussed and evaluated here.

## RESEARCH IN PRACTICE

### *GENERAL LITERATURE REVIEW*

A literature review is not, in and of itself, a qualitative or quantitative research method. It is, however, an essential preparatory step prior to embarking on any research work. A comprehensive survey of the main topic and surrounding knowledge base can avoid the pitfall of unnecessarily repeating prior work, especially when one intends for new research to be original. It is also useful to identify any knowledge gaps in the relevant field, or finding a  foundation on which new knowledge is to be built. It may strengthen or confirm the motivation and impetus that led to an initial choice of topic, and deepen the knowledge of the subject before commencing a project.

The risk in reviewing existing literature, is falling victim to confirmation bias, where we only look to sources that confirm what we already believe about a subject, or that have reported results similar to what we hope to find. Considering the review in Chapter 1, there is indeed ample critique available on the implicit learning paradigm as a whole, with many scholars asserting that no learning can ever be truly unconscious, and criticising the methods and analyses employed in past implicit learning experiments. However, no sources seem to contradict the fact that incidental acquisition, whether truly implicit or not, forms a significant part of all human learning, or refute the inherent benefits of such learning, as has been found in previous studies. The literature review in this thesis has therefore attempted to reflect this view, while avoiding the ongoing implicit learning debate as far as possible.

Another point to consider is the considerable scope of surveying all available works. The subject area of learning as a phenomenon is vast. Even in narrowing it down to this one type of learning  (incidental learning), still left 150 years’ worth of accumulated knowledge, the different subtypes, research approaches, schools of thinking, and more, to consider. An attempt was made to present a brief historical overview of the field, and subsequently focus on those aspects that have specific relevance for the current research. It is, however, a distinct possibility to have missed important information in this process.

A significant aspect of the wider literature review was to identify those experimental measures from cognitive science that would be best suited for replication in a music context. To that effect, the various approaches, methodologies, methods, analyses, and findings, of as many previous studies as possible were explored, analysed, and discussed, providing a solid foundation for the novel application of experimental research undertaken later in the project. Furthermore, the findings of specific advantages inherent in incidental or implicit learning were extensively examined before commencing with the parallel review of the available literature in the music domain, in preparation for envisioning similar potential advantages for musical learning.

### *LITERATURE REVIEW IN THE MUSIC DOMAIN*

Chapter 2 consists of an extended music-specific literature review, including an assessment of, and proposals for, potential equivalent benefits as in the findings from Chapter 1. It introduced salient contributions from the science of music cognition, substantiating the existence and natural occurrence of implicit learning of the underlying rules and structures of music (Rohrmeier & Rebuschat, 2012). Furthermore, it not only considered works that have specifically described and studied the incidental or implicit learning of music, but also widened its focus to include areas of well-documented musical phenomena that have not previously been considered through an incidental/implicit learning lens, such as enculturation. It then extrapolates from these findings, combined with those from the wider review, to envisage potential future applications for musical learning and performance.

This extrapolation and inductive reasoning could be seen as the initial, small steps of formulating a grounded theory, but without following the systematic principles of this research method through to its conclusion (Glaser & Strauss, 2017). In defence, it can be argued that the formulation of a grounded theory of incidental or implicit learning in music would constitute an entirely different study than what was undertaken for this thesis. It may still be considered for future research projects, but in this instance the purpose of the qualitative analysis was to demonstrate the relevance and importance of subsequent research in this project.

### *ETHNOGRAPHY*

In Chapter 3, the findings from conducting an ethnographic observation of everyday music lessons, and a survey of music teachers are reported. The use of ethnography as research method, i.e., the study of a specific culture-sharing group through immersion, and seeking the insider's perspective, is a well-established practice in social research. Its "real-life" location renders it relatable, gives a voice to specific groups, and enables the researcher to explore unknown or socially complex phenomena (Williamon et al., 2021). Risks with this method, in general, is that it is unlikely to be generalisable to other groups, and is susceptible to the researcher's subjectivity.

OBSERVATION. The direct observation of teachers and students and their interaction in the natural environment of the music studio or classroom offered insights that could not be obtained in controlled conditions. An obvious advantage to this method is in its reality. A researcher is able to observe first-hand how participants interact in their natural surroundings, without any artificial impositions. It can also assist in identifying issues that may not have been considered prior to embarking on such a study. Ethnographic studies may offer a good testbed for introducing ideas or practices, confirming its utility in a wider application, although, in this case, no such testing was assumed.

A weakness of this research method is in the possibility of affecting the natural behaviour of participants, and the objective observation thereof, by the mere presence of an observer in the milieu. It was indeed a concern, as the intention was to be as unobtrusive and quiet as possible, but it became quickly apparent that some of the observations and interactions between student and teacher needed clarification, and questions were raised for this purpose. Great care was however taken not to let participants discover the nature of the observations, so that no specific behaviour modification for the sake of the research would be a factor.

Another general disadvantage of this research method is the time-consuming nature of the observations and the analysis of the resultant recordings and notes. This was deemed worthwhile for the rich and descriptive data obtained.

SURVEY. Once the initial design phase of a survey is complete, this is a relatively fast and simple method for collecting large amounts of data, at little to no cost, reaching a wide audience when distributed electronically and remotely. This offered the obvious advantage of a much larger variety of contributions from music teachers worldwide. A broader scope of questions could be posed than in the one-to-one setting of the observed lessons, where interference with the process was avoided as far as possible. However, considering participant interest and engagement still placed a limit on the number and complexity of questions that could be asked.

As with any method, there were drawbacks as well. Surveys, by nature, are one-directional and do not allow for clarification and immediate feedback, which influences the validity of the data collected. Further to that, there is always a risk that some respondents do not provide truthful answers due to the response bias of presenting themselves in a favourable way. In the case of the teaching survey, it could not be stated with any measure of confidence that respondents did not have preconceived ideas regarding "good" or "bad" teaching practices, and wouldn't moderate their answers accordingly, or made any assumptions regarding the purpose of the survey. Answers may also be inadvertently inaccurate if respondents fail to read questions thoroughly, or lose interest.

In addition, a sample may be biased due to the type of person that is more likely to respond to a survey, as in this case, where it was found that more than half of respondents were highly experienced teachers. Fortunately, this did not affect the data collected.

## *EXPERIMENT*

A simple list of principles for good experimental design is randomisation of participants, manipulation of an independent variable, measurement of the effect of the manipulation on dependent variable(s), and the control of other, outside variables. Experimental designs strive for objectivity, replicability, and transferability or generalisability. Limitations to these objectives are the risk of ascribing qualities to an individual based on the qualities of the group to which that individual belongs (ecological fallacy), and researcher bias. It is also challenging (and often impossible) to control all outside variables.

The implicit sequence learning experiment undertaken in this project did not randomise participants, as each participant was subjected to a repeated measures design, where they provided both the baseline (control) and test conditions, with no between-subject comparison. The exposure to a repeated musical sequence over five sight-reading trials was the independent variable, and response time and accuracy were the dependent variables. As many outside factors as could be foreseen were controlled for, but some only became apparent during the test phase, or even in post-experiment analysis. Specifically, a novel composition method was adopted for the material to be used in the trials, controlling for individual enculturation effects, and removing elements as found in traditional sight-reading samples that may influence the performance and measurement. The resulting material was presented in a way that could still be viewed as ecologically valid (resembling a real and possible musical performance task). Participants were recruited from different proficiency levels, and playing a wide range of instruments to make the results as generalisable as possible.

The data were analysed with statistically valid and credible methods, and reported accordingly. Some findings would not have been included in a standard scientific report, as they were observed in isolated sections of the sample, too small to measure statistical significance, or to be generalisable to a wider population of musicians. However, as part of the wider project, and for their relevance to observations in other parts of the research, it was decided to report these nonetheless. Wherever possible, statements to this effect were included as appropriate. All efforts were made to avoid any bias in the interpretation of the results, but it is of course always possible that some was unwittingly introduced.

## *PROOF-OF-CONCEPT/QUASI-EXPERIMENT*

After successfully conducting an implicit learning experiment for music, the project set out to conceptualise an organically developed application of these and other experimental findings from prior studies, in a quasi-experiment under real-life music learning conditions. The feasibility of this practical application was tested with a cohort of young novice musicians, self-selected to take part in a summer music programme. A mixed-method approach, combining the principles of experimental design, with the interpretation of the ethnographic elements of the learning condition, was adopted and applied with flexibility as necessary.

Test material was designed with particular experimental measures in mind, while providing the learners with entertaining and educational musical activities. The independent and dependent variables were introduced, manipulated, and measured without interruption to the programme, and statistically analysed post-experiment. Results were presented as both a rich description of the music programme and the learning experiences of the participants, as well as the quantitative findings from the analyses. Where possible, quantitative findings were explained by qualitative description, and qualitative findings were substantiated with quantitative data.

The benefits of this approach were the generation of a full view on the events and findings, a strong case for ecological, internal, and external validity, as it incorporated the various elements necessary for this, and the ability to answer a complex research question that could not be addressed by either the preceding qualitative or quantitative approaches alone.

Disadvantages were the near impossibility of controlling for outside variables under real-life learning conditions, with young participants not specifically recruited for the study, and the interpretation of complex data of both a qualitative and quantitative nature. This type of study can be demanding for the researcher, but the positive findings were extremely rewarding.

## *CRITICAL EVALUATION*

Much like the literature review at the start of any research project, the critical evaluation is not a research method as such, but a necessary post-study measure to consider the research process. The challenge with a critical evaluation, is that no researcher can ever be truly objective about their own work. However, it did offer the opportunity to reflect on both the positive and negative aspects of this project. It was made apparent where errors occurred, where important aspects were unwittingly omitted, and where improvements could have been implemented. All of these, in hindsight, provide a scope for learning, and incorporating new knowledge and experience in future endeavours.

A critical evaluation does not only focus on the negative side, but also affords a reflection on those aspects of research that were successful and made strides towards the larger research objectives within this field, of which this is but one small, but hopefully significant, contribution.

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# CHAPTER 1: INCIDENTAL LEARNING: A LITERATURE REVIEW

**incidental learning**

/ɪnsɪdɛnt(ə)l ˈləːnɪŋ/

*psychology*

> learning that is not premeditated, deliberate, or intentional and that is acquired as a result of some other, possibly unrelated, mental activity.
>
> *Similar: nonintentional learning; informal learning; experiential learning*

– APA Dictionary of Psychology (2022)

In the late 1800's, the father of modern experimental psychology, Hermann Ebbinghaus (1885), reported the existence of unconscious past experiences, or memories, that could still produce a significant effect to present actions and processes, and could occasionally (but not necessarily) be "incidentally" recalled. For the next few decades, researchers spent much of their time either trying to provide evidence of incidental learning, or discounting it, so that by the 1930's the general consensus among scholars was that incidental learning was at best "capricious", and in any event "markedly inferior to intentional learning" (Jenkins, 1933, p. 477). The pioneering educational theorist, John Dewey (1938), wrote a seminal book about the importance of learning from experience, although at the time it was not directly associated with studies on incidental learning, and it wasn't until the mid-20th century, at the height of the American behaviourist psychology movement, that incidental learning sparked renewed interest.

At the beginning of this era, another influential educational theorist, Kurt Lewin (1951), developed "field theory", where he considered how human behaviour changes as result of individuals' interaction with their environment. Again, this could be classified as incidental learning today, but was not recognised as such at the time. Significantly, several contemporaries of Lewin devised experiments with "intentional" and "unintentional/incidental" learning conditions, and compared the different outcomes. This led to a considerable body of evidence, including a nine-paper treatise by Leo Postman and his collaborators on *Studies in Incidental Learning,* (1954) – (1961)[1]. Postman further considered the laws of effect for incidental learning (Postman & Adams, 1957), the effect of reward and punishment (Postman & Sassenrath, 1961), and the short-term memory of incidental learning (Postman, 1964). Other important works on the subject also appeared, such as by

[1] Nine separate papers were published over a seven-year period, with different co-authors, to form the series "Studies in Incidental Learning I-IX", each with different experimental measures and foci. The first and last are included in the bibliography for reference.

McGeoch and Irion (1952), Tresselt and Mayzner (1960), Mandler (1967), and Winnick and Lerner (1963).

It is not surprising that the study of human behaviour resulted in such a focus on incidental learning research. Although no studies have specifically attempted to compare the magnitude of learning under the different conditions, it can be argued that the average human being, over a normal lifespan, will probably learn far more incidentally than can ever be achieved through intentional effort. The basic motor skills of crawling, walking, and running, the meaning of facial expressions and vocal inflections, the grammar and vocabulary of our first language, sensory and spatial lessons from experiences in our environment (e.g. hot/cold, high/low), and the musical rules and practices from our various cultures; all of these, and many more, are acquired incidentally. The work of these avant-garde behavioural psychologists thus had a lasting effect for incidental learning research today, with research foci including, amongst others, lifelong learning and learning in the workplace (Kerka, 2000; Marsick et al., 2006), memory and retention (Popov & Dames, 2022; Wagnon et al., 2019), musical enculturation (Corrigall & Trainor, 2010; Demorest et al., 2016; Hannon & Trainor, 2007; Stalinski & Schellenberg, 2012), and a vast body of work within the area of language and vocabulary acquisition (Denhovska et al., 2016; Hulstijn, 2013; Saffran et al., 1997; Webb et al., 2013).

By the 1980's, incidental learning was identified as an important learning condition in ground-breaking learning theories, such as Social Learning (Bandura, 1986), Experiential Learning (Kolb, 1984b), and Reflective Practice (Schon, 1983). However, by the next decade, the interest had narrowed to the identification of subtypes of incidental learning, with an intense focus on implicit learning and memory. These were hardly mentioned in any published academic articles before 1990, but within five years, the number of annual publications with either "implicit learning" or "implicit memory" in their titles had quadrupled (Stadler & Frensch, 1998). It is within this specialised area of implicit learning research that the theme for the current thesis originated, and the literature review will thus reflect this interest.

## IMPLICIT LEARNING

A brief overview of implicit learning cannot possibly cover all the lateral interests and related studies that researchers have embarked upon over the last five decades, since Reber (1967) coined the term in his work with artificial grammars. It does however provide a definitive foundation, and suggests future research paths. It also informs the measures and protocols that would have to be considered in designing and conducting similar experiments in a musical context.

Seger (1994) defined implicit learning as "the non-episodic learning of complex information in an incidental manner, without awareness of what has been learned" (p. 163). The important distinction between implicit and other types of incidental learning being that learning can only be defined as implicit when it remains outside of the learner's attention and awareness, without any intention to learn, and without the learner's ability to verbalise the process. Researchers have tended to investigate this phenomenon from three general paradigms, namely abstract learning, perceptual learning, and motor learning (Stadler & Frensch, 1998).

## *ABSTRACT IMPLICIT LEARNING*

Experiments in this paradigm require participants to make an abstract judgement about a presented stimulus. The best example of this would be artificial grammars, such as the previously mentioned pioneering studies conducted by Reber (1967), that led to the original development of implicit learning as a field of study. In these experiments, subjects were presented with strings of letters generated by a finite-state automaton[2], meaning that the letters would always appear in a certain order, according to a set of made-up grammatical rules. Subjects were then presented with new letter strings and asked to judge whether these were of a similar pattern to the previously seen strings, or not. Participants were never informed of the rules but could nonetheless identify letter strings that adhered to the rules correctly at a higher than chance level, indicating that knowledge of the grammatical rules were acquired implicitly. Participants were still able to make the same correct judgements even when novel strings contained different letter combinations, or even numbers and symbols. Furthermore, they showed no awareness of any rules, or were otherwise unable to verbalise what led them to make their judgements of the stimuli.

An important defining factor in abstract implicit learning, is that knowledge is not bound to any surface characteristics of the original stimulus and can be transferred to new stimuli, e.g. different letter strings, numbers, and symbols as above. For Reber (1989), at least initially, this was *the* defining feature of implicit learning in general, in that it is "an unconscious learning process that yields abstract knowledge" (p. 219). Other examples of abstract implicit learning could include:

- The mere exposure effect (Bornstein, 1989; Zajonc, 1968) where subjects were exposed to random stimuli, but with certain items repeated at a predetermined frequency, after which the subjects' preference for each stimulus was rated on a scale. Findings demonstrated a higher preference for stimuli presented at a higher frequency, the occurrence of which was not known to the participants, and which therefore had to be implicitly detected.

[2] A finite-state automaton is a mathematical computational model that can only be in one state at any given time (e.g. YES or NO, but there are usually many more options than two). It can change its state depending on the input it receives and can be programmed to follow rules of state-changing according to input, or can follow sequential logic, such as in the modelling of largescale statistical problems.

- Invariant feature learning (McGeorge & Burton, 1990), in which the number 3 was included in each of 30 four-digit strings. Participants were instructed to perform various basic arithmetic tasks with these strings. Subjects were subsequently presented with ten pairs of novel strings, with only one in each pair containing the number 3. When asked to identify strings they may have previously seen (although there were none), strings containing the number 3 were preferred to a significant extent.

- Covariation learning (Perruchet et al., 1997), based on the principle that when a stimulus is presented with a specific feature variation (the variant), and this coincides with another specific variation (the covariant), subsequent novel stimuli containing the first variant will be identified at a higher rate when the covariant is also present. For example, if the letter E is presented in a grid of different letters, with feature variations like being upside down, or lying on its side, and each grid has a different background colour, then, if an upside-down E (variant) is always presented on a yellow background (covariant) in the learning phase, the upside-down E will be located and identified in subsequent test grids at a higher frequency when also presented on a yellow background.

## *PERCEPTUAL IMPLICIT LEARNING*

Rather than being required to make a judgement regarding a stimulus as above, experiments in the perceptual paradigm measure a participant's ability to perceive or predict a stimulus. One of the most important examples of this, although preceding the term "implicit learning" by several years, would be Hebb "digits" (1961), which has subsequently led to the field of Hebbian learning and the Hebb repetition effect in current cognitive and neuroscience research (Munakata & Pfaffly, 2004; Oberauer et al., 2015). In the Hebb digits experiment, participants were required to listen to 24 strings of nine digits each, with the instruction to repeat them back in the same order. The third string was repeated for every third trial, resulting in the participants' performance on recalling that string improving over time, despite not being aware of the repetition. The repeated stimulus was thus implicitly perceived. More examples of perceptual implicit learning to consider would be:

- Contingent response tasks (Kushner et al., 1991; Perruchet et al., 1990), in which subjects were required to either locate, or predict the location of a stimulus, presented after a seemingly random preceding pattern or events (contingent features). Location/prediction was performed with significant accuracy, due to the implicit learning of the contingent features.

- Function matching (Koh & Meyer, 1991). In this experiment, participants were provided with pairs of numbers, the first being the stimulus and the second being the response to the stimulus, according to a mathematical function (as a simplified example, if the function was a linear equation such as $2x = 3y$, then the pairs might be 3;2, 6;4, 9;6, etc.). When presented with novel stimuli, and required to pair these with appropriate responses based on the pairs previously seen, participants significantly responded according to the function, despite claiming no knowledge of its existence.

## *IMPLICIT MOTOR LEARNING*

Implicit motor learning can facilitate new or improved specific motor responses to presented stimuli. Arguably one of the most influential studies, not only for implicit motor learning, but for implicit learning in general, would be the serial reaction time (SRT) task, as founded by Nissen and Bullemer (1987). In the original experiment, subjects were required to respond to the appearance of an asterisk in any of the four corners of a computer screen, by pressing a corresponding button (motor response). The order of appearance was governed by random selection, interspersed with a repeated sequence. The reaction speed of participants was measured, and found to improve for the hidden sequence over time, to a greater extent than for the random appearances. This improved performance remained consistent even when a concurrent task (counting high and low auditory tones) was introduced. There have been various other types of implicit motor learning experiments, such as:

- Continuous tracking tasks (Pew, 1974; Shea et al., 2001; Wulf & Schmidt, 1997), where a continuous onscreen stimulus, like a moving dot or wave line, had to be pursued (tracked) by participants, using electronic controllers (anything from a joystick to a virtual surfboard) to control an onscreen cursor "chasing" the stimulus. The movement of the stimulus would be determined, as with the SRT experiment above, by random selection interspersed with a repeated sequence. Performance scores improved over time for the repeated section, at a significantly higher rate than the pure motor skill practice of the random section could achieve.

- Stimulus-movement contingent relations (Green & Flowers, 1991). In a variation of the above continuous tracking tasks, this study required of participants to visually track an on-screen dot and intercept it using a joystick. Some were given instruction on stimulus events that would predict the dot's movement, and some were not. The non-instructed group demonstrated greater improvement in execution than the instructed group, and displayed different joystick patterns overall, implying a difference in the processing of visual information dependent on the instructional condition. This was one of the first experiments that seemed to suggest that explicit instruction on a task may actually impede performance, rather than help it.

A combination of the Hebb repetition effect, continuous tracking, and the SRT experimental conditions, will be adapted for a novel design of experimental measures in a musical context (Chapter 4 of this thesis), and implicit sequence learning, as demonstrated here in SRT and continuous tracking experiments, will be used to measure the implicit acquisition of a simple musical sequence in young learners in real-life learning conditions (Chapter 5).

## THE INCIDENTAL AND IMPLICIT/EXPLICIT DISTINCTION

A subsequent step for researchers, after providing evidence for the existence of implicit learning and defining its features, was to discern implicit from explicit learning, and determine the difference between the two. It is generally accepted that implicit learning and explicit learning are opposites, and for all further discussions in this thesis, the term *explicit* will refer to any learning of which the learner is consciously aware, and invests an intentional effort to obtain such learning, whether through self-directed practice/study, or by external instruction.

One of the first instances where research demonstrated this difference was in follow-up experiments from the original Nissen and Bullemer (1987) SRT experiments (Willingham et al., 1989). Using the same experimental conditions and protocol as before, the new aim was to determine the distinction between procedural and declarative knowledge, the role declarative knowledge would play in performance, and to explore the temporal dependence between the two systems. The fact that procedural knowledge was obtained incidentally/implicitly, and that declarative knowledge was explicit, was peripheral to the main focus. Results showed that implicit learning of a stimulus sequence occurred as in the previous experiment before, but this time 20% of subjects became explicitly aware of the sequence, to such an extent that they could verbally describe it, and accurately reproduce it in a generation task. More importantly, their explicit knowledge of the sequence led to vastly improved reaction time scores, more so than the subjects who had learnt it implicitly but did not become aware of their learning.

At first glance this would indicate that, in this case, explicit knowledge led to superior performance outcomes, but in an important distinction between explicit *knowledge* and explicit *learning*, subjects showed improved performance scores as much as four trial blocks before first becoming aware of the sequence, implying that some implicit learning preceded (and possibly resulted in) explicit knowledge. Furthermore, they were allowed to self-discover the sequence (or not). Subjects were never given any information or instruction about the existence or nature of the sequence, thus the learning process itself was never explicit. The importance of this distinction was later demonstrated in the abovementioned experiment (Green & Flowers, 1991), where participants were given explicit instructions about stimulus conditions, which had a detrimental effect on their performance scores, as opposed to participants who may have learnt the conditions implicitly.

This marked difference between the *process* of learning and the *outcome* of learning has important implications for the research undertaken in this thesis. In cognitive science, implicit learning as a specialised subtype of incidental learning, requires that a subject does not become aware of what was learnt, or how it was learnt. However, with incidental learning, there is no expectation that the subject should remain unaware of the knowledge or skills that were acquired (Kelly, 2012). Considering the above examples of the implicit/explicit distinction, it was clear that, in the absence of explicit instruction and until awareness occurred, the *process* of acquisition was still implicit. It is therefore argued here that, if any specific characteristics of implicit learning are inherent to the acquisition process, such as certain advantages of this type of learning (discussed further below), they will remain accessible to the learner, even if awareness of the learning occurs after the fact, i.e. it becomes incidental rather than implicit.

With this in mind, the discussion of the benefits of implicit learning that follows below is not undertaken with a focus on the implicit nature of the learning, but on the advantages that were demonstrated in various fields, and their potential application to the learning of musical material, and the acquisition of musical performance skills. There is a longstanding and highly contentious debate about the classification of any learning as implicit, simply because a learner cannot verbalise what was learnt, or how it was learnt (Haider et al., 2011; Shanks et al., 1994; Shanks et al., 2021; Vadillo et al., 2016). It is however not the objective of this thesis to present any learning instances as "truly" implicit, especially in the ethnographic observations in Chapter 3 where, if the term was used, according to the key definitions at the onset of this thesis, it was to indicate cases where the learner seemed to have no awareness of the learning that occurred. In the experimental conditions of Chapter 4, where a strict implicit learning protocol was followed, and awareness tests conducted, the implicit nature of the learning was of secondary importance, as it was conducted in this manner for the external validity of traditional implicit learning findings for a musical context.

## THE BENEFITS OF IMPLICIT LEARNING

Subsequent to the establishment of implicit learning as a field of study as described thus far, several disciplines have undertaken important research to explore the implications for their specific domains. Significantly, in many cases, substantial benefits of implicit learning were identified, and applications developed to employ such findings in the practical learning environments of the various areas of study.

### *LANGUAGE LEARNING*

Scholars in this field have long surmised that a person's inherently superior first language skills, as compared to those of a second or subsequent language, are due to the implicit acquisition of our first language from infancy. Brown (2000) explains that children acquire the syntactic, semantic, phonological, and pragmatic rules of their first language implicitly, but cannot explicitly describe any of these. He further states that although the implicit process of acquisition may enable the learner to perform language, it does not allow access to the rules governing that performance. In contrast, subsequent languages are typically obtained mostly through intentional study. Doughty & Long (2008), examined the available evidence for and against explicit second language instruction and concluded that its usefulness had been “overstated” (p. 274). Some of the proposed reasons for this were that any additional language learnt would be governed by the same universal grammar, or the more recent thoughts of domain-general abilities (Dąbrowska, 2015), as the learner’s first language, and that the acquisition thereof would likewise be entirely incidental/implicit.

Another important distinction between first and second language acquisition, is that the former, as it is learnt implicitly from infancy, does not only constitute acquisition of the rules, grammar, and vocabulary of performing language (i.e. speaking), but also of the complex skills for meaningful social interaction and communication. Using language is a social act (Sidnell & Enfield, 2012), and learning to use it, by necessity, is an interactive, multi-modal process. In both speech performance and processing, aspects of auditory, visual, and tactile encoding play a role in skill acquisition, and in robust memory and retrieval (Pisoni et al., 1996). We do not only hear the words and scan surrounding word context for meaning, but we also derive meaning from seeing gestures and facial expressions, and we feel the physical formation and articulation of words when we reproduce them. It is easy then to understand the superior fluency in first language use, when the need to develop social communication skills from infancy is a matter of survival (Fonagy et al., 2017), and it is encoded in multiple “channels”, while second and subsequent languages typically are not.

From a neurological perspective, it has been suggested that the neural representation of a consciously acquired second language, as seen in fMRI studies, present differently than that of the implicitly acquired first language, and that only the latter could be spontaneously employed in fluent speaking. Possible evidence for these findings might be seen in the success of immersion learning of a new language, where speakers learn grammar and other language rules implicitly from conversing with native speakers, rather than studying these formally (Dornyei, 2013; Hulstijn, 2005). Applications have subsequently been considered to include implicit learning and teaching strategies for students’ second (or further) language acquisition, to enhance secure grammar usage, and general fluency (Ellis, 2008; Housen & Pierrard, 2005).

More than simply the rules of usage of a language, proficiency is partly measured by the speaker’s grasp of the lexis of any language. The Grammar-Translation Method, a traditional early twentieth century method of teaching “dead” languages, such as Latin or Ancient Greek, through grammar drills and exercises (Larsen-Freeman, 2001), although promoting accuracy, does not enhance fluency and communication (Chang, 2011). Instead, the acquisition and retention of vocabulary is optimised when intentional learning and memorisation is combined with incidental and implicit acquisition of new words. In a first language setting, after the initial acquisition phase of infancy and childhood, new words are often implicitly acquired through extensive reading, by inferring meaning from the context. In second language learning, extensive reading most likely provides implicit learning of the contexts and sentence structure for the use of new vocabulary acquired through intentional study (Choo et al., 2012). There has however been some research that suggests that students performed better in vocabulary tests when words were implicitly acquired through reading for comprehension, as compared to a control group who were given explicit instructions to learn certain target words (Rashidi & Ganbari, 2010).

In an application of these principles, the Directorate-General for Education, Youth, Sport, and Culture of the European Commission (EURYDICE) report of 2006, recommended that schools incorporate a content and language integrated learning (CLIL) approach, where aspects of grammar, vocabulary and fluency are acquired incidentally when other subject matter is presented in a second language (Dana, 2016).

## *MEMORY AND RETENTION SKILLS*

The ability of learners to acquire information about the stimulus environment implicitly, and use such implicit knowledge to the advantage of processes like memory, forms the basis of the Cleeremans connectionist model (Cleeremans, 1993). Using this model, a revised definition of implicit learning has been proposed, although this may also be seen as a subcategory of implicit learning, namely statistical learning:

> [statistical] implicit learning is the process through which we become sensitive to certain regularities in the environment, (1) without trying to learn regularities, (2) without knowing that one is learning regularities, and (3) in such a way that the resulting knowledge is unconscious (Cleeremans & Dienes, 2008, p. 396).

This implicit acquisition of regularities in the environment has been demonstrated in various studies. In an example of utilising the implicit memory of appropriate contextual environments, in object recognition studies (Oliva & Torralba, 2007), it has been demonstrated that recognition was enhanced when objects were placed in a familiar context (e.g. recognising the outline of a kettle when it is placed in a kitchen setting). Spatial context memory studies (Chun & Jiang, 2003) investigated whether novel contexts could be implicitly learnt and recalled, by placing the letter T, lying on either its left or right side, in specific locations within a grid of other letters. In half of the trials the grid of other letters was repeated for the same T conditions and locations, while in the other half, the grid and locations were randomly generated. Participants demonstrated enhanced location and recognition scores when searching for novel objects presented in the repeated context. Awareness tests confirmed implicit learning of the contexts, and retention tests showed enhanced performance both in immediate memorisation, as tested on the same day, and in long-term memory, as tested after a week-long interval. These findings were compared to those of a second test group, where the participants were given explicit instructions regarding the nature of the letter grid and its repetition. This group seemed to gain no benefit from their explicit knowledge in terms of performance scores, and in some subjects, it even seemed to be detrimental to performance.

In addition, it is believed that such spatial context learning is particularly robust and resistant to interference from concurrent working memory load (Vickery et al., 2010). The spatial context of musical notation will be used in experimental conditions (Chapter 5), to test the acquisition and memory of musical elements.

## *NEUROLOGICAL IMPAIRMENT AND LEARNING DISABILITIES*

One of the most important discoveries of implicit learning research for neuroscience, was that implicit and explicit learning access different areas of the brain. Neuroimaging has previously suggested that the neural and cognitive mechanisms that underlie implicit and explicit learning respectively, are distinct and separable. The hippocampus and temporal-parietal cortex seem to be important for explicit learning and knowledge, and a cortical-subcortical circuit, involving specifically the frontal cortex and basal ganglia, holds the same importance for implicit learning and memory (Eichenbaum, 1999; Knowlton, 2002; Reber & Squire, 1994). More recent developments favour the idea that both types of learning utilise overlapping neural networks, but evidence still suggests that, despite shared areas, implicit learning accesses the frontal-striatal network directly, whereas explicit learning uses the insula as mediator (Yang & Li, 2012).

Numerous studies have shown that patients with neurological impairment, related to disease or brain injury, have in many cases an intact ability to acquire knowledge and motor skill implicitly, even when normal (explicit) learning ability has been adversely affected, such as in acquired agrammatic aphasia (Schuchard & Thompson, 2014), motor skill loss after stroke (Meehan et al., 2011), amnesia (Meulemans & Van der Linden, 2003), and in schizophrenia (Danion et al., 2001). This knowledge that implicit learning ability remains intact in certain cases of neurological impairment, combined with the identification of the areas of the brain responsible for such learning, could be applied to rehabilitate cognitive function and motor skills in affected patients, such as with errorless learning[3] in amnesia (Clare & Jones, 2008; Kessels & Haan, 2003; Wilson et al., 1994).

The evidence of implicit learning in subjects with learning disabilities has been contradictory in most cases. Some studies, for instance in autism spectrum disorder (ASD), have suggested that implicit learning may be impaired (Klinger et al., 2007; Mostofsky et al., 2000), while a more recent meta-analysis has found that implicit learning mechanisms are intact in subjects with ASD (Foti et al., 2015). The various findings of studies of implicit learning in dyslexia are especially unclear, with some reporting outright implicit learning deficits (Vicari et al., 2005), some finding impairment of certain types of implicit learning tasks, but not others (Folia et al., 2008; Nigro et al., 2016), and some finding that implicit learning is intact (Roodenrys & Dunn, 2008). Similar findings were seen in subjects with attention deficit hyperactivity disorder (ADHD), in that some forms of implicit learning may be intact while others are not (Barnes et al., 2010), with other studies finding that there are no impairments (Vloet et al., 2010). One study even found that young learners with ADHD outperformed the control group in an adapted artificial grammar task (Rosas et al., 2010). It is clear that more research is needed in the area of implicit learning and neurodivergence. However, in the literature review of musical contexts (Chapter 2), practical applications of incidental or implicit learning for students with learning disabilities will be considered.

## *MOTOR SKILL ACQUISITION*

In this subject area, more so than in any of the above fields, the sports, fitness, and health industries have especially taken full advantage of implicit learning findings. The importance of implicit learning for motor skill acquisition is concisely summarised in a study on injury prevention in sport (Benjaminse & Otten, 2011):

> Motor skills that are acquired explicitly tend to be less resilient under psychological and physiological fatigue, tend to interfere with the normal automatic processing of the motor schema, tend to be less durable and less robust when a fast response is required, and explicit learning may be affected to a greater extent by an individual's intelligence than implicit learning (p. 623).

Several applications for enhanced coaching strategies and performance abilities have since been considered and developed, a few of which will be discussed here:

IMPLICITLY INDUCED DISCOVERY LEARNING. Discovery learning refers to the learning of a new motor skill through trial and error, and modifying its execution based on the outcome. This type

[3] A learning condition, generally regarded as implicit, since it bypasses the need to engage with explicit error elimination processes (Anderson & Craik, 2006). In this type of learning, the level of task challenge is carefully controlled in such a way that participants do not resort to trial and error in order to learn.

of learning is often identified by the ability to apply the "if-then" rule, i.e. if I do X, then Y will happen. Such trial-and-error learning is traditionally guided by explicit instructions and coaching. However, when an athlete obtains implicit perceptual information from the playing environment, similar to spatial context studies, this may lead to improved preparation of movement (Raab et al., 2009), and faster, more accurate decision-making (Milazzo et al., 2016), due to enhanced environmental attention, as opposed to the processing of explicit hypotheses of movement and action.

**ANALOGY LEARNING.** Another form of implicit learning in sport is the use of imagery and visualisation, rather than step-by-step explanations of techniques. In the example study (Liao & Masters, 2001), table tennis players were instructed to visualise a right-angled triangle between the bat, ball, and table, with the imagined trajectory of the ball running along the hypotenuse. This visualisation resulted in the players' ability to accurately perform a forehand "top-spin" shot, despite the inability to describe the motor skill involved, or the acquisition thereof, beyond the visualisation of the triangle. The test group receiving this form of coaching demonstrated a consistent ability to produce this implicitly learnt shot at a significantly higher rate of success than the control group, who were taught the technique through explicit coaching.

**PREVENTION OF INJURY.** A study aimed at preventing knee injuries in gymnastics (Benjaminse & Otten, 2011), found that teaching posture correction and good landing technique through implicit means, such as analogy learning above, may deliver better results in preventing injury than techniques taught through explicit instruction. It was argued that the active recall of instructions for conscious motor control interferes with natural, unconscious motor control processes, leading to a breakdown in movement co-ordination.

In a novel application of injury prevention training (Ciavarro et al., 2008), young ice hockey players were asked to play a virtual hockey video game. The game would, unbeknownst to the players, either reward safe behaviours (positive group) or penalise aggressive behaviours (negative group). A final control group had neither rewards nor penalties embedded in the gameplay. All groups were simply instructed to enjoy the game, allowing the researchers to ascertain whether the implicitly embedded teaching mechanisms would moderate behaviour, as measured by the change in game scores over several trials. The negative and control groups saw no significant change in behaviour (seeing as aggressive play seems to be the norm, even in the control group, which led to the need for injury prevention training in the first place). The positive group did however show significant improvement in playing behaviour, indicating that safer strategies can be implicitly taught through virtual environments.

**RELIABILITY OF IMPLICITLY ACQUIRED MOTOR SKILLS UNDER PRESSURE.** Research found that implicitly acquired motor skills are more reliable under pressure than those obtained through explicit instruction (Lam et al., 2009). In a task involving throwing a basketball through a hoop, a test group performed the task after analogy training, as explained above, and the control group according to explicit coaching instructions. A pressure factor was subsequently added to the task in the form of a time limit, resulting in deterioration of performance in the control group (explicit), but not in the test group (implicit). A previous study by one of the above researchers found the same deterioration in explicitly learnt performance due to other stressors, such as social evaluation, and financial incentive (R. Masters, 1992).

## *MOTIVATION AND AFFECT*

An important lateral finding for implicit learning in general, is the influence of motivation and affect on a person's incidental or implicit learning ability. Much (if not all) of human learning is driven by motive, whether the learner is aware of it, or not. The existence of such motivation is based on a neurobiological conditioning to either attain a pleasurable affective (emotional) state, such as the satisfaction of completing a difficult task, or to avoid a negative affective state, such as punishment for not completing a task on time (Schultheiss & Köllner, 2014). In many instances, such as in the mentioned examples of task completion, motivation may be quite explicit and obvious. However, motivation may also be implicitly acquired, either through lifelong experience and upbringing, or through specific aspects of the learning context.

In an example study (Eitam et al., 2008), one group of subjects was subconsciously primed for an "achievement" motivation by searching for goal-oriented words in a letter grid (*ambitious, aspiration, competition, excellence, first, race*, *win*), with a control group searching for goal-neutral words (*carpet, diamond, farm, hat, table, topaz, window*). The implicit nature of the primed motivation was verified by the self-reported explicit motivations for completing the experiment, which did not differ between the test and control groups. After motivation-priming, both groups undertook an implicit learning experiment, with the test group (who were primed to have the motivation of achievement) outperforming the control group (no priming) significantly.

Further studies have shown that implicit learning and, more widely, incidental learning is enhanced where the affective outcome is congruent with the unconscious motivation of subjects, for example winning or losing in individuals with a subconscious power motivation (Schultheiss, Wirth, et al., 2005), and facial expressions of approval and disapproval for individuals with a subconscious affiliation motivation (Schultheiss, Pang, et al., 2005). This increased implicit learning ability in motivation-congruent conditions is equally found in familiar and unfamiliar learning contexts and materials (Eitam et al., 2008), but is negatively impacted when tasks are perceived as either too easy or too difficult (Hill et al., 1985). The important implication for education is that students can be primed for specific implicit motivation, and when learning outcomes are designed to be aligned with these motivations, incidental learning processes are reinforced. As Schultheiss and Köllner (2014) stated, “learning environments that manage to engage students’ implicit motives instill a sense of flow in the learner and thus promote further motivation and learning in the classroom” (p. 88).

## MUSICAL ANALOGUES

All of the above advantages to implicit learning could have far-reaching implications for music students, teachers, and professional performers, considering the parallels with the fields of interest mentioned. Potential areas for the application of such findings might thus be the learning, fluency, memory, and retention, of musical material, the effective teaching of students with different learning needs, and the acquisition of specialised motor skills needed for musical performance, as well as the reliability of such motor skills under the pressure of performance.

In Chapter 2, incidental learning in general, as well as implicit learning specifically, will be discussed, and made sense of, within the context of music, considering the available literature, and conceptualising potential applications of the findings as discussed above.

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# CHAPTER 2: MUSICAL CONTEXTS

In the book *How Musical is Man?* (1973), John Blacking considers the biological and evolutionary origins of music, including some of the social and communication aspects it shares with language. He points out the irony of a (Western) society that plays music in every conceivable circumstance, and has built a profitable industry out of music, that relies on the ability of every man, woman, and child to hear, discern, and understand musical sounds, but has gone to great lengths to persuade most of its members that they are "unmusical" so that a select few may appear more "musical" (p. 4). If we relieve music of the imposed burden of being elevated to *only* a fine art that is exclusively attainable by educated and trained musicians, scholars, and composers, we begin to see the integral role it plays in the lives of all human beings, just as all human beings use some form of language and communication to connect with others.

Exploring musical learning through a scientific lens, and applying the knowledge to inform and improve our teaching practices, just as it has been done in language learning, the psychological and medical sciences, and physical education, becomes an obvious course of action. More than just the cognitive, neuro-developmental, and physical motor skill aspects of better teaching and learning, we can begin to appreciate the powerful impact music can have on everyday lives, such as I experienced first-hand with children from disadvantaged communities in South Africa. Musical learning promotes not only cognitive and motor skills, but also emotional affect and expression, motivation, and empathic, social engagement. Making music together (whether informally for pure enjoyment, or in the more formal context of student-teacher exchanges and ensemble playing) is a highly specialised type of interpersonal coordination, or social entrainment. Studies have shown that our natural tendency to coordinate our postures, mannerisms, facial expressions, and gestures with those of others we interact with is a "social glue" that produces pro-social behaviours and facilitates harmonious interactions (Vicaria & Dickens, 2016). It is an automatic, non-random process that develops from infancy throughout our lifespans, helping us perceive and empathise with the actions of others, and is a facilitator of the successful creation of social bonds. On an individual level, social entrainment may increase creative thinking (Ashton-James & Chartrand, 2009), and enhance fine motor control (Finkel et al., 2006).

As far as musical social entrainment is concerned, the intentional coordination of pitch and tone, tempo and rhythm, and expressive qualities between two or more players/singers serves to strengthen the effects of the unintentional interpersonal coordination that is inherent in our interactions with others (Kim et al., 2019). Further to this, through the activation of the mirror neuron system, the perceived actions and emotions of others in musical engagement and performance create a neural representation of the same actions and emotions within ourselves and therefore promote empathy and social cooperation (Clarke et al., 2015; King & Waddington, 2017; Rabinowitch, 2017). The importance of applying knowledge and findings from other disciplines that may improve music teaching practices, and by extension the accessibility and learning outcomes for all students, and for their positive interaction with others, thus becomes clear.

Considering the findings from the disciplines discussed in Chapter 1, and the clear parallels that can be drawn to music in terms of cognitive and motor skills, one would expect to see similar research and results in the field of music psychology and pedagogy. Surprisingly, this does not seem to be the case. The vast majority of studies that link incidental or implicit learning and music originate from a cognitive psychology or neuroscience perspective, with musical elements merely the medium or stimulus, but not necessarily the main focus of the research. There are however some salient contributions from the science of music cognition that substantiate the existence and natural occurrence of the incidental, and implicit, acquisition of music and its underlying rules and structures (Dienes & Longuet-Higgins, 2004; Rohrmeier & Rebuschat, 2012; Rohrmeier et al., 2011). This, combined with a momentum towards multiple topics on musical learning and perception, does provide some literature of significant value.

Furthermore, it is worth considering that there may be existing research of musical learning phenomena, akin or homogenous to implicit learning, that have not been classified as such. Exploring the available sources brings some pertinent findings to light, the most relevant of which will be examined here.

## CONNECTING THE DOTS

### *THE COGNITIVE-STRUCTURALIST PARADIGM*

In cognitive psychology, it is known that the system for the internal coding of information will use singular, prototypical elements that are the most normative exemplars in a category or domain, and rate any other elements as to their similarity or relation to the former. A good example would be the focal colours red, blue, yellow and green, with novel colours perhaps rated as “light green”, “off-red”, or “butter-yellow”. A quadrilateral figure may be judged by how closely it approximates a square, and numbers may be rounded to the nearest 10, 100, or 1000. In this system of “cognitive economy” (Rosch & Lloyd, 1978), the objective is to best make distinctions relevant to the domain, whilst conserving as much of our cognitive resources as possible. This theory of codification has also been called cue validity (Beach, 1964; Reed, 1972; Rosch & Mervis, 1975), in which the prototypes/exemplars of a domain or category will have the most features in common with other members of the same category, and the least in common with members of other categories. In this way, a hierarchical structure of encoded elements is established according to their "best fit" with the category itself, or with its exemplars. The same holds true for our encoding of musical pitch.

In any tonal system, across cultures, one particular tone is central to the scale or mode in use. This tone, called the tonic, forms the prototype or exemplar of the tonality and "key", as in cue validity above (Krumhansl, 2001). For example, musicians trained in the Western classical style have displayed a clear hierarchical preference for the tonic, followed by the dominant and mediant (the fifth and third steps of a scale, that make up the main, strongest chord in any major or minor key), and then the other, less prominent steps of the scale in order of their relation to the tonic. They have also demonstrated a clear preference for diatonic tones (those belonging to the scale in question) over non-diatonic tones. Similar findings were demonstrated in the pitch perception of tonal hierarchies in North Indian music (Castellano et al., 1984), in Balinese *pelog* and *slendro* scales (Kessler et al., 1984), as well as in experimental, non-diatonic melodic sequences created not to resemble any existing tonal system (Oram et al., 1995).

The latter is important for our understanding of how musical structure is encoded, as it seems to imply online learning of novel tonal hierarchies, whether from an unfamiliar cultural context, or newly composed music adhering to a previously unknown tonality. In a study using neural nets[4] to model human perception and encoding of tonal structure (Bharucha & Todd, 1989), three different networks were tested: a.) an auto-associative net, where the input of a complete set of scale tones, regardless of cultural context, resulted in the correct "filling-in" of missing scale tones when an incomplete subset of the scale was presented, b.) a hierarchical representation net, where (like cue validity above) the prominence of a tonic was established, and all other tones were rated as to their relation to that tonic, and c.) a sequential net, which established the levels of probability of any specific tone (or harmony, such as in chord progression) being followed by any other specific tone or harmony. The authors concluded that all three types of nets were valid and may at different times be employed in our perception of tonal structure. In addition, an interesting finding was in the distinction between schematic and veridical memory in expectancies of musical tones.

Schematic tone expectancy is "culture-based" and originate from structural regularities abstracted from extensively repeated sequences, whereas veridical tone expectancy is "instance-based" as a result of the encoding of a specific sequence (Bharucha & Todd, 1989, p. 44). To see the effect of previously learnt cultural schemas on the learning of novel particular sequences, the

[4] Singular: neural network – a computer system modelled on the brain and/or nervous system, used to simulate neural processes by programming different inputs and measuring resulting outputs.

sequential net was programmed to learn Western tonal structure, and then presented with sequences from a novel tonal set. It first normalised the sequences to a common tonic, and subsequently rated them according to their familiarity to the previously learnt tonality, with sequences that conformed to the familiar regularities of the already established tonal structure being acquired faster than unfamiliar ones. It would thus seem that, if the tonic of a mode/scale is the exemplar for elements in that key (category), then previous schemata of familiar tonal hierarchies will be the exemplars for encoding a new tonal hierarchy.

This encoding process is influenced by the proximity of a tone to the tonic, i.e. the further away it is (e.g. in a different octave), the more difficult it is to perceive the structure, and by how "musical" the stimulus material is perceived to be, as the same online learning was not found with pure sine tones presented out of context (Krumhansl & Shepard, 1979). It has also been found that the process is enhanced by musical training. This may partly explain why Dienes and Longuet-Higgins (2004) found that non-musicians could not implicitly learn atonal serial or 12-tone sequences, since the presence of a tonic, or categorical exemplar, seems to be an important prerequisite in the absence of prior knowledge and experience. This was further confirmed by Oram et al. (1995), who found the prior schematic knowledge of tonal hierarchies in trained musicians enhanced the veridical learning of novel tonal structures, as compared to non-musicians. However, for the initial schematic encoding of one's own-culture music, musical training is not necessary. In a developmental study on tonal hierarchy, Krumhansl (2001) found that although the average six-year-old showed no particular preference for any tones, diatonic or non-diatonic, by age 10-11 they demonstrated a clear hierarchical structure preference according to their own-culture music (equal to what was seen in trained musicians), which was not obtained through training but acquired implicitly through mere exposure to music in their everyday lives.

## *THE MERE EXPOSURE EFFECT*

As the original mere exposure experiment showed (Zajonc, 1968), we are capable of implicitly acquiring knowledge about, and preferences for, stimuli that we are exposed to at a higher frequency than others. This also applies to music. Rohrmeier and Rebuschat (2012) reported that participants implicitly learnt complex musical elements through mere exposure. They found that regardless of age, culture, musical ability, or previous musical training or knowledge, the majority of participants could perform basic musical cognition tasks, such as recalling and comparing melodies, recognising styles, and even predicting musical sequences. Furthermore, most participants also instantly noticed a dissonant chord or obvious mistake, even if no explanation could be given for why it seemed "wrong".

There are universal aspects of musical structure that can be acquired through mere exposure, for example the ability to differentiate between spectral (pitch – as discussed above) or temporal (rhythm) characteristics of auditory tones (Hannon & Trainor, 2007; Trehub, 2003). However, the most compelling evidence of implicit learning of music through mere exposure can be observed in cultural contexts, as mentioned in the context of learning tonal structure above, and in the acquisition of many of the other regularities of one's own-culture music (Tillmann, 2005; Tillmann et al., 2000).

In a study on age-sensitivity of implicit musical learning (Schellenberg et al., 2005), three groups of 6- to 11 year-olds (*n* = 103: 23 French, 36 Australian, 44 Canadian) were required to classify the ending chord of a musical example. The chord would either be the tonic of the key, or a different, less stable, or even dissonant chord. One group had to identify the last vowel sung as either "i" or "u", the next group had to decide whether the last note was played on piano or on trumpet, and the final group had to state whether the last chord sounded "good" or "bad". Their responses were consistently faster and more accurate when the last chord was the consonant tonic, rather than a more obscure or dissonant one. This would imply a knowledge of "wrongness" in Western harmony, which could only have been implicitly acquired through the children's mere exposure to music from their environments, in a process that is better known as musical enculturation.

## *ENCULTURATION*

Musical enculturation is a process of acquiring knowledge about musical elements, such as structure, that is specific to a culture, from everyday listening to the music of that culture, for example, on the radio or through singing and dancing (Hannon & Trainor, 2007). It is an extensively studied phenomenon, referring to the exposure to homogenous musical structures present within a specific culture over an entire lifetime (Demorest & Morrison, 2015), but it is believed to affect our understanding of musical structure long before adulthood (Morrison et al., 2008). Some studies have even demonstrated a knowledge of own-culture harmony as early as four to five years of age (Corrigall & Trainor, 2010; Stalinski & Schellenberg, 2012). Interests within the subject also include understanding cultural bias in music, how we interact with music from other cultures than our own (Demorest et al., 2016; Stevens, 2012), and the cognitive effects of exposure to multicultural music, in a similar way as being multilingual has been shown to have cognitive and developmental effects (Wong et al., 2009). Considering these aspects, enculturation is thus a multifaceted and complex process, that develops specialised perceptual processing skills for the spectral, temporal, and structural elements of the music of a specific culture. It also facilitates an understanding of what is considered aesthetic and expressive within that culture, and how music is used in different social circumstances (Trainor et al., 2012). In traditional Venda music, for instance, music is only played and sung as part of the social fabric of everyday life, and as accompaniment to various rituals and social events (Blacking, 1995). It has no meaning as a sonic object outside of its social context. Although the music may have systematic rules that can be learnt, like the grammar of a foreign language, it is not learnt in that way by Venda children and could only be implicitly acquired by growing up in the Venda society. After living amongst the Venda people for two years, John Blacking explained that there are "aspects of the Venda musical tradition which are forever changing and which cannot be learned except by total participation in Venda society and by unconscious assimilation of the social and cognitive processes on which the culture is founded" (Blacking, 1971, p. 95). In the literature on enculturation, the fact that this process occurs mostly implicitly, that we learn rules and complex structures pertaining to the specific music of our culture without any intention to do so, without formal instruction or training, or awareness of such learning, oftentimes before we even reach school-going age, seems to have been of passing interest. It is the accepted norm, in the same way as it is accepted that native language learning happens implicitly from infancy. The implicit nature of musical enculturation does however become more significant when viewed from the perspective that its processes are considered to be an example of statistical learning (Ettlinger et al., 2011; Rohrmeier & Rebuschat, 2012; Stevens, 2012). In fact, some studies suggest that musical enculturation would not be possible without its dependence on, firstly, statistical learning, and secondly, probabilistic prediction (Huron, 2008; Pearce, 2018).

At the 2009 World Science Festival, in an event called "Notes & Neurons: In Search of the Common Chorus", the well-known vocalist, Bobby McFerrin, demonstrated our ability for probabilistic prediction in music, based on the statistical learning of the pentatonic scale, which is ubiquitous in music from all cultures (Trehub, 2001). By teaching the audience only three notes in the scale, sung according to his stepping sideways from one position on the stage to another and back, they implicitly knew which notes would come next when he took further steps outside of the ones previously shown (Guardian, 2010). Furthermore, our ability to even detect audible tones may be enhanced by probabilistic prediction of the pitch that may follow (Greenberg & Larkin, 1968). To make sense of this phenomenon, we first need to understand what statistical learning is, how it forms part of our innate learning ability as human beings, and how this applies to music.

## *STATISTICAL LEARNING*

As seen in the Theory of Affordances (Gibson, 2014), our dynamic interaction with our environment affords us knowledge about that environment and how to navigate it. It is relatively simple to obtain basic physical experiential knowledge, for example that we cannot walk on water, or that a hot surface will burn us, but how do we learn abstract knowledge, such as language and communication, music, cultural significances, and societal norms? Human beings (and some other animals) achieve this through an inherent learning mechanism, an ability to implicitly perceive statistical regularities from the environment, in a process known as statistical learning. Some of the first evidence of this mechanism in psychology literature appeared in a paper that demonstrated how certain language acquisition tasks, entirely based on statistical relationships between adjacent tones in speech, could be achieved by eight-month-old human infants (Saffran et al., 1996). More recently, research has revealed that statistical learning occurs not only for language acquisition, but with various different types of stimuli, including pure tones, action sequences, visual cues, and cross-modal relations (Schapiro & Turk-Browne, 2015). It is also not limited to human infants, as it is available to adults alike, and has been identified in other species, such as primates and rats (Hauser et al., 2001; Pons, 2006). Furthermore, statistical learning does not only appear susceptible to simple, one-dimensional serial learning, but occurs even when stimuli are presented with variations in type, frequency, and in co-occurrence with other stimuli (Thiessen, 2017). It is also important to note that although statistical regularities in the environment could obviously be pointed out explicitly, statistical learning in its natural occurrence is an implicit learning mechanism (Stadler & Frensch, 1998; Thiessen & Pavlik Jr, 2013). As Daikoku (2018) points out, "it has been considered an implicit and domain-general mechanism that is innate in the human brain and that functions independently of intention to learn and awareness of what has been learned"(p. 114).

Although most of the salient works on statistical learning have been done within the context of linguistics and language acquisition, its broader applications (as seen above) are apparent, and its importance for music has already been made evident in several studies. One such study that explored the language-music commonality, was a follow-up on the previously mentioned work on language acquisition in human infants. In the original experiment, nonsense-words consisting of 11 pre-determined syllables were chosen as stimuli, but in this case each syllable was substituted with a specific musical note (e.g. the repeated word "bu-pa-da" would become the repeated three musical notes DFE). The results showed that statistical regularities in sound sequences were just as well perceived as in the language experiment, and that the musical element of speech probably enhances language acquisition to begin with (Saffran et al., 1999). Similar studies have also examined statistical learning of auditory stimuli with temporal variations (Terry et al., 2016), multiple concurrent melodies (Daikoku & Yumoto, 2017), and predictability of musical notes (Koelsch et al., 2016).

A gold standard for statistical learning is artificial grammar learning, as described earlier in Chapter 1, which has been applied using musical notes or auditory tones as stimulus material in more than one study. Randomly assigned sine tones were used to demonstrate implicit learning in a finite-state grammar (Dienes et al., 1995), and in a similar experiment, the grammar consisted of the differing timbres of various musical instruments (Bigand et al., 1998). Kuhn & Dienes (2005) set out to demonstrate that implicit learning applies to more than merely chunk learning[5]. To that effect they used musical melodies composed using a diatonic inversion rule, where the first four notes of a test melody were chosen randomly, and the next four were inversions of the intervals between the first four (e.g. 3 steps up from one note to the next now became 3 steps down). This would make the melody "grammatical", as in artificial grammar learning. They subsequently introduced novel melodies to measure participants' recognition of, and preference for, those that adhered to the rule and determined that implicit learning of the rule had occurred at a significant level.

It was only later that some interest developed in the musical significance of these experiments. The thought was that, although utilising musical stimuli, the grammars were not necessarily musical or representative of any recognisable musical structures, as it is not typical for a melody to strictly adhere to mathematical or formulaic organisation (Rohrmeier et al., 2011). A new artificial grammar experiment was designed, using training material composed according to the principles of the Essen Folksong collection[6], thereby making it musical, rather than merely auditory. The test phase included melodies from the training set, novel melodies that were still grammatically correct according to the rules of the training set, and novel, non-grammatical melodies. The participants were arranged into a test group that received training in the artificial grammar melodies, and were subsequently asked to rate the test material according to familiarity with related confidence judgements, and a control group who only received the test material, without prior exposure to the training melodies. Both groups consisted of equal numbers of professional musicians and non-musicians, to determine if there would be a correlation with musical training and proficiency. The results showed significant implicit acquisition of the artificial grammar in the test group, and found no advantage to musical training in the Western classical music tradition when acquiring novel musical structures.

Although this experiment may not have found any difference in the performance levels between musicians and non-musicians for acquiring novel musical elements, it has been mentioned earlier in the cognitive-structuralist paradigm that musical training does enhance the acquisition of novel tonal structure, and sufficient evidence has been found from other studies that musicians may well possess a larger capacity, or greater aptitude, for implicit learning in general. It would therefore seem that not only is the implicit learning of the elements of music universal, as seen in the discussion thus far, but musical training may enhance the cognitive mechanisms responsible for this learning in an apparently synergetic manner.

[5] A cognitive process that rearranges information into related groups to increase the efficiency of, and capacity for, learning.
[6] A computational musicology dataset of more than 6,000 folksongs from around the world, collected by Helmut Schaffrath (1995).

## *THE MUSIC/IMPLICIT LEARNING SYMBIOSIS*

There has been a great interest within the fields of cognitive psychology and neuroscience in the hypothesis that expertise in certain fields may not only lead to enhanced skills in those specific fields, but may also have an effect on general cognitive processes, such as memory, multi-sensory input processing, attention, processing speed, and visual perception. Musical expertise and the ability to play a musical instrument proficiently have often been fertile grounds for the research of this phenomenon, with interesting findings for the current perspective of this thesis.

One such study tested the implicit sequence learning ability of musical instrumentalists, expert video gamers, and a control group of non-experts in a standard SRT test, similar to the original Nissen and Bullemer (1987) design, as described in Chapter 1. Both the musicians and video gamers had significantly higher learning scores than the control group, but interestingly, the musicians outperformed both other groups on overall response time, i.e. the physical manifestation of visual processing speed (Romano Bergstrom et al., 2012). Related to SRT tasks, evidence suggests that musicians perform better than non-musicians in implicit visuospatial sequence learning and recall, even when results have been controlled for short-term memory capacity, non-verbal reasoning ability, education level, and the range of vocabulary of all participants (Anaya et al., 2017).

The effect of music expertise on the implicit acquisition of language has been the focus of several research papers. In one example, findings showed that when a novel (made-up) language was set to music, participants with musical expertise showed greater implicit learning not only of the musical structure as would be expected, but also of the linguistic structure, than the non-musician participants (Francois & Schön, 2011). Another study used a similar approach, but with the exception of comparing music experts with language experts, rather than merely with non-musicians. They found that musicians performed at near-equal levels to language experts in the implicit language learning test, and at far superior levels in the implicit music learning test (Larrouy-Maestri et al., 2015). There is, however, a wider discussion over the possible reasons for musicians' seemingly enhanced capabilities in other cognitive tasks. Musicians are able to perceive a greater range of tonal frequency (Kishon-Rabin et al., 2001), and demonstrate enhanced brainstem encoding of pitch discrimination in both music and speech (Musacchia et al., 2007), which may be explained by a higher grey-matter distribution in the auditory cortex (Bermudez & Zatorre, 2005). They have also been shown to have a larger planum temporale (Keenan et al., 2001), which is central to Wernicke's Area – one of the most important functional areas of the brain for language and auditory processing (Baars & Gage, 2012). Further to auditory skills, musicians also demonstrate enhanced motor skill (Zafranas*, 2004), visuospatial skills (Brochard et al., 2004), and possibly even mathematical processing (Schellenberg, 2001).

Critically evaluating these findings, we have to consider whether musicians truly have enhanced implicit learning mechanisms, or simply possess a heightened aptitude for the standard materials used most often in implicit learning experiments. To further illustrate this point, do musicians fare better in SRT tasks due to a superior ability to implicitly acquire a sequence, or have years of reading music notation and instantly transferring it into the motor skill necessary for playing their instrument afforded them faster visual processing speeds and reaction times? Do they really implicitly learn language better than non-musicians, or do the shared music and language neural pathways dually benefit from musical development? Despite the advances in neuroscience and cognitive psychology, and promising evidence for likely candidates, the definitive pinpointing of implicit learning mechanisms in the human brain are still somewhat elusive. It may even be that the above-mentioned skills are integral parts of such mechanisms. Furthermore, children who eventually become musicians may have a genetic predisposition for these skills before musical training even commences. Although the case has been made that musical training enhances cognitive function in children (Habibi et al., 2018; Schellenberg, 2004), causality has not been unequivocally demonstrated. These questions may therefore have to remain unanswered for the time being. Nonetheless, it is clear that music and implicit learning are symbiotic, and that further research in the area is indicated.

## *CONSTRAINTS ON IMPLICIT MUSICAL LEARNING*

Despite the indication of the symbiosis between music and implicit learning, and the promising aspects of implicit musical learning as have been discussed thus far, there are some limitations on the implicit or wider incidental learning of some elements of music that need to be taken into consideration. For example, the implicit discovery of key signature has been found to be impaired when participants were presented with ambiguous intervals, i.e. those that may belong to more than one key, or even if unambiguous intervals were presented in a different temporal order than it would typically appear in tonal music (Brown et al., 1994). This relates closely to Narmour’s Implication-Realisation theory for melodic perception and processing (1990), which provides five basic principles that govern the melodic construction of the music of cultures from all over the world. In addition to impaired implicit learning with intervallic ambiguity and temporal deviations as above, it was demonstrated in an experimental study with artificial grammar melodies, designed to deliberately violate Narmour’s principles, that novel melodies that did not conform to these principles could not be incidentally acquired to the same extent as those that did (Rohrmeier & Cross, 2013).

Considering the tonal material that make up melodies in any culture, i.e. the scales and modes used, it is interesting to note that the traditional music of nearly every culture, with very few known exceptions, utilise scales made up of five or seven steps before the tonic reappears one octave away from its first iteration. It has been suggested that this universal use of pentatonic and heptatonic scales may be a natural evolution of music, stemming from the cognitive limitation of the human working memory that can only process around seven units of information at any given time, or possibly that it represents the range of pitch inflections in human speech (Krumhansl & Shepard, 1979). Regardless of their origins, in practice, the five or seven steps of each of these scales are arranged in uneven intervals, with the exception of the Javanese *slendro* scale, which consists of five evenly spaced steps. The Western major scale, for example, consists of seven notes that are (in ascending order) 2, 2, 1, 2, 2, 2, and 1 semitones apart. If all 12 possible tones of the chromatic scale are arranged consecutively around a circle, in equidistant intervals such as they are in auditory mode, the seven uneven steps of the Western major or minor scales (and most other scales used across cultures) will present in an asymmetrical pattern, whilst the even steps of a whole-tone scale, or even the chromatic scale itself, will present in perfect symmetry, as in the examples shown in Figure 3 (idea of graphic representation borrowed from Pelofi and Farbood (2021)):

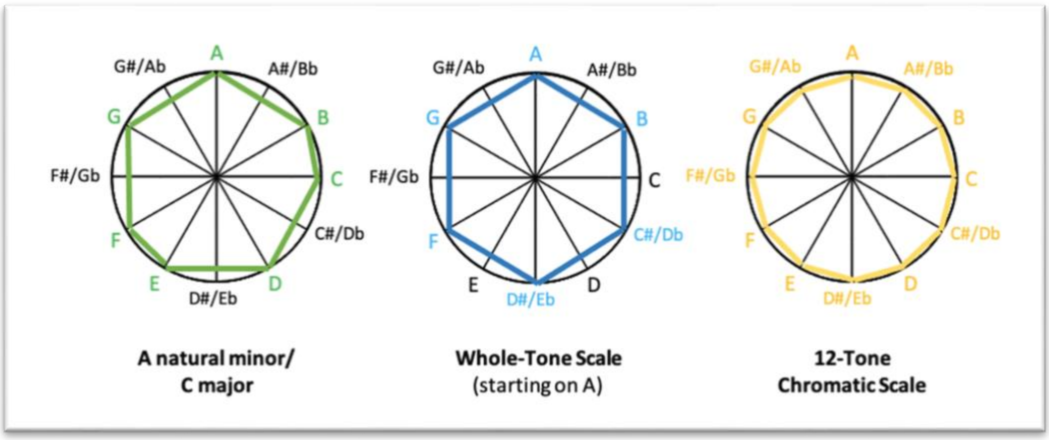


**FIGURE 3:** *Symmetry and Asymmetry of Scales*

According to cue validity and the cognitive structuralist research discussed earlier, the identification of a categorical exemplar is necessary for the processing of new information, and the establishment of a tonic is required to process tonality. We can thus argue that the ubiquity of the cross-cultural use of asymmetrical pentatonic and heptatonic scales is due to this cognitive constraint, since the tones of symmetrical scales have no unique relationships between any intervals, and no note has any more significance than another. It therefore becomes extremely difficult, without prior knowledge or training in that scale, to establish a tonic and process tonality.

It was indeed shown in studies with nine-month-old infants that they could recognize out-of-tune notes in both familiar (to their culture, but not yet to them) and unfamiliar asymmetrical scales, but not in symmetrical ones (Trehub et al., 1999). Interestingly, the same experiment with adults did not obtain the same results, with out-of-tune notes only recognised when presented in own-culture scales, but not in unfamiliar asymmetrical, or symmetrical scales. A similar study found the same effect for familiar and unfamiliar metre and rhythms (Hannon & Trehub, 2005). It would thus seem that, despite the clear evidence of implicit learning of musical elements through enculturation, it produces an own-culture familiarity bias that impedes the implicit learning of novel and unfamiliar musical components.

## POTENTIAL ADVANTAGES OF IMPLICIT LEARNING FOR MUSIC

What is clear from the assimilation of research on incidental learning in music, despite the above limitations, is that it is an integral part of music acquisition, just as it is for the areas identified in the cognitive research discussed in the previous chapter. If we then consider the advantageous nature of such learning that has been discovered in these areas, we can postulate similar benefits for musical learning and performance. The named categories in Chapter 1, i.e. Language Learning, Memory and Retention Skills, Neurological Impairment and Learning Disabilities, Motor Skill Acquisition, and Motivation and Affect, will be discussed here, in parallel, for music.

### *MUSIC/LANGUAGE LEARNING*

It has been stated that our fundamental means of communication are language, music, and gesture, from both an intellectual/emotional as well as a biological perspective (Clayton, 2008). We subconsciously strive for synchrony and entrainment[7] with our environment and other living beings. This acknowledges the relationship between language and music, and how the two are often inseparable in research, and for salient reasons. As has become apparent in the discussion thus far, music and language share neural areas and pathways, so much so that neuroscientists have suggested a common origin of music and language in the human brain (Koelsch et al., 2003), and use the two as substitutes for each other in experiments relating to brain mapping (Patel, 2003).

The complementary nature of the music/language relationship is striking when we review the previously discussed experiment where implicit learning of both musical and linguistic stimuli was

[7] The interaction and consequent synchronisation of two or more independent rhythmic processes.

compared between musical experts and language experts (Larrouy-Maestri et al., 2015). As a relevant focus of interest, an additional group of experts were tested, consisting of dual experts, in both language and music, i.e. professional musicians who were also fluently multilingual. This group had significantly higher performance scores in both modalities than either of the other expert groups could attain in their own domain of expertise. Even in the limited musical expertise and training that children as young as eight years old may have, cognitive advantages have been detected for the implicit learning of both musical and speech pitch violations, over children with no musical training (Magne et al., 2006). Further to this, the musical aspect of speech has been exploited for the benefit of language learning, not only in key academic research (Ettlinger et al., 2011; François et al., 2013), but also in everyday learning traditions. For generations we have learnt words, spelling, rhyme, and more, through song. Logically, there should be substantial evidence for these beneficial effects to be reciprocal. Indeed, there are entire musical learning philosophies based on the commonalities between language and music. Shin'ichi Suzuki, founder of the Suzuki Method for teaching string instruments, famously pondered the fact that "all Japanese children speak Japanese" and therefore wanted to develop a musical learning system built on the principles of first language acquisition (Hendricks, 2011). This led to a system of teaching that is world-famous today and employed by teachers globally.

When considering specifically the rhythmic element shared by language and music, learning and understanding musical rhythms through everyday words, or even made-up ones, has a long history within musical pedagogy.

APPENDIX 1: RHYTHM SYLLABLE SYSTEM COMPARISON

| | ♩♩♩♩ | ♪♪ | ♬♬ | 𝅗𝅥𝅗𝅥 | 𝅝 | 6/8 time | 6/8 time | triplet |
|---|---|---|---|---|---|---|---|---|
| Galin-Paris-Chevé [word-based] | Noir-noir-noir-noir | Cro-che | Dou-ble cro-che | Bla-nch, bla-nch | (?) | (?) | (?) | (?) |
| 1 e and a [number-based] | 1-2-3-4 | 1 & | 1-e-and-a | 1_3_ | 1__ | 1-2-3-4-5-6 | (?) | Tri-po-let |
| McHose/Tibbs [number-based] | 1-2-3-4 | 1-Te | 1-Ta-Te-Ta | 1_3_ | 1__ | 1-la-lee, 2-la-lee | 1-Ta-La-Ta-Li-Ta, 2-Ta-La-Ta-Li-Ta | 1-La-Lee |
| Simplified French Time-Names [new syllables] | Ta-Ta-Ta-Ta | Ta-Te | Ta-Fa-Te-Fe | Ta_Ta_ | Ta__ | Ta-Te-Ti, Ta-Te-Ti | Ta-Fa-Te-Fe-Ti-Fi, Ta-Fa-Te-Fe-Ti-Fi | Ta-Ra-La |
| Luther Mason-adapted French Time-Names | Ta-Ta-Te-Te | Ta-Fa | Ta-Za-Fa-Na | Ta_Te_ | Ta_e_ | Ta-Ra-La, Ta-Ra-La | Ta-Fa-Ra-Fa-La-Fa, Ta-Fa-Ra-Fa-La-Fa | Ta-Ra-La |
| Curwen-adapted French Time-Names | Ta-Ta-Ta-Ta | Ta-Te | Ta-Fa-Te-Fe | Ta_Aa_ | (?) | (?) | (?) | (?) |
| Froseth/Blaser [new syllables] | Du-Du-Du-Du | Du-De | Du-Ta-De-Ta | Du_Du_ | Du__ | Du-Da-Di, Du-Da-Di | Du-Ta-Da-Ta-Di-Ta, Du-Ta-Da-Ta-Di-Ta | Du-Da-Di |
| **Takadimi** [new syllables] | Ta-Ta-Ta-Ta | Ta-Di | Ta-Ka-Di-Mi | Ta_Ta_ | Ta__ | Ta-Ki-Da, Ta-Ki-Da | Ta-Va-Ki-Di-Da-Ma, Ta-Va-Ki-Di-Da-Ma | Ta-Ki-Da |
| **Kodály** [new syllables] | Ta-Ta-Ta-Ta | Ti-Ti | Ti-Ka-Ti-Ka * | Ta_Ta_ ** | Ta__ | Ti-Ti-Ti, Ti-Ti-Ti | Ti-Ka-Ti-Ka-Ti-Ka, Ti-Ka-Ti-Ka-Ti-Ka * | Syn-co-pa |

*Some Kodály proponents use "Ti-Ri" for sixteenth notes rather than "Ti-Ka"
*Similarly, some use "toe" rather than Ta__ for half note

**FIGURE 4:** *"A Historical Journey to Takadimi via the Kodály Method" (p. 125)*

Dating back to the early nineteenth century rhythm teaching of French mathematician Pierre Galin, to the well-known teaching methods of Emile Jaques-Dalcroze, Carl Orff, and Zoltán Kodály, to the more modern Takadimi system, all utilise words to explain and teach different rhythms in music, as can be seen in the above table from the Joshua Palkki (2010) "Rhythm Syllable Pedagogy" (Fig. 4). In fact, if we are to judge by the widespread availability of internet graphics similar to the example here (Fig. 5), then any rhythm can be taught for any instrument or purpose, by using standard speech patterns as scaffolding.


**FIGURE 5:** *Words for Rhythms (Hirsch, 2019)*

The value of substituting words for rhythms becomes particularly apparent when it comes to complex rhythms that are more difficult to read, count, and subsequently perform correctly. Consider the example of piano students and their initial encounter with triplet-over-two, or duplet-over-three rhythm (where one hand has to play three equal notes in the exact same timeframe as the other hand plays two equal notes). This is challenging both in temporal processing (counting), as well as fine motor skill, as each hand has to behave independently from the other, but in a synchronised way. The difficulty can be easily overcome however, by repeating a simple spoken rhyme while playing the rhythm. To demonstrate, two bars from Debussy's first Arabesque for piano (1891) are enlarged here (Fig. 6) and illustrate how the rhyme "I Catch a Fly" (with emphasis on the "I") can be repeated while playing it. In this way both the complex rhythm and the motor skill required to play it are acquired incidentally. The same type of spoken or sung rhyme can be used to obtain the hand independence needed for, for example, three-over-four or four-over-five rhythm.

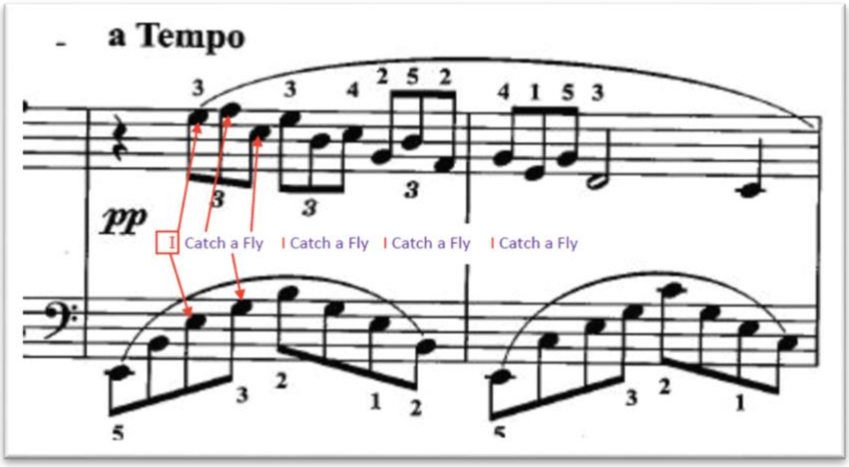


**FIGURE 6:** *Excerpt from Debussy Arabesque No. 1 for Piano (1891)*

The difference in urgency and proliferation of cognitive learning research (incidental or otherwise) between language and music, could be attributed to the fact that it is possible for a person, for the most, to be a passive consumer of music. This is not the case with language, where we necessarily are active participants in the act of reproduction as an essential aspect of human communication. That is not to say that those who do pursue the skill of reproducing and creating music should not benefit equally from advances in subject-specific research, rather than just the inter-domain borrowing of learning devices. Equivalent research into implicit learning of music may lead to faster, more accurate, and more fluent acquisition of musical knowledge.

## *MEMORY AND RETENTION SKILLS*

In the Western classical music tradition, music is primarily learnt by studying the printed scores and notation of the works of composers, or very occasionally by listening and watching someone else play and then repeating what was seen or heard. Like actors learning an entire play or screenplay off by heart, a large aspect of successful musical performance is judged on the complete and accurate memorisation of entire musical compositions (Williamon, 2002). It is not surprising, when one considers the level of repetition and practice that goes into this skill, that musicians have proven to be better at memory and retention tasks, even for non-musical elements (Jakobson et al., 2008), and it is the strategies that are used to practice and develop the skill of memorisation that are of interest for the current topic.

Such strategies have generally been classified as aural, visual, kinaesthetic (Hughes, 1915), and/or conceptual (Chaffin et al., 2005). In a seminal paper on the development of memorisation strategies in both professional and novice musicians (Hallam, 1997), these are discussed further. For aural strategies, musicians may retain auditory schemata by repetitive listening, and then play it “by ear”, without the printed notation. For visual strategies, subjects reported being able to visualise where a certain musical passage or element was located on the page, or looking at the pattern of their fingers on the instrument and “just knowing” what comes next. Kinaesthetic strategies, or as it is often mistakenly referred to as “muscle memory”, employs a totally automated motor programme as the prime source of playing from memory. The significance of the latter will be discussed further in the section on motor skill acquisition below. Conceptual memorisation strategies rely on a systematic and deliberate theoretical analysis of the written music, in order to create a logical mental framework (or “roadmap”) for performance, based on harmonic progression, sequences, and other regular musical structures. In deliberate attempts at memorisation, most participants reported utilising a combination of more than one (or all) of the above strategies.

An interesting finding that came to light in the above paper is that, just like Martino Tirimo was reported as saying in the introduction, subjects thought that the vast majority of memorisation occurred outside of awareness and intention, through engagement with the music and the process of learning the notation. We therefore propose that the memorisation of music, for the most, is an incidental, or even implicit, learning process. Just as in spatial context memory tests, the Cleeremans connectionist model, and statistical learning theory, musicians probably implicitly become sensitive to visuospatial cues on the printed notation, or on the instrument itself, and implicitly perceive statistical regularities in the music they are learning, which will necessarily lead to better memory and retention, as has been seen in cognitive psychology experiments with similar conditions. Only after this incidental acquisition had been established, and only if certain phrases seemed more prone to memory lapses, did the participants in the Hallam study endeavour deliberate memorisation strategies, and most of them relied on rote repetition to master these less secure phrases. As was shown in the informal Morse-code experiment discussed in the introduction, where the phrase was repeated in novel rhythms, incidental mechanisms can be deliberately activated to make the results of this repetition of difficult phrases faster, more accurate, and more secure.

Of further interest in this area, is context-dependent memory (Mishra, 2002), where not only the music, but also aspects from the performer’s external environment and internal state are encoded along with the notes on the page. Simply, if practice and subsequent memorisation always occurs in the same practice room, in the same emotional arousal state, the memory will be dependent on those states to some extent. The implication is that better retention and recall will occur in the same setting and emotional state as with the original memorisation effort (the practice room), but more memory lapses and recall errors will occur when the environment and internal state are altered (the concert hall). The process whereby we associate certain chunks of information with the environment in which it was obtained or memorised, is an embodiment of contextual cueing (Goujon et al., 2015), where the search for a specific stimulus is faster and more accurate when it is presented in a familiar or repeated context, as was seen in object recognition and spatial context memory studies in Chapter 1. Similarly, when memorised music is being recalled, performance will be more secure in the repeated context where memorisation took place than in a strange or novel context.

Contextual cueing is yet another example of statistical learning, which is implicit by nature. It is indeed difficult to imagine that any musician would consciously memorise a piece of music as well as details of the exact environment at the time, yet those environmental details will still affect performance recall either way, as they have been incidentally acquired. This is why experienced performers will a.) rehearse in as many different settings as possible to avoid the music becoming associated with repeated environmental regularities and b.) will rehearse in the eventual performance venue as much as is allowed, to attempt encoding as many of the location-specific external cues as possible. This is a prime example of how knowledge of incidental learning mechanisms could be employed to facilitate better retention, recall, and improved performance.

## *NEUROLOGICAL IMPAIRMENT AND LEARNING DISABILITIES*

In patients with severe amnesia, it has been demonstrated that the implicit memory of pre-amnesic music remained intact (Cavaco et al., 2012; Finke et al., 2012). It has also been found that new music could be incidentally acquired by amnesic patients (Haslam & Cook, 2002; Valtonen et al., 2014). Further to this, music has been used therapeutically for patients with motor skill loss after stroke (Prassas et al., 1997), and those with Parkinson’s disease (McIntosh et al., 1997), to rehabilitate walking ability, employing the implicit need for entrainment to synchronise two or more independent rhythmic processes as mentioned above (Clayton, 2008). Although these findings demonstrate that applications for incidental musical learning are already being developed in healthcare, more research is needed to discover the further potential for patients.

As far as incidental musical learning for students with learning disabilities is concerned, apart from some examples where music has been used as medium to facilitate the incidental acquisition of other skills, such as speech and language in autistic students (Cooley, 2012), the literature on the incidental acquisition of music is relatively sparse. There are however some potential applications that would be best demonstrated through individual case studies.

"SAM" (SHORE, 2002). Dr Stephen Shore is an autistic professor of special education at Adelphi University, New York. In his paper, *The Language of Music*, he describes his experience with Sam, a 12yr-old boy with "low-functioning Asperger's syndrome"[8], whose mother, a professional musician, wanted him to learn to read and play music. Sam was not doing well with formal education, and was experiencing anxiety from being presented with yet another subject area to navigate. As with many autistic students, he had a natural need for order and task completion. Furthermore, he liked to work with his hands, doing small craft-like tasks. Utilising these natural tendencies, over the span of a few weekly lessons, Dr Shore presented Sam with an incomplete grid of letters, from A to G, as per music notation, which he completed in short order. Next, he was asked to cut out every letter square from the grid, a task he naturally enjoyed. In the interim, Dr Shore drew a music staff and treble clef on a large sheet of paper, and subsequently engaged Sam in placing the cut-out letter squares on the staff, guiding him in the correct placement and order. Following these initial tasks, when Sam seemed to grasp where the letters belonged on the staff, and could draw the staff and treble clef himself, as well as "spell" simple words like "bag", "dad", "eat" and "ace", the same letters were stuck on the corresponding keys of the piano. Previous words were now spelled by playing them on the piano, and this eventually led to the ability to read traditional music notes. In Dr Shore's own words,

> By placing the notes on this staff in this manner, Sam learned how to read music and apply it to a piano keyboard. The difference between this approach and traditional music education is that the primary goal of decoding musical notation was incidental to the activity from Sam's point of view (p. 119).

Further evidence of this incidental acquisition of musical knowledge and skill for students with ASD could be seen in one of the participants in the experimental learning conditions in Chapter 5 of this thesis, and will be discussed there.

The next two case studies presented here are from the author's own experience of teaching both neurotypical and neurodivergent students over many years. Since consent cannot be obtained (they are adults now, and no longer in contact), they will be called student X and Z, for the sake of anonymity.

STUDENT X. In my early years of music teaching, I received a phone call from a very concerned parent. Their seven-year-old son had been diagnosed with severe attention deficit hyperactivity disorder (ADHD), and the prescribed medication caused him significant negative side-effects, such as devastating personality changes, lethargy, and depression. The parents had decided not to continue with the medication and pursue an alternative treatment plan. The first part of the

[8] Taken verbatim from Shore (2002). It is however noted here that these terms are now outdated, and Asperger's is considered as part of the autism spectrum.

plan was to encourage him, in all available free hours, to play outside, run around, and take part in every sporting activity they could find, in an effort to keep him as physically active, and to get as much fresh air and exercise, as possible, which seemed to alleviate the worst of the hyperactivity and fidgeting. However, in the hours of formal schooling, his inability to focus in the classroom was still extremely problematic, and he was at risk of exclusion from the local school, which did not have provision for special educational needs. A teacher at the school had suggested to the parents that music lessons might help and provided them with my contact details. I was still inexperienced, with no previous knowledge of teaching students with different learning needs, and did not want to make them any promises, but I agreed to try to help him.

In our first lesson, we proceeded as beginner lessons normally do, with discovering that the musical alphabet has only the first seven letters, A to G, locating middle C on the piano, and playing the letters on the piano keys. This was where student X's ability to focus ended. As soon as we started learning to play the C major scale, we could not get beyond the first three or four notes without his attention shifting. At first, I would attempt to gently bring his focus back to the piano, but this achieved limited success, and growing frustration. I then thought, "if I cannot bring his focus to the piano, I will bring the piano to his focus". The rest of the lesson was spent playing a game, where anything he would pay attention to, would be related to the notes of the C major scale. If he started talking about rugby, the ball would become the notes of the scale being passed around. If the object of fascination was the clock on the wall, it would tick according to the scale. When a cat walked past the window, it meowed in C major. By the end of that first lesson, he could play the scale of C major on the piano.

In subsequent lessons, I found that, by allowing student X to set the level and duration of focus, and by providing the necessary musical knowledge and skills as incidental byproduct of wherever his attention led, he learnt to play the piano at a similar rate to any other beginner student, taught using traditional methods. Furthermore, as he became steadily more proficient, the intervals between attention shifts became longer. By the end of his first year of lessons, he could play through an entire Grade 1 piano piece, without losing focus, and his teacher at school had noticed a marked improvement in his ability to pay attention in class.

**STUDENT Z.** Many years later, while teaching at a private school in Johannesburg, South Africa, student Z, a 10yr-old girl who had already been taking piano lessons for two years, was allocated to me in the usual annual rearrangement of timetables. Her previous teacher told me that she was "very bright and musical, but lazy", as she only wanted to play her favourite songs by ear, and would not practice sight-reading. She therefore could not read music, which was a prerequisite of the instrumental music curriculum of that particular school. Within the first few lessons, I had started to suspect that she suffered from dyslexia, as she was quite capable of reading and playing the notes with one hand at a time, as long as the required hand and corresponding line of music were specifically pointed out. However, as soon as she attempted playing with both hands at the same time, I would notice a confusion about which hand was required to play which musical line.

A hallmark of developmental dyslexia (DD) is the inability to tell left from right, to the point of some children failing to become consistently left- or righthanded (Stein & Walsh, 1997). Oglethorpe (2008) confirmed this with specific reference to playing the piano, by stating that, due to an unawareness of the midline of the body in dyslexia, students are often unable to decide which hand is required to play. I discussed my suspicions with student Z's class teacher, but was told that no such diagnosis or concerns have been registered, and that her literacy and numeracy scores were within the normal range for her age group. This left me with a dilemma: If she had mild DD, of which no other symptoms had been detected in other tell-tale areas, it was still preventing her from reading music. If it wasn't DD, I still needed to find a workable solution to help her overcome this obstacle.

I attempted various methods of associating handedness with the music notation, such as the high-pitched notes on the piano, being on the same side as the right hand, also being the higher of the two music lines on the page, and vice versa. I also replaced the clef signs with various pictures of animals and objects that she associated with high and low pitch. Despite her understanding and aural skills for pitch discrimination being very well developed, none of the numerous attempts had any real success, as she failed to discern left from right as soon as her hands had to work together. Finally, in reading about dyslexia research, I came across the Irlen Method (Nandakumar & Leat, 2008), which consists of placing coloured overlays on reading material in order to overcome focus instability and other optical factors of reading impairment. I considered that, if colours do affect visual stability in dyslexic children positively, a method that combined this feature with the LH/RH distinction might prove useful.

In the next lesson, the notes of the top line (right hand, treble clef) were highlighted in pink, and a pink spot marked on the back of the right hand, and the notes of the lower line (left hand, bass clef) were highlighted in green, with a green spot marked on the back of the left hand (see Appendix B for illustration). To my surprise, and to student Z's, she could suddenly play the notes correctly, with both hands simultaneously. With great enthusiasm, she helped me mark all her other pieces of music in the same way, and came to her next lesson after a week of practice, being able to play with both hands at the same time for every piece. Over time, we switched out copies of music for new ones with less colour each time, until only the clef signs at the beginning of the lines were coloured. Eventually, we were able to attempt new music without using any colour, as the left- and right-hand connection seemed to have finally been established and automated. One could speculate about the learning that occurred, the way it occurred, and the neurology involved, but somehow, implicit in the connection of hands, music notes, and colours, the ability to discern left from right and the appropriate use of that for reading and playing music, was incidentally acquired.

These case studies may demonstrate only isolated events, where a solution was found for the acquisition of musical knowledge and skills for a specific student with specific learning needs in each instance. However, in the interest of making musical education as accessible as possible for both neurotypical and neurodivergent students, an area which has thus far received insufficient attention and resources (Welch et al., 2009), much more research is needed for the development of incidental learning applications that may access different learning pathways in every case. As the *Music for All-Initiative* states:

> Traditionally, people with special needs have been offered musical activities within a social club context, the objectives of which are, as a rule, to enable them to get together socially and simply enjoy themselves. In some cases these activities may also include rehabilitative aspects. However, pedagogical goals are often ignored and left out. Our claim is that every person with a disability does not necessarily need music as therapy, but should have access to music studies and, consequently, the opportunity to develop a musicianship. Thus, there is an increasing demand for professional special music education (Kaikkonen, 2011, p. 10).

## *MOTOR SKILL ACQUISITION*

In addition to several cognitive, emotive, and expressive elements, the playing of any musical instrument requires extremely specialised large and fine motor skills. As was mentioned above in the section regarding memory and retention, some musicians extensively rely on automated motor programmes to perform music from memory, thus it is hardly possible to separate the cognitive and motor aspects of the learning and performance of music. However, any means that may potentially lead to faster and more accurate acquisition and automation of such motor skills, would be of notable importance to musical education and performance, for very distinct reasons.

When one considers the issues surrounding the prevalence of playing-related injuries amongst working musicians world-wide (Bragge et al., 2006), the potential benefit of implicit learning of motor skills aiding in posture correction and injury prevention is of particular interest. In addition, one of the most significant reasons for pursuing research in this field, is the possibility that implicitly obtained motor skills are more secure and reliable under pressure, especially since performing on stage or in an examination has been reported as highly stressful, and one of the major causes of clinical musical performance anxiety (MPA) (Kenny, 2011).

A recent study has found through neural imaging that the part of the front parietal complex responsible for sensorimotor control is adversely affected when we perceive the stress of being socially evaluated, resulting in the deterioration of motor skill (Yoshie et al., 2016). The effects of this have long been studied in sport by Prof Richard S.W. Masters, a former director of the Institute of Human Performance at the University of Hong Kong. He found in numerous studies that this deterioration of motor skill occurs under various stress conditions, not only social evaluation. Other examples include financial incentive (R. Masters, 1992), and time constraint (Lam et al., 2009; Masters et al., 2008). He suggests it may be due to the "turning inwards" of the performer under pressure, in an attempt to recall the steps or instructions for the performance of the required motor skill, disrupting the automaticity gained through countless repetitions and practice runs.

Such recall attempts likely occupy the performer's working memory, the brain system that temporarily stores and processes information gained from the immediate environment (Baddeley & Hitch, 1974). The human working memory is a limited-capacity system, which can (on average) only accommodate six to seven units of information at any given time, as evidenced by experiments where people were given an increasing number of digits to remember while performing another cognitive reasoning task. Task performance remained stable until around the seventh digit, whereafter rapid decline ensued (Baddeley, 1992).

When these "units of information" consist of recalled musical performance instructions, new information from the environment cannot be processed, which will affect performance adversely. Furthermore, there is a time-lapse between the recall of each separate instruction, performing its subsequent action, and recalling the next step (Barrouillet et al., 2004). This may be measured in fractions of seconds, but still results in a slower cognitive processing speed overall. In contrast, implicit motor learning bypasses conscious thought, both in acquisition and recall (Dienes & Berry, 1997). In short, if motor skills are implicitly acquired, there are no instructions to be remembered, as the performer does not know and cannot verbalise how the skill was learnt, leaving the working memory free to concentrate on other musical information such as tempo, dynamics, and expression, as well as coping with any environmental distractions, and the stress induced by the situation.

## *MOTIVATION AND AFFECT*

One of the most significant aspects of music as humanly organised sound, is its ability to express and elicit human emotions. It is generally accepted that this is in part a function of a tension/relief cycle, created through melodic, harmonic, and rhythmic devices, that either meets or violates listeners' expectancies. Familiar music can also further affect emotions in listeners through memories and associations (Juslin, 2019; Juslin & Sloboda, 2011). As such, music is used daily to regulate mood

(Saarikallio, 2011), and reduce stress (Baltazar et al., 2019). It has also been found to motivate behaviours, both desirable, such as in health promotion and exercise (Batt-Rawden & Tellnes, 2011), and undesirable, for example aggressive driving (Brodsky et al., 2018). This motivation can be explicit, for instance when we deliberately play up-tempo music while exercising, but could also be implicit when we do not realise that the music we listen to has behavioural effects. Furthermore, as discussed at the beginning of the chapter, making music in a group setting may implicitly promote pro-social behaviour and empathy. This effect is not exclusive to music performance, but has implications for listening to music, and the subsequent incidental acquisition of musical elements. In an implicit learning study utilising recorded Northern Indian Rāga melodies, as opposed to the usual artificial stimulus material of most previous studies, it was found that expressive and empathic features in the music may have been implicitly acquired in addition to the expected structural and pitch elements, and that this affective aspect may even have improved the overall implicit learning performance of participants (Rohrmeier & Widdess, 2017).

Within the context of teaching music, we know that learning to play an instrument to any relative level of proficiency (whether in the pursuit of professional performance, for pure enjoyment, a sense of achievement, or any other intrinsic benefit associated with making music), requires the discipline and dedication of many hours of routine practice over extended periods of time. Such a long-term commitment is greatly facilitated when students are adequately motivated, i.e. when they attain positive emotional reward states from the learning process. In the absence of adequate motivation, attrition rates for music lessons are relatively high (Lowe, 2011; Williams, 2002). For this reason, amongst others, extensive research has been undertaken into motivational theory in music education (Evans, 2015; Hallam, 2009; Hendricks, 2016; McPherson & McCormick, 2006).

It would be beneficial to consider the parallel findings in Chapter 1, where the identification or priming of students' implicit motivation was seen to improve both the implicit learning of musical material, and learning outcomes in general, when the learning process was congruent with that motivation, and where task difficulty was carefully modulated (Eitam et al., 2008; Hill et al., 1985; Schultheiss & Köllner, 2014; Schultheiss, Pang, et al., 2005; Schultheiss, Wirth, et al., 2005). In theory, these aims should be achieved more easily when we teach music than with other subject material, since music, in and of itself, is clearly a powerful implicit (and explicit) motivator, and can be utilised to affect positive emotional states. Added to this, expressive and empathic elements within music may not only be implicitly acquired, but may also enhance the learning of other musical elements in the process.

## THE WAY FORWARD

Having considered the available research on both incidental and implicit learning from a neuroscience and cognitive psychology perspective, and acknowledging the significant impact music may have in everyday lives, a focus on the application of the benefits of implicit learning for music has been established. We have compared what is known about this type of learning in the music domain, and discussed the potential of finding equal benefits within a musical context. From the research that has been presented thus far, although relatively broad in the fields it consulted, it is markedly apparent that music and implicit learning have synergistic potential.

More than this, given the natural ubiquity of both incidental and implicit learning in seemingly every field of human learning, including music, and the skill acquisition across cognitive, motor, and affective domains, we have to assume that it occurs naturally and frequently within the music instruction setting too. Also, any inherent benefits that these types of learning may hold for the learner, must be assumed to occur with equal frequency. If this is indeed the case, these learning phenomena need to be investigated and documented to gain a deeper insight into their nature, prevalence, and effect. The current role and awareness of teachers in facilitating such learning in the music lesson can guide the research with regards to any experimental designs to test these phenomena under controlled conditions, as well as provide a scaffolding for any formal theory and development of targeted applications in future.

Therefore, rather than only presenting the evidence in theory, as derived from academic research, it is equally as important to find evidence of the relationship between music and incidental/implicit learning through practical observation in the field. To that end, the next chapter will comprise of descriptions and discussions of musical learning in practice, with the aim to identify and record the existence and prevalence of implicit or other forms of incidental learning in an everyday teaching setting.

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# CHAPTER 3: INCIDENTAL LEARNING IN PRACTICE

## ETHNOGRAPHIC OBSERVATIONS

In the first practical research phase of this thesis, the aim was to observe actual daily teaching praxis, to determine the context and prevalence of incidental learning, examine the role of the teacher in facilitating such learning, and identify any potential advantages thereof. Embarking on this project, we could ask what one would expect to see in an average music lesson. The stereotypical image of the austere teacher, rapping the unexpecting student over the knuckles with a wooden ruler for failing to play endless scales perfectly, has long gone. Instead, valuable strides have been made in musical pedagogy considering modern teaching methods, reflective practice, and the learning styles of individual students. Any good teacher, therefore, especially in the one-to-one setting of instrumental/vocal lessons, will differentiate their teaching methods and style to facilitate learning for each student and elicit the best outcomes in every case. This implies that there can be no standard formula for observing individual lessons, as there may be as many different variations on teaching style as there are teachers, and these are still subject to the accommodation of each student's needs.

The challenge, then, is to find those aspects that are indeed shared between all lessons; characteristics that do not vary, even if applied at different times, or in different ways. The constant element of all music lessons is the chosen music that is to be learnt and performed. The objective of music lessons also seems fairly consistent – a.) for the student to learn the chosen musical material, whether from written notation, by ear, or any other means, b.) to gain and develop the knowledge and skills to play that music, whether an understanding of the nature, structure, and interpretive elements, or the physical motor skill needed to produce the necessary sounds on any particular instrument (including voice), and c.) to finally be able to perform that music skilfully, expressively, and preferably from memory, often through deliberate, rote repetition, whether on the concert stage, for an assessment, for pure enjoyment, or any other purpose.

Between the theoretical knowledge of the notes on the page, the musical knowledge of what they should sound like, and the technical knowledge of how to produce those sounds, how does a teacher facilitate the acquisition of so many different kinds of information in thirty minutes or an hour per week? There is no instruction manual explaining the steps for accomplishing this, nor are there any real "steps" to speak of. A music lesson seems rather to be an abstract, complex, multi-tiered process of cognitive, physical, and emotional evolution. Drawing inspiration from Schön's theory of reflection in action (Schön, 1987), Barry (2007) describes the music lesson as an "active and ongoing musical conversation" (p. 52), with aspects of musical problem-solving, where the student is made aware of the musical “problem”. This is followed by experimentation with possible solutions, with performance of the material by either/both the student and teacher. The solution is then evaluated for its “fit”, after which they move on to the next problem, or repeat the cycle until a best-fit solution is found. Wiggins (2001) also stressed the importance of modelling formal music education settings on real-life “holistic problem-solving experiences” (p. 17).

Empirical research into the time allocation for various activities within instrumental lessons has determined that the majority of lesson time (anywhere from 36.6% - 63%) is consumed by the teacher talking (Duke, 1999; Karlsson & Juslin, 2008; Kostka, 1984; Orman & Whitaker, 2010; Sogin & Vallentine, 2021). Despite this, the one thing that all the observed teachers, as discussed in this chapter, agreed upon is that explicit instruction has its limitations within the “musical conversation”. There are certain aspects of musical knowledge and skill that can be difficult to explain outright, such as complex motor skills, and musical expressivity, and teachers often have to be both innovative and imaginative in communicating the desired outcomes. In some cases, this may be achieved by addressing a different skill, or by encapsulating complexities in a simple metaphor, which may result in the difficult-to-explain skill being acquired unintentionally. It is in this realm that the research interest of this chapter has its particular focus: How is knowledge incidentally transferred in such cases? Do teaching methods facilitate incidental learning, and are teachers aware of it? How often does this happen, and are there any discernible advantages?

Jaffurs (2004) compared informal and formal musical learning contexts, in an effort to learn from the natural practices of students when they engage with music outside of school, to establish a diversity in teaching practices for the classroom. Importantly, she noted that much of informal musical learning is incidental, in that learners do not intentionally try to remember any particular information or knowledge, but are still able to, due to meaningful contextual connections (Strauss, 1984). The research in question was based on the ethnographic observation of learning transmission in an informal music group, from the point of view that reflection on the enculturation and socialisation of all participants (teacher and students), as well as a grounding in the literature, was necessary for gaining a new and deeper understanding. Such new perspectives on existing phenomena is the principal goal of ethnography (Szego, 2002).

It is thus the aim of the present chapter to turn the ethnographic lens back onto the formal music learning context, to see the extent to which incidental learning practices have been adopted, or are pre-existing, and shed some light on these issues through the observation of real-time teaching, discussions with the teachers involved, and the surveying of a wider pool of instrumental teachers.

## METHODOLOGY

In planning and preparation for the practical lesson observations, a general qualitative ethnographic observation approach was chosen to examine teacher-student interaction and the acquisition of knowledge and skill within the music lesson context. As the project evolved, it became apparent that discreet observation was not always adequate, and occasional questions were asked to clarify certain aspects of teacher-student exchanges. This was done as unobtrusively as possible, however, and only when appropriate and necessary, always keeping in mind not to interfere too much with the normal flow of a lesson and being aware of the possibility of introducing researcher bias (LeCompte, 1987). This ability to question and clarify some aspects was particularly helpful in deciding whether specific instances of learning should be classified as explicit or incidental, discerning whether students were aware of the learning taking place, intended to learn a specific element, and were able to verbalise the content or process of learning. This task was made considerably easier in cases where it was possible to talk to students about the learning process and/or outcome.

In addition, a measure of direct participant observation or autoethnography was also incorporated into the data collection process from the author's own experience and perspective as a music teacher. With this method of data collection there is an obvious risk of researcher bias, as we may unintentionally influence the observation conditions or subject in some way in pursuit of those phenomena we hope to see. However, by adopting the principles of analytical autoethnography (Anderson, 2006), namely a.) being a recognisable full member of the group being researched, and b.) being "committed to an analytic research agenda focused on improving theoretical understandings of broader social phenomena" (p. 375), the risk can be minimised. To this effect, rigorous ground rules were set in place to ensure separation of the roles of teacher and researcher. In the role of teacher, lessons were to follow their normal course, without any adjustment of teaching practices or attempts at manipulating learning outcomes for the production of usable data, and as researcher/observer, lessons were recorded and analysed with the same equipment and methods as in other observed lessons. The benefit of this research method is a clear perspective as teacher on the desired learning outcome, what information needs to be made clear for the student to achieve that outcome, and when explicit instruction is no longer effective in doing so.

## PARTICIPANTS

Participants in this study were mostly chosen from a convenience sample, i.e. experienced professional music teachers, who were interested in taking part in the research, had the available time in their schedules during the period of data collection, and had several students willing to have their lessons observed and recorded. These parameters yielded a group of five teachers – one violin teacher and one clarinet teacher from a secondary school music department, with students ranging from beginner to intermediate level, one singing teacher with a private studio and students of all ages and proficiency levels, one university-level flute performance teacher, and finally my own experience as piano teacher in a private studio with (currently) adult students of intermediate level. All teachers and students (or their parents in the case of minors) gave consent to be observed and recorded for the use of anonymised research. Ethical approval was obtained from the Royal Holloway, University of London, and since both the researcher and all teachers have Disclosure and Barring Service (DBS) clearance, the observation of existing lessons was not seen as problematic.

## *DATA COLLECTION AND PROCEDURE*

Observations took place over two- to three-hour slots in the various classrooms and studios where lessons were regularly scheduled on days chosen by the teachers. Most individual lessons were an hour long, with the exception of some of the violin and clarinet lessons at only half an hour each. The researcher attended the individual lessons in the role of quiet observer, obtaining an audio recording of each lesson, making notes where appropriate, and very occasionally asking a question if clarification was needed on a particular teacher/student exchange. A total of 20 hours of usable observation was recorded. An Apple iPad with the mobile application *Notability* (Ginger Labs, 2019) was used for both audio recording and taking written notes. This app was specifically chosen for its capability of simultaneous audio recording and note-taking within the same user interface, and for its helpful ability to pinpoint the exact time in an audio recording where a written note was added, thereby placing the note directly in its intended context.

## *DATA ANALYSIS*

The recordings were annotated and objectively coded into the predetermined schemes mentioned below, to identify possible instances of incidental learning in learning events where explicit instruction was absent, and to categorise such instances according to the manner of acquisition in each case. The exception was the category of memorisation, which would be a learning outcome rather than a method of acquisition, but nonetheless was deemed significant enough to warrant a separate category for discussion. Each category was analysed again and compared with existing data obtained from relevant literature to illustrate the incidental nature of the learning involved. The main categories under which potential incidental learning instances could be observed were memorisation (MEM), two types of modelling, i.e. when the student imitates what the teacher demonstrates, whether either is intentional, or not (Hyry-Beihammer, 2011; Laukka*, 2004), namely learning by observation: visual (LOV), learning by observation: auditory (LOA), and analogy, simile, and other forms of verbal imagery, collectively described as metaphor (MET). These will form the structure for further discussion, with examples from the practical observations as a starting point.

## TEACHING PRAXIS FOR INCIDENTAL LEARNING

Before examining learning examples from the observation in everyday music teaching practice, it is important to note that the classroom or studio is not a laboratory. There is no functional MRI to see which parts of the brain are activated to give clearer indications of the kind of learning in question, and students are not repeating endless trials of experimental material that can be analysed and compared to identify different types of learning. The only method of analysis available in this case, is to identify instances where explicit, overt instruction and demonstration are absent, and determine what kind of skill or knowledge is being acquired, in which way, and the level of intent and awareness of both teacher and student in these exchanges. The researcher can only use the observational evidence available in situ and compare it to what is known about incidental and implicit learning from the literature to attempt a best practice definition of learning as such, or not.

After coding the observations into their respective categories, either according to the learning outcome (MEM), or the method of acquisition (LOV, LOA, MET) as explained above, it was decided that in each category, apart from metaphor (MET), one particular case study would best serve as an example of how incidental learning may occur under the relevant conditions. For metaphor, the examples were so numerous, and learning outcomes so diverse, that it warrants particular investigation as a separate phenomenon.

### *MEMORISATION*

In the discussion of the research on memory and retention skills in Chapter 2 (Hallam, 1997), it was suggested that memorisation is mainly an implicit process that occurs naturally as we engage with musical material. This became even more apparent in one specific observation made in the violin teacher's lessons of a particularly interesting student who seemed to memorise music instantly, as the teacher explained:

> He doesn't play by ear. He doesn't memorise the notes on the page, like [with] a photographic [eidetic] memory. He sight-reads the music and plays it, and when he's done that once, I can take away the sheet music and he can immediately play it from memory.

In the implicit memorisation process referred to above, the critical element is engagement with the music. Repeated visual, auditory, and motor processing will eventually lead to the skill of performing the music without the aid of the notation, i.e. from memory, becoming an incidental byproduct. However, in the case of this student, there seemed to be a kind of "shortcut" to this repeated visual-auditory-kinaesthetic process, and in addition, the process itself seemed to be incidental, as memorisation was not intentional. When probed about this skill, the student, only 14 years of age, seemed to have no awareness of the process involved, no discernible strategy for memorisation, nor the intention to memorise at all ("I don't know… it just happens"). The reason for his enhanced memorisation abilities were not clear, but in theory, the potential for storing musical information in a way that facilitates perfect recall without notation at some point should be available to any student, as the presence of basic human learning mechanisms under normal circumstances are universal. As Chaffin et al. (2016) state in the chapter on performing from memory in the *Oxford Handbook of Music Psychology*, memory is a variable trait in any person, just like any other trait or characteristic: "beneath a superficial diversity, the cognitive and neurological systems involved in memory are common to all human beings" (p. 568).

The case of this student's impressive memorisation skills seemed important enough for the current research to warrant further investigation and hence additional observations were arranged for the following two lessons. With the teacher and student's consent, there were some questions to be answered, such as:

a.) whether the student had a good memory in general, or in his other school subjects, as this would, at least in part, explain the phenomenon witnessed in his music lessons, if he simply possessed an overall exceptional memory.

- "I think it's okay… but not great. My mum says I forget stuff a lot… and I have to study [for] other subjects, it's not like I remember everything the teacher said in class".

b.) whether he practices from the sheet music or from memory when not in the lesson, which would indicate how strong the memory formation was, i.e. is there a level of retention, or does he have to repeat the whole process again in practice sessions.

- "I don't really take my [sheet] music out much [when I practice] at home. Maybe sometimes to double-check a note, or if my teacher wrote [in] a position or finger".

c.) whether he can start playing anywhere within a piece of music or has to start over from the beginning each time, to determine what structure the memorisation consists of, i.e. associative chains/contextual cues (see explanation below).

- [without thinking for very long] "it depends how many times I've played it… like, if I just learnt it (learning, for this student, being synonymous with memorisation) I probably have to start from the beginning, but if I've practiced a bit, I think I can start anywhere".

To verify the justifiability of his confidence, it was prearranged with the teacher for the final observation to subtly ask him to start playing at various random places within the piece of music. On doing so, it became clear that the newer the music, i.e. the less time he had to engage with it, the harder it seemed to start at a random point.

Implicit musical memory most probably relies on associative chains and involves procedural, or motor-based, knowledge (Chaffin et al., 2016). This means that when we play from memory, each section of music cues the memory for the next section and playing can only continue for as long as the chain remains unbroken. This is problematic, as any memory lapse or performance mistake cannot be overcome without starting the piece from the beginning again. In addition to incidentally acquired memorisation, expert performers may use deliberate memorisation strategies, as previously discussed in the section on memory and retention skills in Chapter 2 of this thesis, to transform auditory and motor skill chains into “content-addressable” cues, i.e. memory signposts within the music, based on phrases, harmonies, melodic sequences, structure, and various other musical elements. This type of musical memory is more likely to involve declarative knowledge. It creates a “safety net” for recovery from any location in the music, allowing the performance to continue despite any lapses or mistakes that may otherwise disrupt memory chains.

In the case of this specific student, the above explanation didn’t fit entirely. Initial memorisation did seem to consist of associative chains, acquired incidentally. Further engagement with the music, and repetition of phrases, did seem to create content-addressable memory locations, also acquired incidentally, and not due to any explicit strategy as suggested above. A possible explanation for this was suggested by a different part of the observation.

On the first page of the Gluck/Kreisler Melody for violin and piano (ABRSM, 2019, p. 12), which the student reportedly only started learning the week before observations commenced, there is a 12-note run, in an A-minor scale pattern, to be played relatively fast and in one continuous bow. At some point, the teacher made the student practice this in rhythms, similar to the Morse code rhythms described in the introduction to this thesis (Appendix A). In this case, however, it was not done to facilitate memorisation, as he was already playing it from memory, but rather to attain mastery over accurate finger placement and hand-shifts, while bowing smoothly. The hypothesis here, is that this kind of repetition, aimed at a different learning outcome, may be the catalyst for implicitly obtaining content-addressable memory cues, in the same way as it was seen to facilitate general memorisation in the original rhythm experiment with other students.

Another possible explanation, at least in part, might be based on the theory of “multiple memory systems” (Rubin, 2006), where a memory, such as that of performing music, does not consist of merely the memory of the music notation, but is contributed to by various systems that were involved in the encoding of the original memory. For music, this may include the auditory, motor, visual, emotional, structural, and linguistic systems, and it is the interaction of related memories from each system that allows for the generation of a memorised musical performance. This is evidenced by studies where neurological patients with amnesia were able to recall and perform music from pre-amnesic acquisition, as well as learn new music, although their episodic memory was severely impaired (Cavaco et al., 2012; Finke et al., 2012; Haslam & Cook, 2002; Valtonen et al., 2014). It is possible that any one or more of these systems, or simply the way the systems work in synergy, are exceptionally robust for this student. An interesting test of this account would have been to see if he could do anything else with the memorised music, such as singing it or writing it down. The ability to sing the music from memory as well as he played it, would indicate a strong auditory system component to the memorisation process. Likewise, an inability or difficulty to write the music down would indicate that the memorisation relied on one or more different memory performance systems, rather than just the memory of the visual material itself.

In essence, this student seemed to have compressed the entire process of the incidental memorisation of music into a micro-timeframe (like watching a video recording of the process on fast-forward). He may be the exception to the rule, as most students complement natural incidental memorisation with deliberate memorisation strategies at some stage in their learning, and usually over a much longer period of time. However, this case may be a prime example of an implicit form of memorisation when appropriate engagement with the musical material occurs. The level of such engagement that is necessary for memorisation may differ between individuals, and apparently seemed to be very little for this specific student, but the neurological mechanisms involved exist in all. If we study observations such as these as blueprints for how these implicit mechanisms work in music, they could be employed to develop faster, more accurate, and more reliable strategies for the memorisation of music in general.

## *MODELLING: LEARNING BY OBSERVATION*

As will become evident in further discussions in this section of the lesson observations, classifying observational learning as incidental was extremely challenging. In addition, it seemed counterintuitive when both the awareness of the skill being observed, and the clear intention to learn it through observation, were present, rendering it an explicit learning process. In the music lesson context, unless the teacher purposely obscures the aim of what they are demonstrating, the student will likely be aware of exactly what they are trying to learn, and will have a clear intention of doing so, thereby negating the requirements of both incidental and implicit learning. However, cognitive science literature provides evidence that incidental and even implicit learning through observation does occur (Gaskins & Paradise, 2010; Heyes & Foster, 2002; Vinter & Perruchet, 2002), which would indicate the need for closer inspection of the nature of observational learning in the music context.

One example of the incidental acquisition of skills though observation, is when the intention to reproduce an observed skill activates the process of motor simulation (Grezes & Decety, 2001; Jeannerod, 2001). This complex process involves shared neural structures between the observation and execution processes of an action (including the pre-motor cortex, supplementary motor area, the inferior parietal lobule, cingulate gyrus, and the cerebellum), with mirror neurons in the frontal cortex firing in the same way during observation of a skill as when the skill is physically performed (Badets et al., 2006). In addition, certain mirror neurons, called "echo" neurons, are activated by the sounds of an action (Kohler et al., 2002), indicating that motor simulation works for not only visual but also auditory observations. This partly explains the powerful imitation ability that infants seem to develop when learning to speak (Kuhl & Meltzoff, 1996). It has been demonstrated that impulses are discernible in the muscles of the tongue required to reproduce certain speech sounds when the subject is merely listening to an audio file of these sounds (Rizzolatti & Craighero, 2004). The same holds true for the muscles needed to perform a specific musical sound/s on an instrument (Rizzolatti & Craighero, 2004; Schiavio et al., 2014), and in the context of this discussion, it can therefore be argued that the intention to reproduce an observed action (or sound) benefits the implicit process of acquiring the procedural knowledge of the performance of that action/sound. It is indeed only in its *process* that the incidental nature of observational learning truly shows itself, as no average learner observed in this part of the project seemed capable of verbalising exactly *how* they obtained the ability to do something by simply watching or listening – no declarative knowledge of the process seemed to be present.

The fact that an implicit "mental run-through" of an observed skill takes place while observing it, underscores one of the values of teaching by demonstration. If the observation of an action results in similar cognitive processes as when physically performing the action, the benefits for practice efficiency should be considered, as described by Badets et al. (2006) in relation to sport, but with relevant meaning for music. The researchers found that when a participant engaged in observational practice, they did not risk injury, use equipment, or expend equal amounts of energy as in physical practice. This allows for a functional increase in the amount of time that a learner can spend practising a task, resulting in a higher improvement rate for that task.

Despite these theoretical instances of incidental acquisition through observation, and the clear implication that it should occur equally in the observation of a musical skill, in practice it is not clear exactly where the distinction lies between explicit and incidental elements of the learning process. The case studies presented here are thus reports of where and how incidental acquisition of musical skills and knowledge *might* have occurred through observation, either through watching or listening. These are the two main observational learning methods employed by music students in vocal/instrumental lessons, and they very often work in tandem. However, as they belong to the separate modalities of visual and auditory learning, they will be discussed separately.

LEARNING BY WATCHING. Learning a task by watching someone else performing it is an innate and universal human learning mechanism (Gaskins & Paradise, 2010). It may occur in any of the various stages of life, in both informal and formal learning contexts, and may include both implicit and explicit learning. A child watching their mother cook a certain dish may obtain implicit knowledge of the ingredients and cooking methods involved, in the same way as an apprentice craftsman may watch a master at work for months or even years, obtaining not only explicit knowledge about related tasks, but also implicit subtleties of how to perform such tasks. In previous eras, observational learning may have been the sole medium of vocational training for nearly any chosen career (including music). In the modern technological era, learning through observation has only become more abundant and accessible, as seemingly anyone can learn to do virtually anything by watching someone else doing it on a *YouTube* video. It is to be expected, then, that teaching by demonstration forms an indispensable part of any music lesson, especially since there are certain musical skills and elements that cannot be easily verbalised, if at all (as will be seen in the later discussion on the use of metaphor for teaching). The challenge is to identify which of these elements of music lessons may be acquired incidentally.

In a quick summary of the introduction to this section, watching a skill being performed activates an implicit motor simulation of that skill, from having performed similar gestures or related skills previously, in a mental rehearsal of the observer physically performing it themselves. Although awareness of the desired skill being observed and the intention to eventually acquire it may be present whilst observing, the ability to perform the skill – the procedural knowledge necessary to advance from watching to doing – may still be an incidental byproduct of the process of observation.

This provides a rather convenient explanation for implicit motor skill acquisition through observation, whereby watching any motor skill being performed with the intention to repeat it, will necessarily include some implicit elements in the acquisition process. Despite the literature providing credible evidence of this, it seems overly simplistic. The risk is that the explicit/implicit boundaries between intentional and incidental acquisition may become completely blurred upon further scrutiny of individual learning instances. Rather than subject each case to further testing, a far more robust model of categorising the learning would be for the observation-based acquisition of a *different* motor skill than was intended. To illustrate, when a music teacher demonstrates Motor Skill A, the performance may also include Motor Skill B (and many more). When the student then attempts to reproduce Motor Skill A, but also (or instead) displays Motor Skill B, it can be argued with a fair level of confidence that the acquisition of Motor Skill B was implicit.

An example from an observation in one of my own lessons demonstrates this phenomenon quite clearly. A student had difficulties with the *legato*[9] playing of an upwards run from a piece of piano music he was learning. There were two motor skill adjustments that could immediately be done to facilitate ease of playing, the first being "leading" with the right elbow, which would alleviate tension in the hand, as it is pulled across the keys rather than being pushed, and the second being that the student was using a rather awkward finger pattern. It was my intention to address the latter, but I had already started talking about the elbow movement and decided to demonstrate that first. In this demonstration, I instinctively employed a more comfortable and natural finger pattern to play the notes, and when the student subsequently attempted to play the phrase by leading with his elbow, I noticed to my surprise that he had adopted the same finger pattern as I had used. Upon querying this, the student insisted that he was not aware of changing his fingers at all, or even that he had been watching my hand rather than the elbow movement. It can only be concluded that the acquisition of this skill was incidental.

This has echoes, once again, to the original Morse code experiment, where the intention to perform one skill (play a difficult phrase in novel rhythms) resulted in the acquisition of another (unintentional memorisation of the phrase), which serves as a reminder that this is by no means a novel concept. Heyes and Foster (2002) were able to demonstrate that their subjects could not only obtain the necessary skill to perform the serial reaction time task involved, but also acquired the faster reaction speed for the implicit sequence, all by merely watching someone else perform the task. In another study on implicit motor learning through observation, the authors concluded that the physical performance of a motor skill is not strictly necessary for the implicit acquisition of that skill (Vinter & Perruchet, 2002), but as we can see here, neither is overt observation of the skill itself, as it may be obtained incidentally while observing another related motor skill.

This finding has implications for the complexity of students' ability to learn through observation. This ability has been described as consisting of hierarchical attainment levels (Browder et al., 1986), where the first level is simple imitation of a skill, as instructed by the teacher. The second level is reached when a student begins to imitate without instruction to do so, and the final level is achieved when knowledge obtained through imitation can be transferred to other areas of performance in the absence of the observed model. Although the above-mentioned study by Vinter

[9] Legato – smooth and connected.

and Perruchet (2002) found that children demonstrate equal capacities for implicit learning of simple motor skills by observation as adults, it is not entirely clear whether the implicit acquisition of the complex skills necessary for musical performance is only available once the third tier of observational learning has been attained. Further exploration in this area is needed.

LEARNING BY LISTENING. The main discussion in this section is based on a report by the violin teacher, of the preceding events that led to the expressive performance ability of the student that was being observed at the time. The student had previously developed an apparent "mental block" about playing with *vibrato*[10] in the left hand. The teacher had tried every conventional means available, and researched several more, to help the student overcome this challenge. This included all the standard exercises for learning vibrato in the curriculum: demonstrating, physical exercises away from the violin, imagery, explanation of the biomechanics involved, and more, but to no avail. The teacher suspected that the student had difficulty with the idea that the finger(s) should remain firmly on the string, while the hand, wrist and arm need to relax sufficiently for comfortable and rapid movement. Reportedly, every attempt would eventually lead to the left hand virtually seizing up with tension, and the student halting their playing in frustration.

The student was at a stage where playing without vibrato would no longer be adequate, and the teacher feared that this obstacle would hamper the natural progress of learning. As an interim solution, they embarked on several baroque pieces, which can generally be played without vibrato in the style of the time, and which would allow for adequate progress in the standard of repertoire and other techniques involved. After a few months of proceeding in this way, the teacher decided to attempt working on vibrato again, and gave the student a piece of romantic era music, with long flowing phrases, which would eventually necessitate using vibrato. In order to familiarise the student with the rhythms and character of the music, a recording of the piece by a famous virtuoso violinist was played in the lesson. The student started playing along with the recording and, unprompted by the teacher and seemingly oblivious to what was being achieved until after the fact, began to use a beautiful vibrato technique in imitation of the sound that was heard.

It was a few weeks after this point that the lesson observation took place, and there was no indication from the student's playing that there had ever been any problems with the technique – it seemed appropriately applied, well-practiced, and natural. When asked how the vibrato sounded so "easy" after such a struggle, the student described an association with the desired sound, and as long as thoughts of what the left hand was doing to produce that sound didn't interfere with the process,

[10] Vibrato – a more or less rapidly repeated slight alteration in the pitch of a note, used to give a richer sound and as a means of expression, created by the backwards and forwards motion of (usually) the left hand, wrist, and arm.

it seemed to “work okay”. The teacher hypothesized that all the preparations that had gone into learning the technique before had “done their job”, but like a jigsaw puzzle of which the image is not clear until the final piece is added, the student needed that association with the sound to make every piece fall into place. This may possibly have been the case, but it doesn’t explain how or why a previously elusive motor skill could suddenly be performed in imitation of an auditory stimulus.

The phrase “playing by ear” is most often used to describe the replication of musical material based on listening, as played by the performer on an instrument that they most likely already know how to play. We do not readily take it to mean the replication of a previously unfamiliar motor skill based on an auditory observation, while learning to play an instrument. There are, however, longstanding aural traditions in several world cultures of learning to sing or play instruments, i.e. obtaining the necessary motor skills to do so, simply by listening to someone else’s singing or playing (Blacking, 1973). Still, it is probably unlikely that a student such as this one, from a Western tonal background, already enmeshed in the formal classical music training system, would somehow spontaneously start using a playing technique simply by listening to someone else performing it. The previously acquired explicit knowledge of how to perform the skill, through extensive and repeated instruction, probably did contribute to the eventual successful execution of it. What remains unexplained is how such theoretical knowledge became practice – how *talking* about it became *doing* it. We know that through the repeated practice of a task, the theoretical knowledge about the task may be transferred to the procedural knowledge of how to do the task (Anderson, 1992; Rosenbaum, 2009; van Hezewijk, 1999). However, this would imply at least one initial successful performance of the task, even if imperfect. This was clearly not the case here, as, despite countless attempts, the vibrato skill was never performed at all, let alone repeated.

A possible explanation may be related to the modality of the eventually effective observational learning being auditory rather than visual, i.e., through listening rather than watching. Clues to this are found in the student’s own description of deliberately not thinking about the physical aspects of executing the skill, but only associating it with the desired sound. If this wasn’t the case, the skill would have been learnt by visually observing the teacher performing it. Furthermore, from the descriptions of the teacher, all the preceding exercises, explicit instructions, and even the demonstrations and verbal imagery, were related to these physical aspects of skill execution, rather than to the sound of it.

Evidence suggests that, despite the strongest relationships of the motor system being with visual and somatosensory stimuli, and visual processing being generally dominant (McGurk & MacDonald, 1976), the auditory and motor system relationship has unique characteristics not typically observed in the others (Zatorre et al., 2007). Consider the common human tendency to start tapping a foot when we hear metrically regulated sounds (aka rhythm and music). The same does not happen when we watch a rhythmical visual stimulus, such as a ball bouncing.

In a study on cross-modal learning, Engel et al. (2012) taught non-musicians to play piano melodies, either through auditory-motor learning without visual feedback, or visuo-motor learning without auditory feedback. Participants were then required to recognise these melodies by listening to, or watching, the opposite modality than in the learning condition in each case. The results demonstrated the above-mentioned unique auditory-motor relationship for music, since the auditory learning condition generalised far better to visual retrieval than the reverse. This was evident in both the measurement of retrieval accuracy, as well as in the stronger activation of brain areas associated with motor skill acquisition, as seen on fMRI.

Further evidence of the auditory-motor interaction can be seen in rehabilitative studies with stroke patients (Prassas et al., 1997), or those with Parkinson's disease (McIntosh et al., 1997), who experienced marked improvement in walking ability when treated with rhythmic auditory stimuli (RAS), such as a metronome or pre-recorded music. This is due to the rhythmic entrainment that exists not only in physical and biological systems, such as pendulum clocks or fireflies, respectively (Rosenblum & Pikovsky, 2003), but also between human sensory and motor systems (Thaut et al., 2015). The neural structures and areas involved in this interaction are numerous and complex, and for some parts still unexplained (for an in-depth description and explanation of the different neurological areas and functions of auditory-motor processing, see Zatorre et al. (2007)).

Of particular importance for musical performance, and for the present discussion, is the auditory-motor feedback loop (Fig. 7), where sound is produced by a motor movement, and processed in the auditory cortex, which in turn informs further motor movement in a continuous cycle. Pfordresher (2019) proposed that auditory feedback is not necessary for performing accurate motor skills in music *after* a skill or piece of music has been learnt. He stated that, according to the *Ideomotor Principle*, perceptual feedback is multi-modal. Playing an instrument will provide auditory, tactile, kinaesthetic (muscle movements), visual, and even possibly vestibular (based on head movements) feedback. After the initial encoding across all modalities, this integrated perceptual representation of physical action can correct an error before the performer even commits it, by anticipating what playing the correct note(s) should "feel" like (across any/all abovementioned modalities) before the sound is produced (i.e. before the onset of auditory feedback). However, he emphasised that in *learning* to play, auditory feedback is essential. Several studies have found that the premotor and supplementary motor areas in the brain are activated when listening to music, and contribute to motor planning and the synchronisation of the auditory and motor systems (Chen et al., 2012; Lahav et al., 2007; Mutschler et al., 2007). This leads to a deeper processing of learnt material through the presence of sound (Craik & Lockhart, 1972). Evidence of this could be seen in studies that found a significant advantage of auditory over visual or motor-only learning, both in recognition and recall of newly learnt melodies, even in experienced musicians (Brown & Palmer, 2012, 2013; Finney & Palmer, 2003).

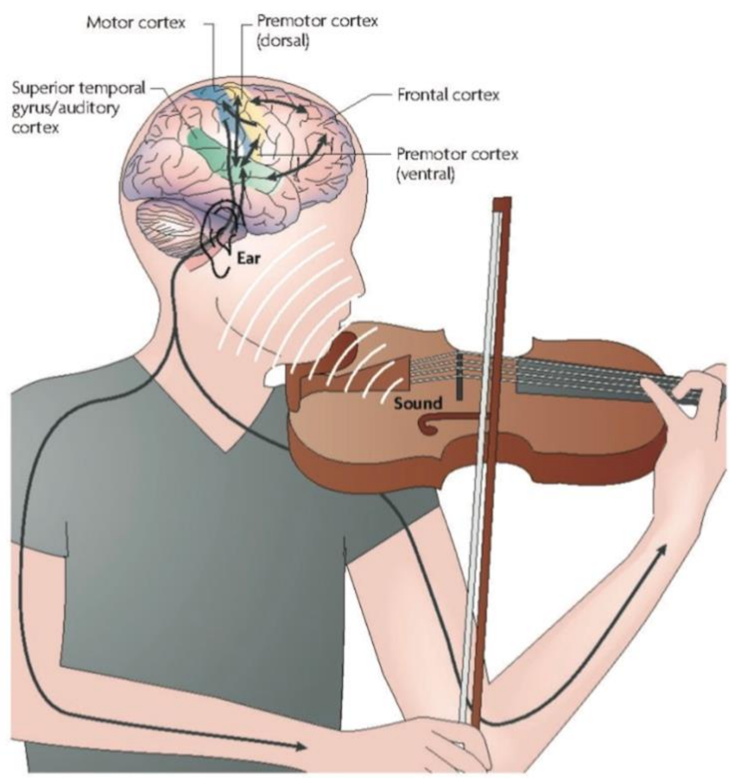


Figure 1 | **Auditory–motor interactions during musical performance.** This figure illustrates the feedback and feedforward interactions that occur during music performance. As a musician plays an instrument, motor systems control the fine movements needed to produce sound. The sound is processed by auditory circuitry, which in turn is used to adjust motor output to achieve the desired effect. Output signals from premotor cortices are also thought to influence responses within the auditory cortex, even in the absence of sound, or prior to sound; conversely, motor representations are thought to be active even in the absence of movement on hearing sound. There is therefore a tight linkage between sensory and production mechanisms.

**FIGURE 7:** *The Auditory-Motor Feedback Loop (Zatorre et al., 2007)*

Due to the anticipatory nature of motor adjustment from multi-modal perceptual feedback, this cycle is nearly imperceptible in expert performers, but the importance of the auditory modality in the learning phase could be clearly seen in the observations of several less proficient violin students when a note was played slightly out of tune and fingers were subsequently moved to correct the pitch. When questioned about this, some of them showed no awareness that they had made any kind of corrective motor adjustment. We may prompt students to employ this system regularly, when we direct them to “listen to yourself” as they are playing, which may aid in development of this system, but unless the instruction is explicit (e.g. "that note is sharp, you need to move your second finger fractionally towards the scroll of the violin"), the subsequent motor movements seem to be incidental, at least for some.

Armed with this knowledge of how an auditory observation can incidentally affect the performance of a motor skill, in other words, how the feedback loop mediates motor skill in order to produce the desired sound, we can return to the discussion of the violin student and the (eventual) auditorily induced successful vibrato technique. Interestingly, Wollman et al. (2015) found that the left-hand fingertips of expert violinists may be slightly more sensitive to vibrotactile feedback than the average human threshold, and that better quality violins may be perceived as more "vibrating" than inexpensive instruments, therefore providing increased tactile feedback. This emphasises the importance of the auditory feedback channel for a learner violinist once again, as increased sensitivity had probably not yet been achieved, and would not provide the student with the same "feel", especially on a relatively inexpensive student instrument. Nonetheless, one has to wonder why it took so long for this particular student to capitalise on the operation of the auditory-motor loop – they must have heard vibrato in violin music before, and they could have imitated the teacher's sound during a demonstration of the technique.

A hypothesis can be formulated from the previously discussed findings in sport psychology, where it was demonstrated that motor skill will deteriorate when a performer attempts the recall of too many individual instructions at once, resulting in the cognitive overload of the working memory (Lam et al., 2009; Masters et al., 2008; Maxwell et al., 2000). In this case, the student's processing centres were likely occupied with attempts to recall previous instructions for performing vibrato to the exclusion of all else, resulting in an inability to perform the skill. It was only in the act of listening, and not thinking of any of these instructions, that the auditory-motor feedback loop could finally operate unhindered, and the skill could be successfully performed. This is one example from direct observation where, as has been suggested in the literature, e.g. Chun and Jiang (2003), that (too much) explicit instruction may not only be ineffective but could actually be detrimental to the process of learning.

In every observation category thus far (MEM, LOA, LOV), one particular individual case stood out as representative of possible/potential incidental learning instances observed in that category and was discussed in depth. When it comes to the use of verbal imagery, the opposite was true. Examples were so numerous that it was challenging to decide which to include in this chapter and which not. This warrants a thorough examination of our existing knowledge of the phenomenon of using metaphor in music instruction. However, even more important than this, was the careful consideration whether to include metaphor use in the context of incidental or implicit learning at all. Making a blanket statement that metaphor facilitates incidental acquisition would provide prolific evidence of incidental learning in music teaching, by virtue of the sheer proliferation of metaphor use. This introduced a clear risk of researcher bias, which could only be mitigated by objectively applying the existing knowledge of both metaphor use in educational settings, as well as that of incidental and implicit learning as discussed in both the general and music-specific literature reviews of this thesis.

The use of metaphor is often quite an explicit teaching method, as it may simply facilitate cross-modal transfer of existing skills, or employ tacit knowledge that may not necessarily have been acquired incidentally in the first place. It may also embody Piaget's transition from concrete to formal operations (Huitt & Hummel, 2003), which is the logical and appropriate transfer of pre-existing knowledge or skills to novel or abstract contexts, although this may still occur outside of the learner's intention or awareness and thus still potentially be incidental. As Rohrmeier and Widdess (2017) stated, "one may be aware of one's knowledge without necessarily being aware of the concrete and correct content (or rule) of the knowledge" (p. 1320). This was also previously mentioned in implicit language acquisition in Chapter 1, that children may know how to use language correctly, but have no access to the rules that govern correct usage (Brown, 2000). It thus became clear that, like learning through observation, the classification of skill acquisition through metaphor as incidental, or not, would be a significant challenge.

In sport psychology, it is commonly accepted that learning through analogy and metaphor constitutes the incidental acquisition of specific motor skills and playing strategies (Chatzopoulos et al., 2022; Komar et al., 2014; Lam et al., 2009; Liao & Masters, 2001; Poolton et al., 2006). This is evidenced through three specific criteria, namely a.) the analogy or metaphor encapsulates several complex steps and movements into one short instruction, b.) the performers have no declarative knowledge of the separate steps and cannot verbalise the process beyond the metaphor itself, and c.) a control group receiving explicit instruction on the separate steps will perform significantly worse, or experience significant performance deterioration under pressure, as compared to the performance of the group instructed through metaphor. It was therefore decided that, although there could be no control group to compare learning outcomes in the lesson observations of this chapter, incidental learning through metaphor would only be considered if a.) the metaphor truncated several complex performance instructions, and b.) learners would not be able to verbalise the process or display declarative knowledge of the separate performance instructions represented by the metaphor.

Adhering to these principles, examples from the lesson observations of all the different instrument groups with students at all different levels of proficiency were incorporated as applicable and will be discussed here. Finally, a survey of music teachers provided a broad view of the use and prevalence of figurative language, potentially facilitating incidental learning, in many different music teaching settings.

## *METAPHOR*

> The essence of metaphor is understanding and experiencing one kind of thing in terms of another (Lakoff & Johnson, 2008, p. 5).

From the very first lesson observed in this part of the research, it became evident that verbal imagery and figurative description are inherent in the musical conversation of any lesson. From the flute student's attempts at explaining how a specific articulation, the starting point of a particular sound, is produced ("…it's in the tongue…more of a wave motion, rather than sharp like a woodpecker"), to the comment of a violin teacher ("keep the bow heavy, but smooth, like syrup"). The metaphoric process has been called a ubiquitous basis of cognition (Johnson, 1981), rather than merely a linguistic phenomenon or literary device, due to the fact that all human experience is likened, compared, and made sense of, in relation to other/previous experiences. In music too, metaphors may create a link between our musical experience and other types of human experiences (Rice, 2003). Thus, "to think, talk, or write about music is to engage with it in terms of something else, metaphorically" (Spitzer, 2015, p. 1). This extends to music instruction: the use of metaphor is an often-reported, integral part of any good quality music lesson (Juslin et al., 2004; Laukka*, 2004; Van Zijl & Sloboda, 2011; Woody, 2000, 2002).

In this part of the chapter, more so than with any of the other categories that were analysed for instances of incidental learning, an in-depth investigation of the use of metaphor as teaching method is warranted. The reason for this is the prolific nature of its use. In two unrelated studies, firstly a survey of 135 conservatoire students in England, Italy, and Sweden (Lindström et al., 2003), and secondly, interviews with 46 college Music majors from a large American university (Woody, 2000), students reported that, out of three teaching methods for expressivity (aural modelling, felt emotion, or metaphor), metaphor was both the most commonly used, as well as the most effective teaching strategy employed by their teachers. From the observations of music lessons undertaken and discussed in this chapter, it was apparent that not only were these students correct in their estimation, but the use of metaphor extends beyond teaching expressivity, to almost every aspect of lessons, both musical and technical. This may be of great importance to the research aims in this chapter, as it could be argued that metaphor is the ideal vehicle for incidental or implicit learning. By encapsulating complex motor skills, or numerous performance instructions, into one concise analogy, students can acquire these separate components incidentally, and often implicitly, since they frequently have no awareness of the number or nature of complexities contained within. Examples from these observations will be used to demonstrate this, but it is first important to understand the reasons for the universality of metaphor use in teaching and the mechanisms that make it so effective, allowing for incidental learning to occur.

UNDERSTANDING AND RELATABILITY. The first reason is that metaphor makes musical instructions understandable and relatable for students. A study designed to evaluate the use of software in providing performance feedback to music students as opposed to feedback from (human) teachers, demonstrated this clearly (Karlsson et al., 2009). Although the students enjoyed their interaction with the software and rated it highly, they still overwhelmingly preferred feedback from teachers. One of the reasons suggested for this was the use of figurative language and metaphors used by the teachers to explain what the music should sound like, rather than the equivalent acoustic analysis provided by the software.

Similar to the observations undertaken in this part of the research project, Wolfe (2019) recorded over 80 hours of advanced level music lessons over five different instrument groups (strings, woodwinds, brass, percussion, and keyboard), looking specifically at the use of metaphor in instruction. She states that appropriate metaphors in musical instruction can turn subjective interpretations into the intersubjective, where the desired outcome becomes clear for both teacher and student, and in this way, it becomes a “bridge to learning” (Cortazzi & Jin, 1999). This “bridge” makes use of students’ natural inclination to engage with music in terms of analogy and metaphor. In a study of ninety 11-year-old children (Antovic, 2009), the researcher explored how children would verbalise their experience of five musical sequences, with opposing elements in each (e.g. high/low tones, fast/slow tempo, loud/soft dynamics). The children were divided into three groups of 30 each: one group with two to three years of musical training, the second with no musical training, and the third also with no musical training but from a different cultural (and therefore musical) background. Although there were differences in the types of descriptions utilised by the different groups, and some children with musical training used musical terms to describe the opposing musical elements (e.g. *piano/forte* for loud/soft passages, *staccato/legato* for detached/connected notes), 87.36% of all answers consisted of metaphor and figurative language to describe the musical excerpts (e.g. heavier/lighter, thicker/thinner, small/big, hopping/walking, “running a race”). This confirmed the hypothesis that metaphor is dominant in children’s description of musical relations and led to the conclusion that the use of metaphor is a fundamental mechanism for our human comprehension and description of music.

A side issue highlighted by the above study, if we are considering understanding and relatability, is the appropriate use of metaphor. It was found that children from different cultural backgrounds used different metaphors to describe the same musical contrasts. This is not surprising when many metaphors reference culture-specific events, objects, linguistic devices, and experiences. In the survey discussed later in this chapter, teachers from several different countries and cultures responded, and it could be seen again (especially in American responses) that local products, television characters and specific sports (e.g. American football) are referenced in instructional metaphor, which would make little sense to students from any other culture. The importance of contextually appropriate metaphor usage is even clearer if we consider that different cultures do not even describe the human body or its relation to the external world in the same way. Although spatial relations such as up/down, left/right, and in/out, may all be universal physical attributes, the metaphors we base on them are not the same for every culture (Lakoff & Johnson, 2008). Similarly, in music, such spatial relations are not used to describe elements consistently. In parts of Africa and Indonesia, low notes are described as “big” and high notes as “small” (Schippers, 2006), and in Farsi, Turkish, and Zapotec, high notes are described as “thin” and low notes as “thick” (Shayan et al., 2011). To further complicate matters in the latter instance, these terms are also used to describe volume or dynamics, with loud notes being “thick” and quiet notes being “thin”. It thus becomes very clear that metaphor is often a product of enculturation and may be subjectively understood in different ways. In the search for intersubjectivity, especially when we are ever more likely to teach students from various backgrounds and cultures, it is then of utmost importance that educators are aware of these differences if metaphor is to be applied and understood effectively. Only then can we begin to consider the possible benefits of metaphor use as a pedagogical tool for incidental learning.

If we return to the aims of a typical music lesson, to learn notes, the motor skill to produce them, and the musicality and expressive skills to ultimately perform those notes as *music*, one wonders what particular function metaphor plays in facilitating this. From a physics point of view, music consists of patterns of predetermined sounds, with spectral and temporal shifts, and differing aspects of timbre and volume. However, when we think of music beyond its merely sonic properties and include its aesthetic and emotionally affective qualities, as well as the perceived motion of rhythmic elements, it becomes apparent that metaphor is almost indispensable. We add vertical and horizontal planes to music (notes move up or down, music moves forward or backwards), we give it mass (music is light, it’s heavy, the harmony supports the melody), we attribute human qualities to it (music speaks, it moves, it paints us a picture), we describe it in terms of emotions (music is passionate, it’s tragic, it’s joking, it’s joyous), a rhythm can be driving, a typical jazz bass line is walking – the list, it seems, is endless. However, the fact that much of our lexical description when speaking of music is based in metaphor does not mean that this is the only language available to do so. Any of the above-mentioned sounds, the motor skills to produce them, and the adjustments in duration, velocity, and tonal qualities to render them musical, can, to a certain degree, also be explained to students in terms of the necessary physical movements required, and from the observations of music lessons undertaken, this is indeed done frequently. There must therefore be more reasons why metaphor is used so regularly.

SIMPLICITY. Sometimes it is just easier to explain aspects of musical performance in terms of an experience or movement that the student is already familiar with (Schippers, 2006). A good example of this is telling beginner piano students to play *staccato* (very short, detached notes) as if the piano keys are burning hot, rather than isolating the hand and finger motions to be used. Other scholars have suggested that when the vocabulary used in teaching incorporates "living processes" through metaphors, analogies, and other imagery, this integrates students' personal experiences with new musical knowledge (Tait, 1992, as cited in Woody, 2000).

REDUCED COGNITIVE WORKLOAD. Another possibility is that the number of explicit instructions needed for performing all the notes of an advanced piece of music, with all the exact adjustments of movement and sound, including accessing felt emotion for expressivity, and presenting it as a comprehensible whole, becomes impossible to retain without losing control of one or more of the constituent parts. As Woody (2000) explains:

> It would be too cumbersome for a musician to remember and retrieve vast amounts of detailed performance operations each time, for example, a *ritardando* [slowing down gradually] is to be performed. Instead, musicians can more efficiently handle the information by abstracting it into a single extramusical analogy. A repertoire of templates is acquired, using analogies borrowed from a number of domains (p. 15).

Retrieving the analogy as a single representation from the performer's long-term memory, places far fewer demands on the working memory, which otherwise has to process both the retrieved performance instructions, and any other incoming information from the performer's immediate state and environment. The working memory can at any given time only process, on average, around six or seven individual instructions or operations (Baddeley, 1992). By condensing instructions into one metaphor, cognitive overload is avoided. This has been a recurring theme throughout this thesis, as seen in the potential applications of implicit learning benefits for music in the literature review, as well as having been proposed as a possible explanation for the violin student's inability to play with vibrato in the previously discussed observations, where they were so overwhelmed by the number of different instructions for performing the technique, that they developed a mental block. They could only eventually overcome this by "forgetting" all the instructions and only focusing on the desired sound. Thus, avoiding "clogging up the system" and facilitating easy retrieval of performance skills may possibly be one of the most important benefits of incidental musical learning, whether truly implicit or not.

Sloboda (2014) proposed that even when teachers use technical language and explicit instructions for the adjustment of motor skill needed to improve technique or expressivity, students will still map these onto extra-musical analogies to remember them more easily when practising alone. If metaphor is clearly an effective method of chunking[11] information for ease of retrieval, it makes sense then that teachers should provide students with appropriate and intersubjective analogies, or at the very least help them to discover their own. The advanced or talented student will already have acquired an extensive repertoire of extramusical templates consisting of metaphors and analogies from a wide range of domains on which to map sets of performance instructions (Sloboda, 2014). It is thus especially important for teachers to initiate this learning process with younger students, so that they may learn to translate explicit instructions into metaphor for themselves (Woody, 2000).

Observing and evaluating such teaching of "translation" skills in the practical lessons discussed in this chapter has brought to light that (broadly speaking) there are two categories of instructional metaphor used by teachers. Firstly, those that facilitate the acquisition and performance of a motor skill, most frequently (but not exclusively) used for younger/novice students who are still learning how to play their instrument. Secondly, those used to elicit felt emotion and musical expressivity, more often for older/more advanced students who have reached a point in their playing where the necessary motor skill is largely acquired or mastered, and the musicality of their performance becomes paramount. In each case, examples will be presented, and the possible incidental nature of the learning demonstrated.

## *METAPHOR FOR MOTOR SKILL*

As mentioned above, the use of metaphor for the acquisition or enhancement of motor skill is more frequently used for younger, less advanced students. This is logical considering that they have more instrumental motor skills still to acquire and that older/more advanced students would ideally already have built up their own repertoire of motor-affective metaphors. However, it is even more significant when teaching very young students, as studies have found that pre-school children (the age at which music lessons often commence) are a.) not yet capable of successful modelling of sequential motor skills without any verbal instruction, and b.) that the successful learning of such skills is significantly better when said verbal instruction is metaphor-based (Sawada et al., 2002). This is in keeping with previous research in paediatric exercise (Weiss et al., 1993), finding that young children learn new

[11] Chunking – recoding smaller units of information into larger, familiar units; often assumed to help bypass the limited capacity of working memory (Miller, 1956; Thalmann et al., 2019).

physical skills by labelling them through metaphor, simile, or analogy, e.g. a "whale's tail" or "sticking your hand in the cookie jar", and then relating these labels to their own experiences.

Although none of the observed music lessons in the current project were with pre-school aged children, there is still at least one example of this type of metaphor use for the acquisition of new motor skills in a relatively young student. In this example, the clarinet teacher told a beginner student that her fingers were "baby meerkats", who had to stay close to their dens if they did not want to be caught by the fox. A basic tenet of good technique on most instruments is the efficiency of movement and energy expenditure. In essence, the further fingers travel from one position on the instrument to another, the more energy is expended, and the longer it takes to return them to playing position, which will eventually lead to difficulty in playing very fast passages of music. It may seem easier to just tell a student explicitly to keep their fingers close to the instrument, but it is a natural physical tendency for them to unconsciously do the opposite. Therefore, the explicit instruction would have to be repeated at regular intervals, as the technique only seems to become embodied after extensive repetition, and often only after explaining the principle behind the technique very clearly. By using this simple, age-appropriate metaphor, all of the technically complicated explanations and much of the repeated instruction are incorporated, allowing the student to acquire this skill incidentally, without ever being aware of the intricacies of the motor skill that was learnt, or the reasons for its use.

Similarly, in a distinct memory of being a young piano student, the author was instructed to play a certain musical phrase "like a jellyfish on rice". This painted a very vivid picture of playing with "sticky" fingers that couldn't leave the piano keys even if they wanted to for *legatissimo*[12] playing, a kind of hyper-legato technique which would otherwise have been quite difficult to explain in terms of the precise hand and finger movements if no figurative language was available. The author has since employed similar images for teaching the same technique successfully to many students over years of teaching the piano, allowing for the incidental acquisition of a complex motor skill with several biomechanical components necessary to perform it correctly.

Anecdotes such as these, of verbal imagery used by teachers for the acquisition and development of motor skill are commonplace amongst musicians and music teachers alike; in her various interviews with music students, Barten (1998) reported that they could all remember vivid metaphors used by their own early music teachers, years after the fact, and never experienced difficulty in understanding what the intended outcome was. However, the evidence for the efficacy of metaphor for affecting motor skill and for obtaining the precise physical movements and adjustments

[12] Legatissimo – exceedingly smooth, close, and connected (Stainer, 1876); very smoothly (Thomsett, 2016).

required is not merely anecdotal. It has, for example, been observed through endoscopic videography (through a nasally introduced camera to the vocal folds) that instructing singers to pretend they are biting into a big apple while singing produces the exact de-constriction of vocal cords necessary for the tonal adjustment required for Western classical singing (Estill, 1995, as cited in Schippers, 2006).

The motor skills of singing are particularly well placed for the development of figurative explanations, since the "instrument" (vocal cords) is not really visible, and each singer will have a different mental approach to using theirs to produce the desired musical sound. This challenges the vocal teacher to find ways to make a general concept or physical skill relatable and personally effective for each student. An example of this could be seen in an observation of a singing lesson, where the student found it challenging to maintain breath support over a long musical phrase. The desired technique to extend a singer's breath is called diaphragmatic support and this works by "contracting the abdominal muscles, creating higher pressure in the abdomen and thorax, allowing the diaphragm's relaxation (and upward rise) to be carefully controlled" (O'Connor, 2008). It would arguably have been possible for the vocal teacher to explain this biological function of the diaphragm and how to manipulate it, which may or may not have been grasped by the student. Instead, the teacher instructed the student to imagine a fully inflated inner tube of a bicycle around his waist and not to allow it to lose its perfectly circular shape as it deflates upon exhalation through singing. A strangely elaborate analogy, but perfectly effective, as the student was subsequently able to sing through the entire phrase without running out of breath. This example demonstrates the difficulty of identifying the implicit/explicit learning boundaries in terms of intention and awareness. The student intended to learn how not to run out of breath while singing. The student was also aware that this was what the teacher was instructing him on. Yet, when asked if he could explain what he had just learnt and how, there was no awareness of the process or the steps of motor control for diaphragmatic support. He could only answer that "I learnt how to breathe properly by imagining a bicycle tube around my waist". Implicit in this metaphor, are all the separate steps and biomechanics of a difficult technique, which, arguably, despite both intention and awareness, was incidentally acquired.

Using metaphor in this way was not always successful. The above-mentioned technique of diaphragmatic support is also essential in the playing of brass or woodwind instruments, for good tonal quality and sustained notes or long phrases. In one of the observed clarinet lessons, the teacher instructed the student to imagine he had gills like a fish in his sides, and that he had to allow the air into his sides, rather than from the top through his nose or mouth. This did not result in acquisition of the skill and may be an example of a metaphor that did not quite achieve intersubjectivity – the teacher did not ask whether the student had ever seen the gills of a fish or knew how a fish breathed and it is possible that the student just could not visualise this physical analogy.

Further challenges in teaching motor skill for wind instruments abound when considering that certain parts of the motor movement necessary for producing sounds are not visible (similar to the vocal cords in singing), in particular the *embouchure*.[13] As the flute teacher explained, it is impossible to see the inside of a student's mouth when they are producing certain sounds, and neither can the teacher demonstrate the inside of their own mouth while playing. Added to this is the fact that, as mentioned earlier with singers, every student's anatomy is slightly different, negating the possibility of a standard way of physically producing a specific sound. It thus becomes a case of listening and estimating what a student *might* be doing based on what is heard. Therefore, it is hardly surprising that teachers resort to verbal imagery to affect a certain motor skill and learning outcome, when explicit instruction and even demonstration fails to adequately describe the motor skill involved. The clarinet teacher confirmed this when asked about articulation:

> If they can say it, they can play it. It is easy enough to teach "duh" or "te-te-te", but how do you, for example, teach flutter-tongue[14] when English-speaking kids don't roll their Rs?

He then went on to demonstrate how he instructs students to imitate the sound of an old alarm clock. When they can adequately pronounce the "Trrrrrrrr" sound, it is then transferred onto the clarinet mouthpiece and applied to the music as required. This demonstrates a very important aspect of using metaphor for teaching motor skill, in that it is virtually impossible to describe only the physical movement of the tongue for perfecting this example technique – the sound and feel of it are just as integral to understanding and executing it successfully. It can be argued that most physical movements needed for playing a musical instrument have a predominant sensorimotor nature, due to the importance of the sound produced, and the feeling of the instrument in relation to the hands, mouth, and body in general. Abrahamson (2020) explains that when we teach motor skills through explicit instruction, we tend to focus on what the student needs to *do*, but not how it should feel, sound, or look. We seem to forget that as soon as the student attempts to perform the action, their sensory perception will be crucial in learning and performing the task:

> I might tell you to grab the neck of a cello as though you are grasping a strawberry, yet only once you attempt to do so will you become cognizant of the string's strawberryesque haptic sensations that, moreover, you then discover, covary with the amplitude of the string's vibrations. These sensations were never mentioned yet are instrumental to calibrating the grasp per masterful performance (p. 217).

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[13] Embouchure – the way in which a player uses their lips and facial muscles to produce sound from a brass or wind instrument (Cambridge English, 2017).

[14] Flutter-tongue – from the German *flatterzunge*, also Italian *frullato*, or French *tremolo avec la langue* (spoken tremolo); rolling the tip of the tongue as rapidly as possible while producing a sound on an instrument, typically flute or clarinet. Also called a voiced alveolar trill, or rolling 'R'-sound, <rrrrrr>.

As was seen with the auditory feedback loop in the earlier discussion on learning by listening, in ideomotor theory (Hommel, 2013), the bi-directional connection between a motor action and its sensory consequences results in anticipation of what an action will look, feel, or sound like, allowing (in music) for enhanced instrumental technique, informed by, and in anticipation of, the sound and feel of performing an action. The feedback loop is thus not only auditory, but multi-sensory. By using a metaphor such as in this quote (describing not only a gentle but secure grip on the instrument but also how the feedback from the strings should feel), a teacher can encompass all the sensorimotor aspects of learning a new physical skill on an instrument. This allows for the student to incidentally acquire not only the steps of the movement required but also how that movement should feel and what sound it should subsequently produce.

Related to this, it can also be argued that using a metaphor that portrays a physical movement (and its sensory experiences) in itself, will be more effective for facilitating the acquisition of another motor skill than one referring to something abstract or imaginary. To illustrate, in one of the violin lessons, the student was practising accented double stops (playing with the bow on more than one string at a time on the violin, like a chord on a piano). After every few attempts, the teacher would offer some advice or guidance and then allow the student to adjust their playing accordingly. The first was a demonstration of the required action and sound, then an abstract metaphor followed ("like lightning bolts coming down from the sky"), and finally a physical metaphor was used ("like angrily ripping a piece of paper in two"). From the observation it could be seen that the final metaphor had the most marked effect on the student's playing, and that it also met the teacher's expectation of the execution of the technique. Evidence suggests that we more easily relate physical metaphors to physical experiences, and abstract metaphors to abstract experiences (Lakoff & Johnson, 2008; Wis, 1999) – a "like-for-like" use of metaphor in teaching would therefore probably result in the most intersubjective understanding between student and teacher, facilitating the incidental acquisition of the performance instructions contained in the metaphor. If we conclude from this that physical metaphors are the most effective for obtaining new motor skills, then it is interesting to note that, for expressivity, the range of available metaphors widens considerably. It becomes possible to not only use physical metaphors to describe the motor adjustments needed for expressive playing and encourage the embodiment of felt emotion, but also to use abstract metaphors to describe complex or otherwise difficult to verbalise emotions (for example the "feeling" one gets when there is a grey, stormy sky).

## METAPHOR FOR MUSICAL EXPRESSION

The subject of expressivity and emotion in musical performance, as well as the use of metaphor in relation to it, is one of the most well-documented in the literature. In almost every report, there is some iteration of the statement that the difference between a good performance and a great one is the performer's ability to express meaning and emotion through music in a way that the listener feels they understand and can relate to (Gabrielsson, 1988, 1999; Woody, 2002). Sloboda (2014) asserts that performing music, according to the notation, accurately and fluently, at an appropriate tempo, is the beginning of artistic excellence, not the pinnacle. Music teachers and musicians themselves also view expression as one of the most important skills for an effective performance (Juslin, 2003; Laukka*, 2004; Lindström et al., 2003). Summarising such thoughts, Schippers (2006) states that the difference between a merely competent performer and an excellent one is not in technique or knowledge but in the "intangible realm of expression" (p. 210).

In a 1999 interview with Fidelio Magazine, world-renowned cellist Mstislav Rostropovich expressed how musical meaning can be captured and conveyed through metaphor:

> Normally, one can only convey the intentions of composers through images. I still remember a rehearsal with Sviatoslav Richter, as we were intensively studying Brahms' E-minor Cello Sonata, and he suddenly asked me: "In what kind of weather, do you think, did Brahms compose this sonata?" And sure enough, it went better (Rostropovich, 1999).

This does bring into question the idea of "intentional fallacy", that opposes the concept of authentic performance in its strictest sense, since the exact reproduction of the historical, social, cultural, and physical contexts shared by a composer and their immediate audience can never be attained. Further to this, Davies (1991) suggested that the act of performance is a creative one, and should allow for performers' autonomy, or risk a lifeless reproduction of a musical score. However, he also stated that, even without sacrificing any creative autonomy, the performer still enters into a "contract" with the composer:

> The performer can be intending to perform the work in question only when intending to perform that which is constituted as the work by the composer…not to be improvising or fantasising on that work instead, [and] must be dedicated to preserving those of the composer's intentions which are determinatively expressed and which identify the work as the individual which it is (p. 3).

In a very simple example of this "contractual obligation", no performer will play a piece, designated by a composer to be a funeral march, and marked as *largo doloroso* (slow and sad), in an upbeat, "happy" fashion, despite using their own personal felt emotion and expressive devices in a creative way to achieve the designated meaning of the music. Exceptions of course do exist, if such a performer deliberately violates expectations to make a specific statement or to shock audiences, but this is not the norm. If we thus assume that composers, in general, did/do wish for the intended meaning behind their music to be conveyed in performance and understood when listened to, and if the ability of performers to fulfil that wish is considered a paramount skill, the concept of such meaning demands some scrutiny – How is it ascribed to abstract sounds? How are these sounds, with temporal and frequency shifts, transformed into something more aesthetically and emotionally affective – in short, what makes it *music*?

Human beings seem to be primally programmed on a neurological level to have visceral reactions to sounds, even in the absence of other corroborating sensory input (Paunović, 2020). Consider how loud noises, or the menacing growl of a predator, or even an unfamiliar sound at night in the dark, may cause fear. Similarly, we naturally feel distress or an urge to intervene and nurture when we hear an infant's cries (Li et al., 2018). We listen for and use changes in tone of voice and minor inflections to enhance our communication with and understanding of others (Cowen et al., 2019). It is not a big leap then to understand how the nuanced subtleties of musical sounds, and the meeting or violation of listeners' expectancies, can elicit complex reactions and emotions. Research in psychophysical functions has found that acoustic differences in music elicit discernible neural patterns, associated with emotional responses, for the physical stimuli of musical pitch, dynamics, tone, and texture (Wolfe, 2019). As simply stated by Juslin (2019, p. 3), "wherever there are human beings, there is *music*; and wherever there is music, there is emotion".

The question of importance for the lesson observations discussed in this chapter, however, is how we physically perform music in an emotive manner, and more significantly, how teachers facilitate the development of expressive and emotive playing in their students, when explicit instruction is often inadequate to explain such an abstract concept. It is simple enough, at a very basic level, to instruct that "happy" music should be played lively and loud, or for "sad" music to be slow and more subdued, for example, but just as human emotions quickly evolve beyond the very elementary emotions of early childhood, so does musical meaning grow in complexity as proficiency increases. In some cases, it would seem impossible to even describe what it is that we do differently to bring out an emotive sound quality, let alone instruct someone else as to how to achieve the same effect. Unsurprisingly, metaphor and imagery are often the default way of allowing students to incidentally acquire the various technique and motor skill adjustments that result in the appropriate and intended musical meaning and emotion.

Despite this noted complexity of expressivity in musical performance, and the ability of metaphor to integrate several complex performance instructions into one, as was shown with motor skill previously, it is still possible to instruct students explicitly on the tonal, dynamic, and duration adjustments that constitute an expressive performance. As far back as 1938, psychologist Carl

Seashore pioneered the theory that expressive musical performance is made up of deviations from the measurable mean in acoustic properties such as intonation, articulation, dynamics, and tempo (Seashore, 1938). This method of acoustic analysis to measure expressivity in musical performance still prevails today and informs psychology experiments on the topic as well as artificial intelligence (AI) development and computer software in the field of music. Importantly, Seashore never speculated about the origin of expression within the performers themselves, calling it "that mystic inner something which is spoken of as feeling", but rather wanted to measure the outward signs of such expression. However, Juslin (2003) argues that this reduces musical expression to wave files and numerical data, which tell us nothing about the origins of such expression, or how to teach expressive skills to students.

From the lesson observations undertaken in this project it could clearly be seen that teachers often advise students about the acoustic or technical deviations in motor skills required for expressivity and it is certainly possible, even necessary, to guide students as to when to play faster or slower, louder or softer, or when to hesitate or pause, in the pursuit of expressive skills. This, however, rarely happened in isolation without the addition of figurative language to elaborate on the mood, emotion, or meaning to be conveyed. This is reminiscent of the previously mentioned study where students had to rate the feedback from computer software, and clearly indicated that acoustic analysis does not make a good substitute for the metaphors used by their human teachers (Karlsson et al., 2009). This would imply that explicit teaching methods alone will not lead to a truly expressive performance. Woody (2000) found in his survey of university-level music students that those who were mostly taught expressive tools/devices, rather than expression itself, felt that they had been at a disadvantage until they matured and discovered musical expression for themselves, or through a different teacher: "I had previously learned about dynamic control, attack, tempo, etc., and was able to use it to *simulate* expressivity, but I was never [as] 'concerned' with it [as I should have been]" (p. 18). A contemporary of Seashore, Alexander Truslit, said that such expressive devices as listed by this student can be learnt as rules, but that simply applying the rules will never result in a truly expressive performance (Truslit, 1938, as cited in Repp, 1993). Schippers (2006) also argued the same point:

> The beauty of a piece of music will never be fully explained by an analysis of its structure, or by carefully pulling apart pitch, pulse, amplitude and timbre, just as human beauty can only be partially explained by looking at a skeleton, and probing skin, muscle texture and organs spread out on a dissection table (p. 214).

Using metaphor for teaching musical expressivity, therefore allows for the incidental encoding of these "rules" of expressivity by eliciting students' felt emotions and lived experiences for more authentic communication of musical meaning.

It is important to note that any changes effected in students' playing through means of metaphor, or any other way, still stem from small changes in the physical manipulation of the instrument – the "deviations from the regular" that Carl Seashore spoke of (1938). However, apart from learned expressive mechanisms, which we have seen do not convey true expression, the process through which a musician changes these physical movements in order to make a sound emotive or more meaningful, remains unclear. We could theorise that, much like mirror neurons pre-rehearse movements when we learn through observation, musicians may hear the sound internally that would elicit the desired feeling or convey the intended meaning for themselves. Utilising the same auditory feedback loop as is used for continuous pitch correction on string instruments (see Learning by Listening earlier in this chapter) they would then subconsciously make motor skill adjustments until the sound from the instrument matches the sound imagined by their inner ear. This does not mean to imply that expressive "deviations" are impulsive or random. Sloboda (2014) evaluated research and observation of these expressive changes, and found that they are:

a) intentional, and not "noise" from the motor system or technical deficiency,
b) encultured, so that performers within the same culture tend to use similar expressive devices,
c) nevertheless unique to each performer, despite point b. above, leading to high-level performers having a discernible individual playing "style",
d) detectable by the listener, informing judgement about the expressivity of one performance over another,
e) developed over long timespans, with decades-long performers showing superiority in consistent use and effectiveness of expressive devices in experimental conditions, and
f) automated in experienced performers, so much so that when asked to give emotionless or "deadpan" renditions of a piece of music, acoustic analysis still find the "deviations" present, with performers completely unaware of utilising them.

This last point is very important for the focus in this chapter. Implicit learning theory in other fields demonstrated that skills acquired incidentally may offer a shortcut to the automation of those skills, by either consolidating numerous instructions needed to perform a skill into one, freeing working memory to deal with other information (Benjaminse & Otten, 2011; Lam et al., 2009; R. S. Masters, 1992; Vickery et al., 2010), or even bypassing working memory entirely, as we could argue that, in some cases, if there was no intention to learn a skill, or awareness of doing so, there can be no instructions or related information to occupy working memory at all (Dienes et al., 1995; Dienes & Berry, 1997). The original acquisition of expressive skills in expert performers may not necessarily have been implicit. It is most likely that they obtained such skills through various degrees of both intentional and incidental methods. However, after long years of practising and performing those skills, the expressive devices become completely automated – so much so that the performers are often not aware of utilising them, as seen above. If we thus accept the premise that expert performers possess and subconsciously utilise automated expressive devices, regardless of the method of initial acquisition, then the automation of expressive skills *in itself* would be a desired outcome for students. Ergo, if incidental learning speeds up the process of automation, and metaphor provides the vehicle for that learning, the importance of metaphor as a pedagogical tool for incidental skill acquisition is self-evident.

The benefits of incidental learning as observed in the practical lessons discussed in this chapter are thus clear. Firstly, in learning by observation (modelling) of teachers, either visually or auditorily, students incidentally acquire skills that teachers may not otherwise be able to verbalise explicitly, or that may even be additional to the skills originally intended by the teacher. Secondly, incidental memorisation occurs when engaging with the music in other ways than intentionally memorising the notes. Finally, the use of metaphor and figurative, extra-musical, language as a pedagogical tool creates templates for incidentally storing and retrieving a multitude of performance operations. These operations may pertain to enhanced motor skill and instrumental technique, or transform musical expressivity from mechanical skills into the embodied practice of felt/lived expression. Furthermore, it may also be a shortcut to skill automation, which has been shown to lead to more robust and reliable skills under pressure.

## TEACHER SURVEY

In the final section of this chapter, more than a hundred instrumental teachers were surveyed to ascertain not only the prevalence of the use of extra-musical language in everyday lessons, but also to gauge teacher awareness of this practice, as well as, when they are aware, their reasons for doing so.

### *METHOD*

In the survey discussed earlier (Lindström et al., 2003), out of three methods, metaphor, modelling, and felt emotion, conservatoire students rated metaphor as the most effective and most often used by their teachers for teaching expressivity. However, posing the same question to conservatoire teachers (Laukka*, 2004) saw them rate metaphor as the least frequently used and least effective. From what was seen in the observation of everyday music lessons discussed in this chapter, the students' perception of teaching practices in their lessons would be the more accurate of the two contradictory findings. Furthermore, this does not only count for expressivity, but, as has been shown, is applicable to motor skill and technical aspects of music instruction as well. Although it was already shown earlier that both metaphor and modelling (learning by observation) may lead to incidental learning, and the interest of this project does not lie in the comparison of different teaching methods, the inconsistency found in the above studies still brings into question the perspective of music teachers. Considering their views on the use of extra-musical, figurative language in everyday music lessons, through an incidental learning lens, may provide valuable insights. A survey focusing on metaphor usage in music instruction was thus undertaken and results analysed accordingly.

PARTICIPANTS. All 108 participants were currently practicing music teachers recruited online from various reputable professional forums such as UK Music Teachers, Instrumental Teachers in the UK, Music Teachers (International), and The South African Society of Music Teachers, as well as through the distribution of email invitations to the known professional teaching network of the author. A total of 108 responses were received over two days from teachers of a wide range of musical instruments, from various countries, and with varying levels of teaching experience:

- Very experienced – More than 20yrs, *n* = 49
- Experienced – 10-20yrs, *n* = 27
- Somewhat experienced – 5-10yrs, *n* = 16
- Inexperienced – less than 5yrs, *n* = 16

The respondents provided music instruction to various age groups and proficiency levels, with most teaching at two or more different stages:

- Early years, *n* = 31
- Primary School, *n* = 93
- High School, *n* = 64
- University/College, *n* = 21
- Adults (Beginner to Advanced), *n* = 37

All responses were completely anonymous, and from vetted members of the various groups mentioned above.

APPARATUS AND MATERIALS. A questionnaire was compiled in *Google Forms*, with the title "*Abstract Teaching Methods*", and subtitle "*Looking at non-musical language in everyday teaching practice to explore different pathways to specific skill learning*". It comprised of questions pertaining to the following: Confirmation of current teacher status and demographics (experience, instruments taught, age groups taught), which was followed by an explanation of what was meant by "non-musical language", with examples of common metaphors used in music teaching, and providing a space for respondents to add their own examples. Finally, they were asked about their awareness of, and reasons for, using these methods in teaching. The questionnaire was disseminated via electronic uniform resource locator link (URL) to private membership *Facebook* pages of the abovementioned forums, and via email to known music teaching professionals from the researcher's contact list. Responses were received electronically via the *Google Forms* link, downloaded as a spreadsheet, and objectively coded and analysed.

**DESIGN AND PROCEDURE.** Much thought was given to the risk of introducing bias in the survey design. In different types of response bias, if participants (mis)interpret the purpose of the survey, they may attempt to respond in ways that would contribute to that purpose. Similarly, if they have prior knowledge of the topic, they may have preconceived opinions and judgements, or attempt to display that knowledge. There was also the risk of conformity bias, where subjects in this case may perceive the topic of the survey to reflect the quality of teaching practices, and thus attempt to present themselves as "good" and knowledgeable teachers. It was thus decided to make the pre-emptive brief used for recruitment, as well as the title and subtitle, as vague as possible, whilst still making it sound interesting and worthwhile. In the recruitment phase, prospective participants were informed that this PhD project was exploring different methods that teachers use to facilitate skill acquisition for their students in music lessons, and that the topic of the survey in particular, was the use of "non-musical" language as method. The non-informative title "*Abstract Teaching Methods*", and subtitle "*Looking at non-musical language in everyday teaching practice to explore different pathways to specific skill learning*" were chosen, in a deliberate attempt not to refer to the terms incidental or implicit learning in any way. No further qualifying or explanatory information was provided. A total of six questions were included, with the first four being confirmation of current teacher status and demographics, and the final two pertaining to metaphor use in music lessons. Questions were thus structured as follows (Fig. 8):

1.) Are you currently a practising music teacher?

- Yes
- No

2.) How long have you been teaching music for?

- < 5yrs
- 5 - 10yrs
- 10 - 20yrs
- > 20yrs

3.) Which instrument group(s) do you teach? Select all that apply:

- Strings
- Brass
- Woodwind
- Keyboard
- Percussion
- Vocal
- Other – please specify

4.) Which age or attainment group(s) do you mostly teach? Select any applicable options:

- Very young/pre-school/beginners
- Elementary/primary
- High school/secondary

- University/college
- Adults – all levels

5.) Music teachers often use non-musical language to explain or facilitate a difficult technique/motor skill, or expressive playing. For example,

- “Pretend you are holding a tennis ball in your left hand” for correct left-hand posture on the cello, or
- “Play it as if something is chasing you” for a sense of tension and urgency.

Give an example(s) of similar non-musical language that you have used in your own teaching practice (name as many or as few as you want)

6.) Why do you think you use this teaching method? Choose any that apply:

- my own teacher used this method with me
- students grasp the concept quicker
- it is easier than trying to explain the physical movements involved
- there is no other way of explaining it
- other – please specify

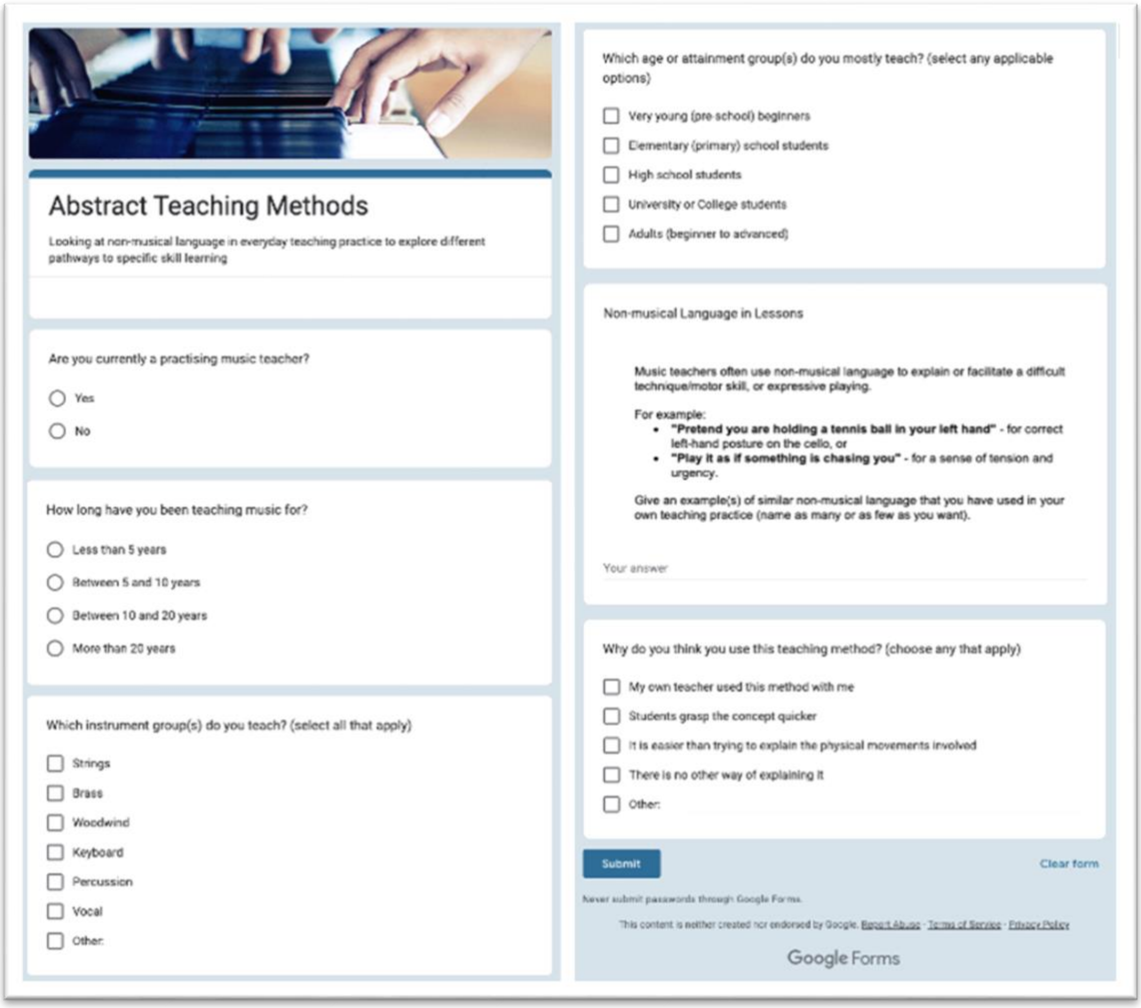


**FIGURE 8:** *Metaphor Survey, Google Forms*

This survey was distributed to the online forums as listed above, via URL link, and in emails to known professional music teachers. The desired minimum sample size (100) was surpassed within 48 hours (*n* = 108), and the survey was subsequently closed for responses. This was done to limit the amount of data to a manageable level, since the qualitative nature of some of the responses would need time-consuming, in-depth analysis. The collected data was downloaded and analysed according to criteria as will be discussed below.

## *RESULTS*

**TEACHING EXPERIENCE.** In the results, it could immediately be seen that the response was biased with regards to experience, with nearly half of all participants falling in the "very experienced" category, having taught for more than 20 years (*n* = 49). The remaining group also showed a higher rate of responses for higher experience levels, with a quarter being "experienced" (10 – 20yrs), and the rest being equally distributed between "somewhat experienced" and "inexperienced" (Fig. 9):

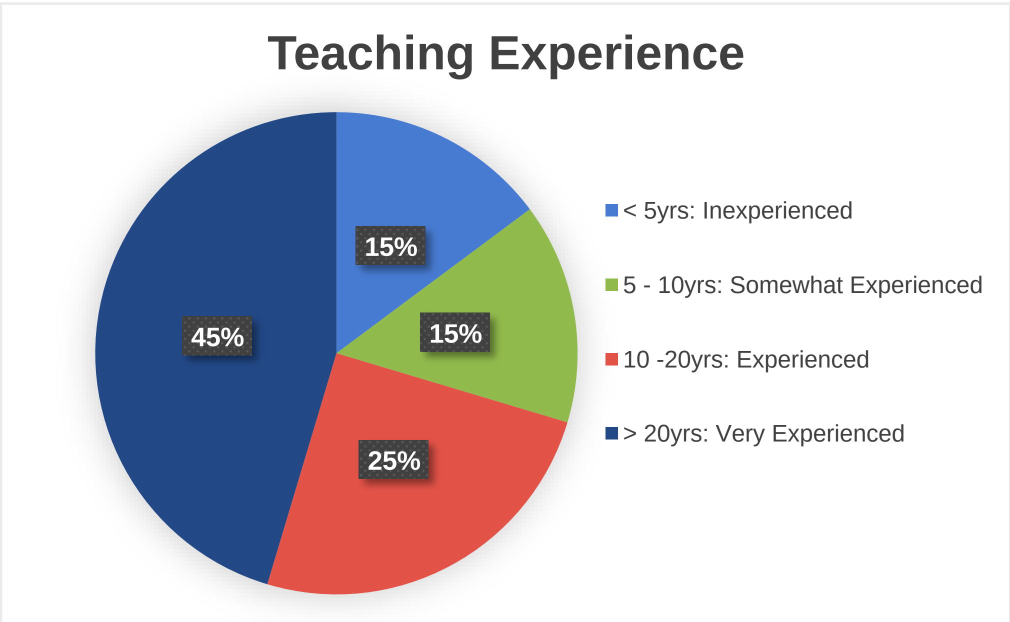


**FIGURE 9:** *Distribution of Teaching Experience in Survey Respondents*

This may be due to several factors, such as highly experienced teachers having more confidence in their abilities and being more open to questioning, or that they have more accumulated subject knowledge to share. It may also be purely coincidental. One could speculate about the negative impact of such bias, by considering that older/longer serving teachers could possibly be set in their ways and not up to date with new developments in pedagogy and progressive teaching methods, but this would be stereotyping. From extensive interactions with music teachers of all ages and experience levels, the author has not found this to be true. In reality, teachers that have, throughout this project, requested the most additional information and shown the most interest, have overwhelmingly been those with more teaching experience, continually exploring new information for improved praxis. Furthermore, it is difficult to see how such characteristics would have a detrimental effect on the results of the survey, as none of the questions pertained to teaching attitudes or the use of unfamiliar teaching methods. Rather, what could be seen in the results, was that highly experienced teachers offered, on average, twice as many examples of metaphor use than inexperienced teachers, and that they were more likely to suggest reasons of their own for using metaphor, other than the multiple-choice options in the survey.

INSTRUMENT GROUPS. A wide range of instruments were covered by the survey respondents, with most teaching across two or more groups, including some ensemble and orchestral teaching (Fig.10).

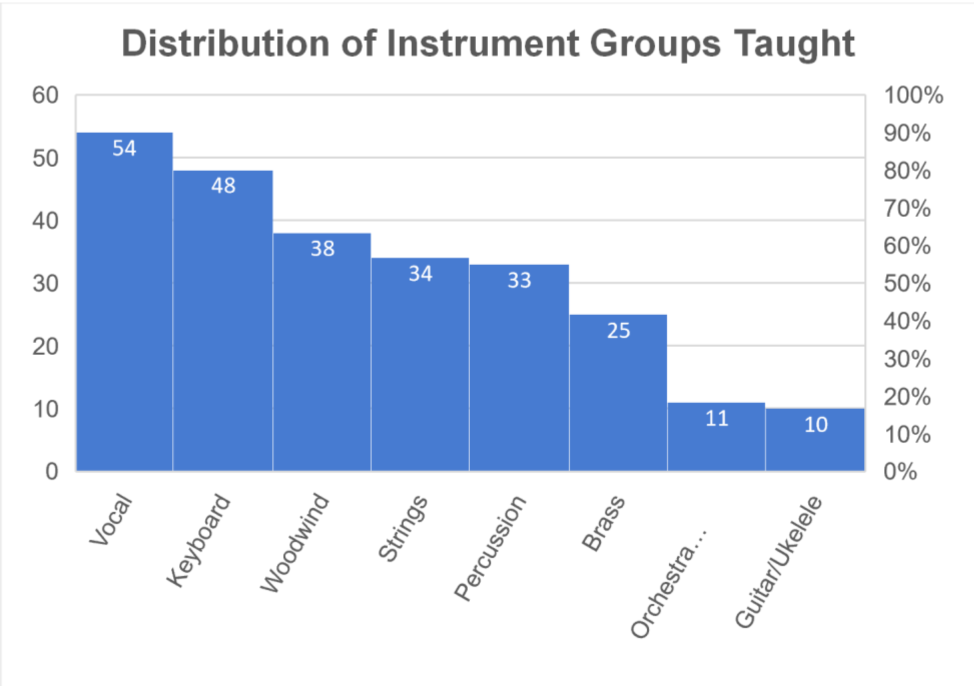


**FIGURE 10:** *Instruments Taught by Survey Respondents*

Knowing which instrument(s) a participant teaches was important for providing contextualisation of the examples of metaphors used in lessons. Of 96 examples pertaining to motor skill, 89 were instrument-specific, and only seven addressed general postural issues. Other than this, the number or type of instrument(s) taught had no influence on the number or type of metaphor examples provided, or the reasons for metaphor use.

AGE OR ATTAINMENT LEVEL TAUGHT. It was apparent from the responses that around a third of teachers specialised in teaching only one age group or attainment level (*n* = 37). However, the majority of respondents tended to teach at either the start, middle, or end of the range, e.g. early years and primary school, primary and secondary school, secondary school and university, or university and adult education. In many cases, the ranges overlapped, but only eight participants reported having students in every age group in the range (Fig. 11).

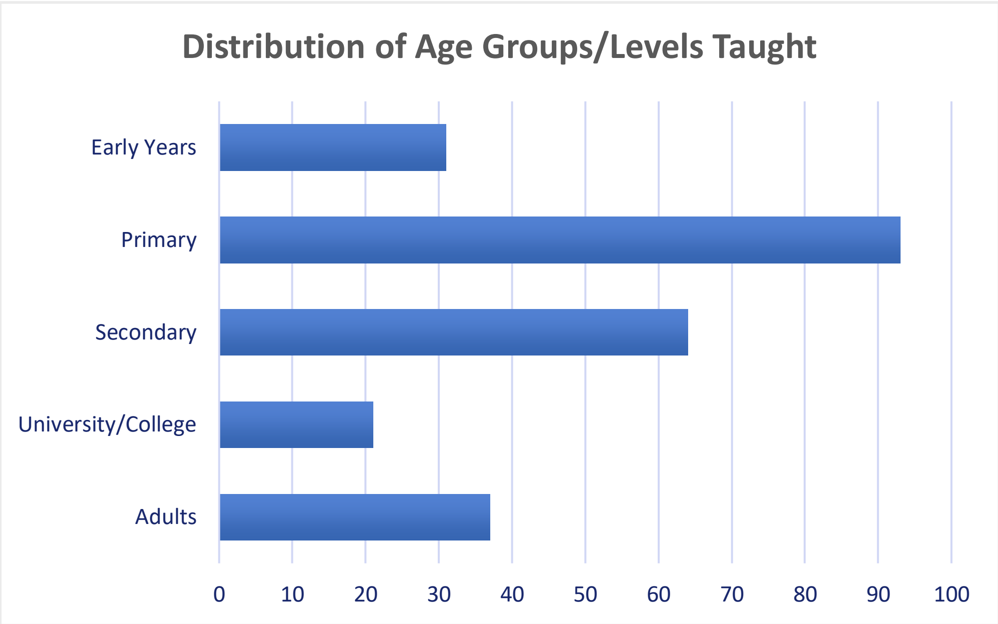


**FIGURE 11:** *Ages/Levels Taught by Survey Respondents*

The relevance of age group and attainment level for metaphor use could be seen in the types of examples given. For very young students, metaphors contained images and descriptions of cartoon characters, animals, and basic movements, e.g. running, jumping, and waving. For the middle age range, the movements referred to became more specific and specialised, with many sport analogies. From secondary school and upwards, metaphors often referred to sensations, and were more likely to affect expressive playing than the largely motor skill focus with younger students. Reasons for using metaphor with younger students were more likely to include the students' lack of technical knowledge, and ease of understanding.

METAPHOR EXAMPLES. A total of 153 examples of metaphors for teaching music were received. The responses were overwhelmingly motor skill orientated (96/153), which could be due to the fact that the largest proportion of teaching was directed at primary school age students, who are still learning how to play their instruments, and where expressivity has not yet become the most important focus (Fig. 12).

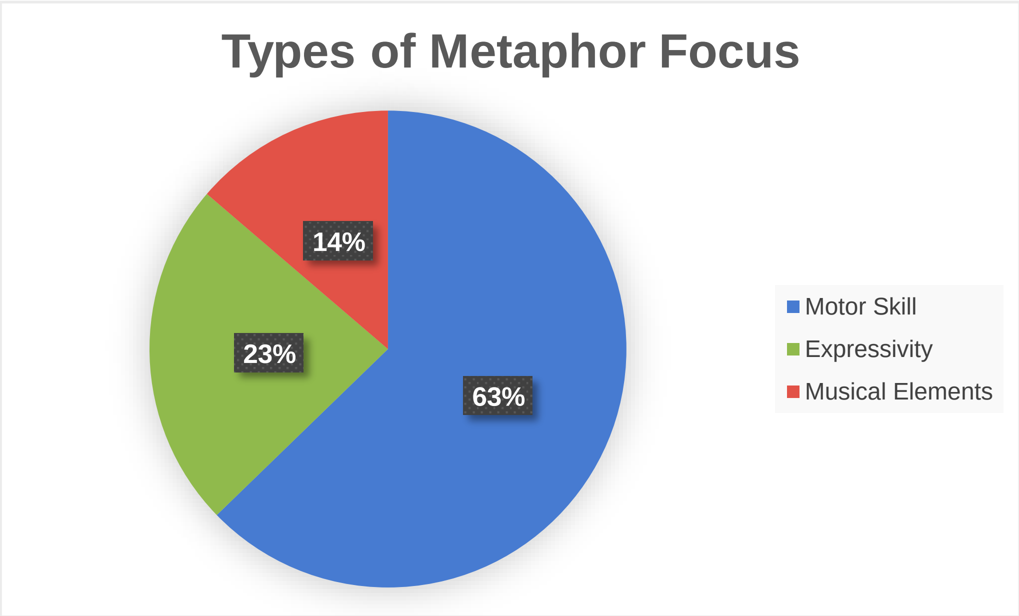


**FIGURE 12:** *Areas of Focus of Metaphor Examples*

Some participants may have misunderstood exactly what metaphor/figurative language/non-musical language is, despite the clear and simple examples provided in the survey. Four respondents offered examples that were not metaphor-based, e.g. “relax and take a deep breath”, or “if Messi [famous football player] has to practice, then so can you”. The total number of metaphor examples came from 90 of the respondents, with 18 opting not to give examples. They did however provide reasons why metaphors can/should be used in teaching.

REASONS FOR METAPHOR USE. The multiple-choice options provided in the survey were renamed/categorised as own experience (my own teacher used this…), speed of acquisition (students grasp the concept faster), ease of explanation (it’s easier than trying to explain…), and no other way (there is no other way of explaining). Respondents offered 17 additional reasons for the use of metaphor in music instruction. These were categorised according to three separate focus areas, namely understanding and relatability, student appeal, and substituting the known for the unknown. A final category was added, for a small number of respondents (*n* = 8) who felt that there was no use for metaphor in teaching, and who rely solely on modelling and explicit instruction instead. This resulted in a total of 182 responses regarding reasons for using metaphor (Fig. 13). As mentioned before, teachers with extensive experience were more likely to offer additional reasons than inexperienced teachers. Interestingly, inexperienced teachers were more likely to offer own experience (their own teachers using metaphor) as a reason. This may be simply because their own education was more recent in memory, but also possibly because they had not yet gained the knowledge or confidence to use methods other than those they know from personal experience.

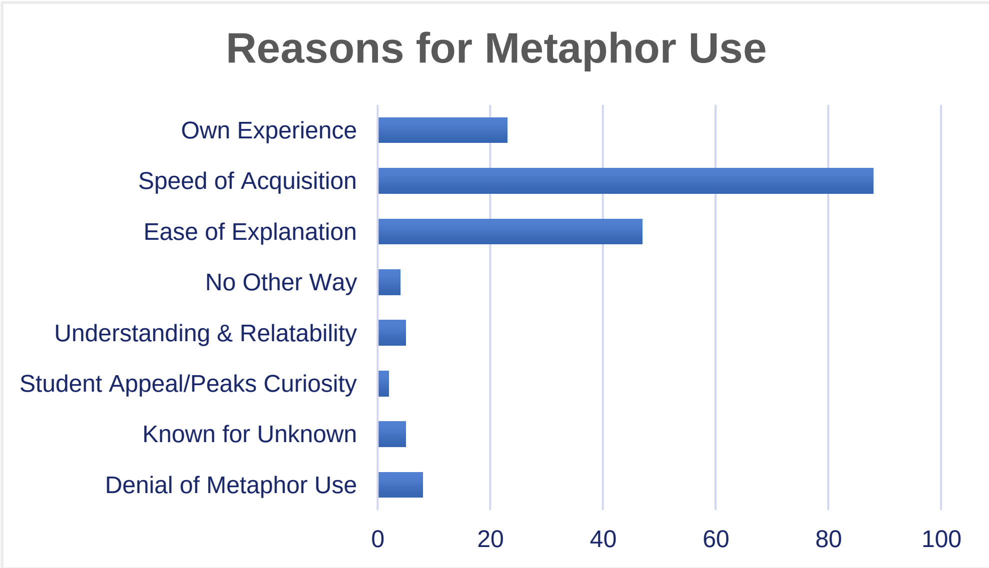


**FIGURE 13:** *Reasons for Using Metaphor in Music Instruction*

Nearly 50% of all responses provided the reason that students grasp concepts (or acquire skills) faster with metaphor use than through other teaching methods. The second most offered reason (around 25%) was that it made the task of explaining easier for the teachers themselves. Many respondents also included the reason that their teachers used to employ metaphor in their own lessons, but, except for inexperienced participants, this was offered in addition to other reasons. Only four respondents felt that there was no other way of explaining a concept to students, indicating that teachers use metaphor by choice, and not because they have no other options.

Other reasons given were that metaphor simplifies complex musical and biomechanical information, especially in younger students who may not yet have sufficient knowledge of such aspects to understand explicit instructions, and that it also makes these concepts relatable to students' own experiences. A few respondents stated that using interesting metaphors appeal to students and pique their curiosity, making them more inclined to learn the relevant material or skills. A final reason mentioned was that, by using metaphor, students can "replace the unknown with the known", e.g., know how to grip xylophone mallets, because they know how to grip the handlebars of a bicycle. The implications of this will be discussed below.

## DISCUSSION

Much of what can be seen in these results confirms what we already know about the use of metaphor in music instruction. It is a long-standing practice that is still used frequently today. It simplifies difficult skills and knowledge and makes those skills and knowledge understandable and relatable for students, and easier to explain for teachers. In addition, metaphors need to be appropriate for the age and level of the students, as well as for the instruments they play. There are, however, several new and key insights to take away from the results of this survey.

The first surprising finding, although not directly relevant to incidental learning as such, but still important enough to mention, is that the vast majority of metaphor examples given by participants pertained to motor skill, and not expressivity. In the considerable body of evidence on metaphor use in music, the focus in every case is metaphor for expressivity. When the literature was consulted for information on metaphor for motor skill, there was virtually nothing to be found within the music field. This presents an ideal opportunity for future research, where the efficacy of metaphor for motor skill acquisition, as well as its implicit/incidental nature, can be investigated and tested, using both ethnographic and experimental methods.

Another unusual aspect was the fact that some respondents believed that they do not use metaphor when teaching music. Four participants simply marked the example and reason fields in the survey as “not applicable”, and it is thus impossible to conclude what their reasons may have been for doing so. Three others, although agreeing with some of the reasons that metaphor might be useful, expressed the opinion that students learn through modelling, and that any kind of explanation, whether explicit or metaphor-based, was therefore “pointless”. This echoes the findings from the survey of conservatoire teachers mentioned before (Laukka*, 2004). It is however difficult to reconcile this with the observations undertaken in this chapter, and with the evidence that a large proportion of lesson time consists of verbal explanations by teachers (Duke, 1999; Karlsson & Juslin, 2008; Kostka, 1984; Orman & Whitaker, 2010; Sogin & Vallentine, 2021). Another respondent stated that they do not use metaphor in instruction, as “it is better for students to have the correct understanding of physical movements, even if it takes longer”. Although it would not be possible to categorically state that these participants were mistaken, not having observed any of their lessons and relying on their self-reporting instead, any accounts denying the use of this method do seem implausible. The evidence from the metaphor section of this chapter demonstrates how difficult it would be to avoid metaphor when describing music and its various elements, and in the observations of everyday lessons undertaken, there was not a single lesson entirely devoid of any metaphor use. Barten (1998) reported that one specific teacher interviewed insisted that they never use metaphor, as it is “too vague and imprecise to be useful” (p. 94). The same teacher was then later observed using metaphor repeatedly during a lesson, explaining the finer points of flute technique to a student. These instances speak to teacher awareness of using metaphor in music instruction. Further evidence of this lack of awareness could be seen in the spontaneous feedback received from participants after the survey. Several commented on the fact that they had not been aware how often they use metaphor, until the survey pointed it out to them. As one respondent posted on *Facebook*, “some of my analogies have become so habitual for me that I never stopped to think about how much I use them”. If music teachers are sometimes not even aware anymore of using metaphor to describe the component steps of a motor skill or expressive device to students, let alone explicitly describe them, it is difficult to see how the students’ acquisition of those component steps could be anything but incidental or implicit.

Finally, the example was given earlier of how metaphor allows students to replace the unknown (how to grip xylophone mallets) with the known (how to grip the handlebars of a bicycle). This demonstrates how the implicit memory of a related or similar skill can be accessed for acquiring a new skill. There is a discrepancy in the literature about whether learning through accessing implicit memory can be described as implicit learning in and of itself (Stadler & Frensch, 1998). However, if we take the Schacter et al. (1993) explanation that implicit memory is the influence of previous skill learning on subsequent or new learning without conscious awareness or memory of how the first skill was learnt, we can then argue that the new skill was acquired incidentally due to the implicit knowledge of a related skill. This specific use of metaphor, for acquiring new motor skills by relating them to known, everyday actions, could be seen repeatedly in the examples given in the survey, as well as in the lessons observed in person.

The majority of examples provided by participants in the survey could be analysed for the separate biomechanical components of motor skill, or performance instructions for musical elements and expressivity. It is thus concluded that, whether teachers are aware of doing so or not, when they do use metaphor, it allows for the incidental acquisition of these small, individual units of information. Furthermore, this occurs regardless of whether students are aware of the overarching learning goal, or whether they intend to attain that goal, since they have no awareness of the constituent parts.

## SUMMARY REMARKS

In this chapter, several hours of one-to-one musical instruction were observed and analysed. The relevant literature was consulted to enhance understanding of the practices seen in these observations, and to compare what other researchers have found in similar studies. Incidental learning examples could be found in the contexts of learning outcomes, such as the unintentional memorisation of musical material, and in the methods used by teachers to facilitate skill acquisition for students, such as visual and auditory modelling, and the use of metaphor. Over a hundred music teachers provided their perspectives on the latter method in an online survey.

Potential advantages of incidental learning could be identified throughout this chapter, for instance, in the ease of acquisition of skills that would otherwise be difficult to explain, or learning additional skills observed in teacher demonstration, even when those were not the specific skills the teacher intended for the student to learn. It was demonstrated how skills could be incidentally acquired by auditory observation, through the activation of the feedback loop, by unintentionally and unconsciously adjusting motor skill until the desired sound was produced. Furthermore, it was found that the feedback loop is not merely auditory but multi-sensory, which allows for the same incidental acquisition by adjusting motor skill until all sensory information is in harmony. Metaphor was found to be the ideal vehicle for incidental learning, by integrating numerous and complex instructions into one simple analogy, whether for motor skill, musical understanding, or expressive capabilities.

These findings provide a strong motivation for going beyond potential benefits of incidental learning for music as spontaneous occurrences in daily teaching practice, to lend them credibility and validity through experimental evidence of incidental (and possibly implicit) learning in an ecologically valid musical task, which will be the focus of Chapter 4.

⌘

# CHAPTER 4: IMPLICIT SEQUENCE LEARNING IN A SIGHT-READING TASK

It was clearly demonstrated in Chapter 3 that incidental learning is a common phenomenon in everyday music lessons. In addition, research has shown that incidental learning plays a life-long, integral role in music acquisition from a very young age (Rohrmeier & Widdess, 2017; Trainor et al., 2012; Trehub, 2003), that this occurs regardless of musical training (Rohrmeier et al., 2011; Tillmann, 2005), and also that musical training enhances the ability to learn non-related material incidentally (Anaya et al., 2017; Francois & Schön, 2011; Larrouy-Maestri et al., 2015; Romano Bergstrom et al., 2012). Despite the growing body of evidence of the fundamental role of incidental, implicit, and statistical learning in music, its relevance has not been fully recognised in the field (Rohrmeier & Rebuschat, 2012). More research is required to support the cross-cultural validity of music research and research from other disciplines, to demonstrate that both core elements and more complex features of music can be implicitly acquired and to establish music research as an important part of the cognitive sciences (Pearce & Rohrmeier, 2012).

It can be argued that demonstrating such cross-cultural validity will have more far-reaching implications for music than merely showing new types of information that could be obtained through implicit learning. Importantly, as discussed in the literature review of research in other fields, several advantages of implicit learning have been identified, such as faster learning of vocabulary and improved fluency in second-language acquisition (Choo et al., 2012; Rashidi & Ganbari, 2010), enhanced memory and recall, with less concurrent task interference (Chun & Jiang, 2003; Vickery et al., 2010), preserved learning in the context of neurological impairment (Meulemans & Van der Linden, 2003; Roodenrys & Dunn, 2008; Schuchard & Thompson, 2014), faster decision making and preparation of movement (Milazzo et al., 2016; Raab et al., 2009), and robustness and reliability of motor skill under pressure (Benjaminse & Otten, 2011; Lam et al., 2009). In Chapter 2, the parallels between music learning and performance and the various topics of study mentioned therein were discussed, and in every case, equivalent benefits of incidental or implicit learning for music have been hypothesised. However, there currently seems to be no credible basis for directly transferring knowledge and findings from one domain to another. The generalisability of implicit learning findings to the musical domain can however be obtained through the successful replication of implicit learning phenomena in a setting with musical parameters. This would not only confirm the applicability of the experimental protocol to a music context, and that the learning mechanism operates in relation to musical material, but would also demonstrate that it can produce commensurate advantages for music learning specifically. To that effect, in this chapter of the thesis, the author has endeavoured to design and conduct an implicit learning experiment for music, demonstrating its effectiveness, and identifying inherent benefits for musical learning.

Much has already been written here and elsewhere about the incidental or implicit acquisition of musical elements, such as melody, harmony, timbre, and rhythm (Rohrmeier & Rebuschat, 2012), through the process of enculturation throughout the human lifespan (Hannon & Trainor, 2007; Morrison et al., 2008), to the extent that we can immediately recognise specific songs or styles after only hearing the first few notes of the music (Bella et al., 2003). It has further been demonstrated in experimental studies that these same elements can also be incidentally acquired for novel, unfamiliar music (Dienes & Longuet-Higgins, 2004; Kuhn & Dienes, 2005; Rohrmeier et al., 2011). One area that hasn't yet been explored, is whether a specific musical skill can benefit from incidental, and possibly implicit, learning, as demonstrated by a measure of improved performance, such as increased accuracy or faster reaction times, as has been seen in other fields of study.

In identifying such a skill, the performance of it, and any change in performance, needs to be observable, measurable, and quantitatively comparable. Furthermore, to render any findings of learning effects generalisable to a wider population of musicians, the chosen skill needs to be integral to musical learning and performance, and also universal and standardised in its use. One such skill that meets these criteria, at least in the Western classical paradigm, is sight-reading. Essentially, sight-reading is a measurable skill in terms of the accuracy of executing the written notes, both in pitch and duration, as well as in the speed of processing of the visual material for increased fluency and the application of an appropriate, consistent tempo. It also demonstrates both the cognitive (reading and understanding the notation) and motor skill aspects (playing the notation on an instrument) necessary for musical performance, rather than only the auditory learning, discrimination, and prediction mostly seen in previous incidental learning experiments within the music domain. Several previous studies have explored various measurable aspects of musical sight-reading, in order to gain insights into its significance from diverse research foci, including its correlation with verbal comprehension (Cara, 2021), the skills involved in sight-reading proficiency (Kopiez & In Lee, 2008; Mishra, 2014), and the areas of brain activation during active sight reading tasks (Sergent et al., 1992). As far as the potential implicit learning of musical symbols and notation is concerned, it has been previously demonstrated that the incidental acquisition of visuospatial contexts is intact and robust for musical symbols (eighth-notes) in both familiar and unfamiliar presentations, in both musicians and non-musicians (Becker, 2018). Iorio et al. (2022) also found that non-musicians could incidentally obtain knowledge of standard notation to the extent that automatic influences on recognition and recall resembled that of skilled musicians. All of these characteristics of sight-reading would therefore suggest that it is a suitable skill for demonstrating advantages of incidental/implicit learning in the musical domain.

The view of the sight-reading of musical notation as the "only" way of learning Western art music (henceforth referred to as classical music), has been contentious (Green, 2017; Lilliestam, 1996; Woody, 2012). There are many valid arguments stating that the aural tradition of music has been a part of human culture long before written notation existed, and numerous cultures still impart their musical knowledge through other means (De Azevedo, 1983; Thorn, 2007; Trimillos, 1989). It has also been demonstrated that the embodied practice of learning music "by ear" may hold advantages in the development of aural skills and musicianship for students, over traditional sight-reading methods (Baker & Green, 2013). However, for our current application, it cannot be ignored that sight-reading still remains one of the most widespread skills required for musical performance in the way classical music is taught globally. The Associated Board of the Royal Schools of Music (ABRSM), the main examination body for instrumental and vocal music in the United Kingdom, conducts over 650,000 music examinations every year, in over 90 countries worldwide (ABRSM, 2022), and Trinity College London, which offers examinations in various performing arts as well as English language, conducts over 850,000 music examinations in over 60 countries (Trinity, 2022). Sight-reading is a standard tested skill in the graded curricula of both these institutions and the use of classical notation and rules in these tests are the same for all instruments and all levels of proficiency globally. Many countries have their own musical grading systems and examination boards such as the three-tiered school systems in France and Russia, the University of South Africa (UNISA), Conservatory Canada, and the United States Music Certification Exams (USMCE), utilising the same traditional ways of teaching and testing musical proficiency in the classical music style, which would augment the above figures substantially. One only needs to look at the entry requirements of classical conservatoires worldwide to realise that sight-reading is a standard, universally required skill in classical music performance.

Having settled on the musical skill to be tested, the next step was to decide on an experimental paradigm for demonstrating incidental and possibly implicit learning in the musical domain. From Hebb digits (1961) and Reber's pioneering artificial grammars (1967), to Nissen and Bullemer's serial reaction time (SRT) (1987), countless implicit learning experiments have been undertaken since, using different paradigms, novel conditions, and diverse stimulus material, in an attempt to either replicate findings, or refute them. The challenge was thus to identify a paradigm, or combination of paradigms, that would be the "best fit" to measure the potential improvement of musical sight-reading as a result of implicit learning. Musical sight-reading, at its basic level, is the encoding of sequential visual information, through pattern recognition, as the stimulus for the motor response of playing the notes on an instrument (Wolf, 1976). An immediate connection was thus evident with implicit sequence learning, as specifically represented by:

- SRT tasks, where the order of a part of the appearances of the visual stimulus occurs according to a predetermined sequence, and motor response times improve due to implicit learning of the sequence.
- Continuous tracking tasks, where certain segments of the continuous stimulus movement are governed by a predetermined sequence, resulting in increased accuracy of movement for those segments, again due to implicit sequence learning.
- Hebb repetition learning, where, unlike other types of implicit learning paradigms, performance accuracy is measured over the entire sequence rather than for individual stimuli, since sight-reading is not typically evaluated note for note but as a whole.

(See the Literature Review in this thesis for a detailed description of these three paradigms)

It was thus decided to embed a repeated musical sequence in otherwise random compositions for sight-reading, to measure participants' performance speed and accuracy, and compare the performance scores for the repeated and non-repeated material to determine if a.) learning of the repeated sequence occurred, b.) whether the learning was implicit, as verified by post-experiment interviews to determine awareness of the repeated nature of the sequence, and c.) whether the performance improvement was greater for the repeated sequence than for the other (non-repeated) parts of the music. The beneficial nature of any such findings, and the potential applications thereof, will be considered in the discussion below.

## DESIGN CHALLENGES

### *THE PROBLEM WITH SIGHT-READING…*

As mentioned above, sight-reading is an exercise in pattern recognition. It was also argued in Chapter 2 that reading music is a form of visual context learning. Sight-reading is analogous to reading text, in that we do not look at individual letters of words to read them, but rather recognise the shape and pattern of words to allow for speed and fluency of reading (for an in-depth discussion of these aspects, see Wolf (1976), as well as Sergent et al. (1992) for both the shared and distinct neural substrates of verbal and musical reading). More than this, in visual context learning, information is obtained from several elements on the sheet music, other than just the notes. To illustrate, we may look at any example such as in Figure 14, a random[15] representative piece of music generated in the

[15] The piece created is musically nonsensical, to incorporate all the required musical symbols and elements for demonstration purposes only. It is not intended to be played or to sound "good".

music scoring software, *Finale* (MakeMusic, 2020), demonstrating the information that any given sheet of music notation may include (as marked with corresponding numbers):


**FIGURE 14:** *Example of Information Included on Sheet Music*

1. Tempo or style indication
2. Dynamic markings
   *(loud/soft/variations of either)*
3. Clef
   *(indicating the pitch range, for instance on a piano, whether it will be played by the left or right hand for low and high ranges, respectively)*
4. Key signature
   *(deciding the use of naturals, sharps, or flats, i.e. either the white or black notes on the piano)*
5. Time signature
   *(indicating not only how many specific notes are allowed in a bar/block, but also the pulse or metre of the music)*
6. The notes
   *(with the vertical placement deciding pitch, and different appearances of the note itself deciding duration)*
7. Articulation
   *(staccato/tenuto/legato, the execution of a note, whether notes are played short and detached, long but detached, or connected, respectively)*
8. Tempo changes
   *(accelerando/ritardando, gradually faster or slower, respectively)*
9. Recognisable shapes and patterns
   *(9a: scale, a stepwise ascending or descending run of notes/9b: Alberti bass, alternating notes of a chord in a repeated up and down pattern/9c: triad, the three main notes of a chord played together)*

Highly proficient sight-readers will use any or all of the above to inform and improve their mental representation of how the music they are about to play might sound, based on their existing musical knowledge and experience. For instance, with a stepwise pattern as in 9a of Figure 14, they merely need to look at the start and end notes of the pattern, noting that there are no accidentals[16], to know how to execute it, without reading any of the notes in between. Similarly, all of the additional information seen above may, to a more or lesser degree, aid in accurate and fluent performance of the written music. Also, as seen from previous research of the implicit learning of musical features (Rohrmeier & Rebuschat, 2012), any or all of these elements may be implicitly acquired to varying degrees, which may interfere with the measurement of the hypothesised implicit sequence learning.

In addition to the musical information on the page, there are even more elements inherent to what the music *sounds* like that may aid in improved reading and playing. As was previously seen, the auditory engagement with sound informs motor movements in further production of subsequent sounds, in a continuous feedback loop. For example, when music has a certain tonality (e.g. major or minor), a musician will immediately make subconscious assumptions about the specific pitch of certain notes that may appear later on the page, based on the standard intervals between notes in different scales. The skill of audiation, i.e. the ability to anticipate what a note will sound like and to predict and understand how the music is constructed, is central to an effective sight-reading process (Mishra, 2014). In a related issue, if the test material was composed using the style and rules of any specific genre or cultural music tradition, this may benefit participants who are encultured in that style, leading them to faster reaction and more accurate performance, unrelated to implicit sequence exposure.

Another challenge was the suitability of the task for a range of instruments. Due to the architecture of different instruments, and the unique required techniques used to produce sounds, a piece of music that is playable on one instrument may be virtually impossible to reproduce on another. It would seem that a simple solution might have been to design the experiment for participants that all play the same instrument. However, this would limit the ability to generalise the findings beyond a single instrument. It would not be practical to generate a separate set of materials for each instrument (or instrument group), customised to the different note ranges, clefs[17], and technical abilities or limitations of the various instruments, as this would require an adequate sample for each group of instruments, increasing the scale of the study considerably. It would also bring into question again the standardisation of the test material and would complicate embedding a standard repeated sequence within all trials.

[16] A specified note pitch that does not belong to the notes of the scale or mode indicated in the key signature, by the addition of a natural, sharp, or flat sign placed before the note to raise or lower the pitch by one semitone.

[17] **As with the piano, where clef indicates the range of pitch to be typically played by either the left (low) or right (high) hand, instruments with a low pitch range typically read their music in bass (low) clef 𝄢, and those with a high range will read in treble (high) clef 𝄞, while some instruments like viola and bassoon even read with an in-between clef, called the tenor or alto clef 𝄡.**

As far as the repeating sequence is concerned, there was a concern that the musical nature of the stimulus might render it conspicuous. It is a common human experience, for instance, that even a short jingle in a radio or television advertisement can be quite memorable, indeed sometimes too memorable (Beaman, 2018). The risk of participants becoming aware of a sequence repeating would be considerable if that sequence were particularly musically memorable, especially if it was to be repeated in every sight-reading piece, with skilled musicians primed to engage with the material in a focused manner. Since it is a standard requirement of the experimental protocol of implicit sequence learning that, in order for learning to be qualified as implicit, the participants should not become aware of the existence of the repeating sequence, this was a significant challenge to overcome for the experiment to produce meaningful results. Considering these challenges, it seemed that in the design of test material, the following criteria needed to be met:

1. As little as possible musical information, other than what is basically necessary for playing correct pitch and rhythm to be measured for speed and accuracy.
2. No specific tonality or characteristics taken from existing genre, style, or cultural music traditions.
3. Standardised musical pieces, playable on all instruments, including the repeating sequence.
4. All sequences to be musically indistinct so as to reduce the likelihood of participants becoming aware of a repeating one.

Considering what was learnt about the perception and processing of tonal hierarchies in cognitive structuralist research, where the presence of a tonic and its relation to other notes enhances implicit learning, it became even more important to avoid any discernible tonality in the experimental material. The aim was to measure any improvement in sight-reading due to the implicit acquisition of a repeated sequence, and this could potentially be obscured by the presence of other confounding variables, such as the implicit learning of tonality and its influence on performance scores. Fortunately, post-tonal theory, i.e. that of a significant segment of Western art music eschewing traditional tonality, composed from the 20$^{th}$ century onwards, provided an abundant resource for atonal musical material, and its construction (Kostka & Santa, 2018; Roig-Francolí, 2021; Straus, 2016). Amongst stylistic and technical variations of compositions from this era, ranging from the atonal intervallic or motivic cell compositions of the Second Viennese School (Schoenberg, Berg, and Webern) to serialism and post-serialism, neo-tonality, neo-romanticism, and minimalism, it was important to identify a system that could deliver simple, atonal melodies meeting the experimental requirements as set out above. The most likely candidate was serialism, in particular Arnold Schoenberg's "12-tone technique" or dodecaphony (*dodeca* = 12) from the 1920's. If we pared this system down to its most simplistic, "bare bone" principles, the 12 distinct notes in a chromatic scale (i.e., all the black and white notes in one octave on the piano, e.g., from middle C to the B before the next C) are randomly arranged to form a new scale or "series", on which compositions are then based (Whittall, 2008). This could allow for the omission of any information other than pitch and duration, no discernible tonality or recognisable encultured style, and the creation of fairly obscure sequences. In addition, if the music was limited to a one octave chromatic scale, this could then be exactly copied to the readable and playable range of any and every pitched instrument, ensuring complete standardisation of all trial material.

One of the original principles of dodecaphonic music was that no particular note of the 12-tone series should be in any way emphasised or heard more than any other, in an effort to avoid creating a "tonal home" or any form of traditional tonality. If we consider that in sight-reading the initial stimulus is visual rather than auditory, the possible series for this experiment would need to incorporate not only the 12 *sounded* pitches, but also their different visual representations. For example, the black note just to the right of middle C on a piano is the pitch one half tone higher in frequency (middle C = 256Hz, the adjacent black note = ~277.183Hz), but in visual representation on music notation, that singular frequency can be written as either C-sharp or D-flat[18], also known as *enharmonic equivalents* of the same tone. Depending on the instrument played, some musicians favour reading music in key signatures that represent such chromatic half-tone steps as flats, while others prefer key signatures using sharps. To equate matters between different instruments, therefore, the test material included both possibilities for any of the twelve tones that could be represented in either way. After feedback from participants in the pilot experiment, a concession was made to moderate the difficulty level by not using notes that would usually only appear in music in key signatures with more than five sharps or flats, thereby omitting E-sharp/F-flat and B-sharp/C-flat. Relatedly, with the aim of standardising the test material across instruments, a total range of one octave, ascending from middle C up to and including the B preceding the next C, would be easily transposable and playable for any instrument. This resulted in a series of 17 notes, each assigned a number as follows (Table 1):

**TABLE 1:** *Assignment of Numbers to Chosen Series of Written Notes in an Octave*

| Note: | *C♮ | C♯ | D♭ | D♮ | D♯ | E♭ | E♮ | F♮ | F♯ | G♭ | G♮ | G♯ | A♭ | A♮ | A♯ | B♭ | B♮ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |

*Note that the natural sign is implied in any non-sharp or -flat note and will only appear if necessary to "cancel" a previous sharp or flat sign that may have appeared in front of the same note in the same bar. The standard reading convention is that any accidental is valid for every subsequent appearance of the same note, for the remainder of the bar, unless cancelled by a new accidental.

[18] Using the piano as reference, C and D are adjacent white notes that share one black note in between them, therefore it is a single tone that can be written as both a semitone higher than C, or a semitone lower than D.

For the sight-reading trials to resemble pieces of modern atonal music, they needed to include different note durations in addition to pitch, to create metre and rhythm. For metre, the pulse or beat of the music, the music was organised in common time, i.e., four crotchet (one-count) notes per bar. This is the most commonly used time signature in music and is simple and easy to read and follow. In terms of different note durations to simulate rhythm, the use of randomly assigned note lengths has precedence in integral serialism in music, where anything from note duration to dynamics can be assigned a specific series (Whittall, 2008). Testing different combinations of pitches and note duration in pilot trials demonstrated that the ideal range of note durations should be limited to minims, crotchets, quavers, and semiquavers (half -, quarter -, eighth -, and sixteenth notes). There are both longer and shorter note durations available, but it could be seen that using combinations with longer notes made sight-reading too easy, and those with shorter notes made it too difficult. In addition, limiting the range of note durations, would simplify the measurement of speed and accuracy, which would rely on inter-onset intervals, i.e. the time from the onset of one note or segment to the onset of the next note or segment (Friberg & Battel, 2002). These four note durations were thus assigned numbers as follows (Table 2):

**TABLE 2:** *Assignment of Numbers to Chosen Note Lengths*

| Note Length: | Semiquaver (sixteenth) | Quaver (eighth) | Crotchet (quarter) | Minim (half) |
|---|---|---|---|---|
| Representation: | 𝅘𝅥𝅯 | 𝅘𝅥𝅮 | 𝅘𝅥 | 𝅗𝅥 |
| No: | 1 | 2 | 3 | 4 |

Having acquired a series for both pitch and note duration, the premise of integral serialism was continued, using a computer to determine the melodic lines to be used in the sight-reading trials, rather than risk introducing any possible bias towards the encultured musical practices and rules of the researcher. A reputable online number generating service was utilised to create two blocks of true[19] random numbers for each trial (Haahr, 2022), one block with numbers from 1-17 (Fig. 15: pitch), and the other with numbers 1-4 (Fig. 16: duration), as per the following examples:

[19] True random generators use unpredictable physical phenomena such as radioactive decay to produce irreplicable strings of numbers, whereas pseudo-random number generators use mathematical algorithms to produce seemingly random strings. However, statistical analysis will demonstrate that the latter will eventually repeat itself and can therefore never be considered truly random.

**True Random Number Service**

## Random Integer Generator

Here are your random Notes:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 1 | 7 | 11 | 15 | 5 | 17 | 14 | 5 | 9 |
| | 11 | 15 | 11 | 10 | 9 | 16 | | | |
| 16 | 3 | 15 | 17 | 2 | 14 | 10 | 13 | 17 | 4 |
| | 4 | 6 | 17 | 14 | 10 | 14 | | | |
| 17 | 11 | 11 | 9 | 12 | 4 | 1 | 15 | 13 | 12 |
| | 10 | 9 | 5 | 10 | 4 | 8 | | | |
| 2 | 15 | 4 | 11 | 11 | 16 | 13 | 10 | 11 | 12 |
| | 3 | 12 | 13 | 11 | 10 | 7 | | | |
| 16 | 5 | 10 | 5 | 1 | 5 | 8 | 12 | 14 | 14 |
| | 13 | 5 | 16 | 4 | 6 | 8 | | | |
| 16 | 13 | 1 | 2 | 5 | 4 | 14 | 8 | 14 | 2 |
| | 17 | 8 | 4 | 1 | 2 | 13 | | | |
| 17 | 15 | 4 | 14 | 9 | 16 | 16 | 12 | 3 | 4 |
| | 3 | 17 | 2 | 10 | 15 | 11 | | | |
| 9 | 11 | 11 | 3 | 10 | 2 | 15 | 15 | 3 | 7 |
| | 8 | 11 | 12 | 5 | 17 | 13 | | | |
| 11 | 10 | 15 | 2 | 13 | 2 | 1 | 17 | 15 | 10 |
| | 9 | 17 | 10 | 2 | 4 | 7 | | | |

**FIGURE 15:** *Random Numbers Generated for Note Pitches*

Here are your random numbers of lengths: 1 sq -2 q -3 c -4 m

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 3 | 3 | 1 | 2 | 1 | 1 | 4 | 4 | 2 |
| | 2 | 3 | 4 | 4 | 4 | 3 | | | |
| 1 | 1 | 1 | 4 | 3 | 1 | 4 | 3 | 2 | 3 |
| | 4 | 1 | 4 | 3 | 4 | 3 | | | |
| 2 | 1 | 1 | 3 | 3 | 3 | 3 | 1 | 2 | 4 |
| | 1 | 1 | 1 | 4 | 4 | 3 | | | |
| 2 | 2 | 4 | 3 | 1 | 4 | 1 | 2 | 2 | 2 |
| | 4 | 2 | 2 | 3 | 1 | 2 | | | |
| 4 | 3 | 1 | 3 | 2 | 1 | 2 | 1 | 3 | 1 |
| | 3 | 4 | 1 | 1 | 4 | 4 | | | |
| 2 | 1 | 4 | 4 | 3 | 1 | 2 | 3 | 2 | 2 |
| | 2 | 2 | 2 | 4 | 4 | 4 | | | |
| 3 | 1 | 4 | 3 | 4 | 4 | 3 | 2 | 3 | 3 |
| | 3 | 4 | 2 | 4 | 3 | 3 | | | |
| 4 | 1 | 2 | 1 | 1 | 4 | 2 | 4 | 3 | 3 |
| | 1 | 3 | 2 | 1 | 3 | 4 | | | |
| 3 | 3 | 2 | 2 | 3 | 2 | 4 | 1 | 3 | 4 |
| | 4 | 3 | 3 | 4 | 3 | 2 | | | |

**FIGURE 16**: *Random Numbers Generated for Note Lengths*

For practical reasons of measurability, as well as for presenting participants with test material that might resemble typical sight-reading tests, the basic framework of the material would consist of a 12-bar melody, with three distinct four-bar phrases. This provided a middle section of equal length to those appearing before and after. Despite being ideal for embedding a repeated musical sequence in the middle of each trial, in keeping with SRT and continuous tracking experiments previously seen in implicit learning research, and ensuring a fair comparison of the performance of one phrase to another, this did cause some concern about the sequence becoming too perceptually salient.

However, after none of the participants in the pilot experiment seemed to notice the repeating nature of the middle sequence, it was decided to take the risk in light of the benefits in simplicity and measurability. The clef was determined by the instrument used, and being atonal, there would be no need for key signatures. This limited the amount of information on the page (other than the notes themselves) to the bare minimum, while still retaining enough familiarity with standard sheet music to avoid participants seeing the material as completely alien, undermining their confidence in completing the task.

With the use of *Finale*, the 12 empty bars of each sight-reading trial were then populated using these random numbers from left to right, with each number in the pitch series being paired with a number from the duration series. Where random note durations extended beyond the four-crotchet (or equivalent) allowance for each bar, the bar was filled up with the appropriate number of rest symbols. The resulting first trial thus appeared as follows (Fig. 17):

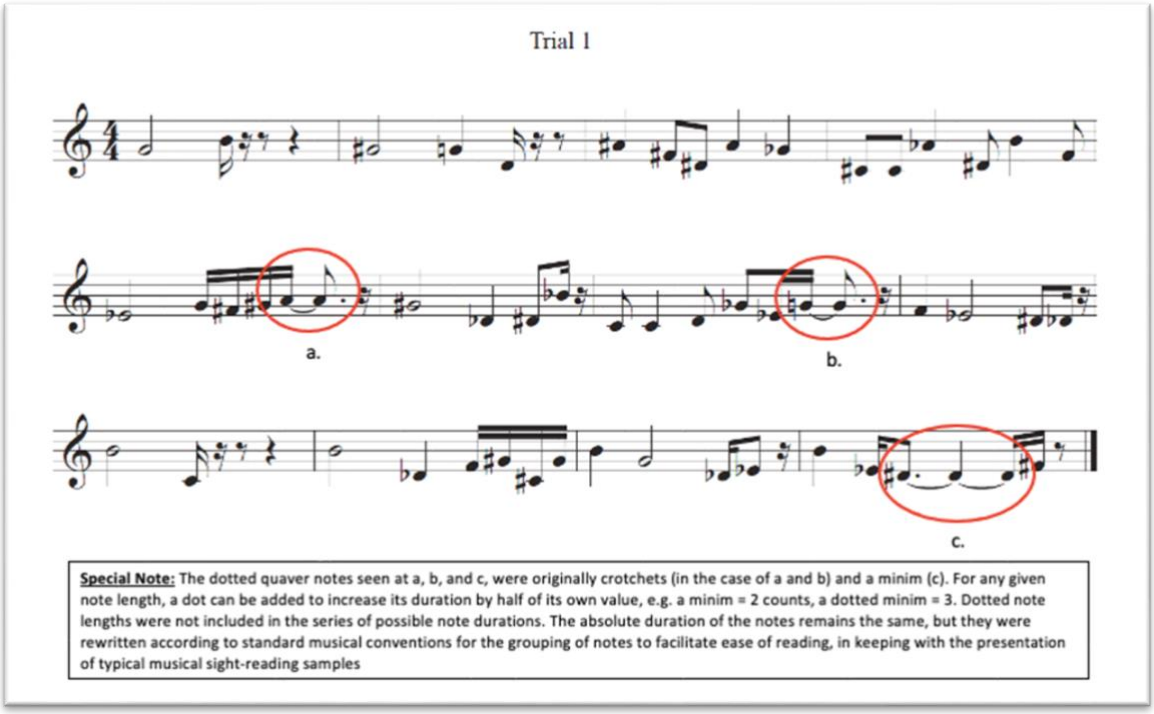


**FIGURE 17:** *Sight-Reading Trial 1 with Adjusted Grouping*

The middle four-bar phrase as above was identical in all trials, whilst all other lines were unique. For instruments not reading in treble clef, the notes were transposed (mapped) into other clefs as necessary. In this way, standard trials were thus created for any instruments that participants might play.

## *WHAT TO MEASURE AND HOW TO MEASURE IT*

For the vast majority of both traditional and current implicit learning research, the measure of implicit learning has either been accuracy in recognition and recall, or reaction time to some form of implicit stimulus presentation. In musical sight-reading, accuracy is an obvious and simple performance measure – a note is either played or sung at the correct pitch, for the correct duration, or it is not. However, sight-reading does not merely consist of the accurate recognition of musical symbols, but also requires timely motor responses, in a continuous and fluent stream, at an appropriate and consistent tempo. Identifying a valid and credible means of measuring this important aspect of sight-reading was not straightforward. Several concepts from the existing literature were considered in finding a feasible solution, including streaming, fluency, visual processing speed, and response time.

STREAMING. Streaming is the cognitive organisation of sensory input, which allows us to mentally represent the activity of a source of sensory stimuli over time (Bregman & Pinker, 1978). This organisational system, i.e. the appropriate segmentation and grouping of incoming sensory signals, enables us to effectively interact with our environment. Visual streaming allows for the processing of visual information about objects, with the ventral stream responsible for the processing of form and feature, facilitating perception and recognition in the temporal lobe (Ingram, 2002). The time this process takes (often <50ms), might be a definition of visual processing speed. However, sight-reading is not about visual processing alone, but is also mediated by auditory feedback. Significant for sight-reading skills, auditory streaming not only allows us to focus on the signal of interest, but also to predict signal progression. Our expectations about the signal then facilitates further processing of subsequent signals (McCabe & Denham, 1995). This would thus be the neural organisation that allows for audiation, which was named earlier as an important factor in sight-reading proficiency (Mishra, 2014). If streaming, both visual and auditory, represents the cognitive organisation of sensory *input* (i.e. reading and hearing the music while sight-reading), then we would still need to find a way of measuring the resultant *output* (i.e. playing/singing the notes) in a meaningful way that could demonstrate implicit learning of the repeated sequence.

FLUENCY. The term fluency has diverse meanings and applications in different fields of study, but in a general sense, it is taken to mean the relative ease with which a task is completed, as evidenced by high levels of accuracy, as well as efficiency and speed of task execution (Poldrack & Logan, 1998). In the reading of text, we refer to fluency as the ability to read the correct words in a comfortable and continuous flow, with appropriate prosody. This is analogous to sight-reading fluency, seen as a continuous flow, at an appropriate tempo, of the correct pitch and duration of notes as indicated, and adhering as closely as possible to any other performance directions as specified. It is clear that neither accuracy nor speed in isolation is sufficient to attain fluency, and researchers have therefore included both response time and response accuracy in measures of fluency (Wang & Chen, 2020). For the sight-reading trials in this experiment, measuring accuracy would be a relatively simple undertaking, but how to measure performance speed would require further consideration.

VISUAL PROCESSING SPEED. This has been defined as the time needed to make an accurate judgement about a visual stimulus (Owsley, 2013). Methods of determining visual processing speed have often relied on behavioural measures, such as reaction times, but this necessarily includes not only the visual processing time, but also the time required to execute a response, which obscures exact measurement (Thorpe et al., 1996). In reading text, visual processing speed is a predictor of reading speed, but not of reading fluency (Lobier et al., 2013), since the latter depends on the ability to simultaneously process multiple letters in words, and not on speed alone. This is once again analogous to musical sight-reading in the way that multiple elements are processed from any music note (i.e. pitch, duration), and that one note in turn becomes another single element in a longer string of notes. To further complicate the measurement of visual processing speed for musical material, it would seem that the more complex the musical material is, the longer the visual fixation on each separate element will be (Wurtz et al., 2009), and that the level of anticipatory processing (i.e. how far one is able to "read ahead") is influenced by musical phrase boundaries (Sloboda, 1977). A final complication is the role that auditory signals play in visual processing speed. Findings have shown that unfamiliar/unexpected auditory input slowed down visual processing, while familiar/expected auditory input did not (Robinson & Sloutsky, 2007). This would mean that playing a wrong note in sight-reading (i.e. unfamiliar/unexpected auditory input) may affect the visual processing of subsequent notes. It was thus clear that measuring the visual processing speed in the sight-reading trials would be a challenging prospect, with many variables to consider.

RESPONSE TIME. In the motor learning paradigm of implicit learning research, response time is usually measured as a singular discrete response to one stimulus at a time, as could be seen in the original SRT task (Nissen & Bullemer, 1987), and in all of its descendants. This was clearly not a suitable way to measure sight-reading, as the visual stimulus material would not be presented one note at a time, but as a complete unit of three lines of music per trial. It has also been made clear by now that, just as we do not read one letter at a time when reading text, sight-reading is not the visual processing of or response to one note at a time, but a continuous and complex process of audiation, anticipation, and motor response to auditory feedback. However, in all the literature surveyed, there was no alternative term that could adequately describe what the sight-reading experiment would measure.

From the concepts discussed here, it was evident that several facets of sight-reading, and the measurement of a successful performance of it, were interrelated – a.) streaming is the neural organisation of the sensory information necessary for accurate and timely responses, b.) fluency is a function of both speed and accuracy of response, and c.) visual processing speed can be measured, but is not an accurate predictor of fluency on its own, nor does it provide a full account of sight-reading without considering the auditory pathway. Response time, complementary to accuracy, unifies and accounts for all of these elements, despite the apparent unsuitability of its traditional application. It was thus decided that, for this experiment, the term would be redefined:

***Response Time:*** *The total time taken to respond to either the entire visual stimulus, or any part thereof, as measured by the inter-onset intervals between those parts.*

### THE NUMBER OF TRIALS

In deciding the number of trials to be conducted, the heuristic maxim of "as many as is practically possible" seems to be the norm. Having no prior experiments similar to this for guidance, the traditional implicit learning paradigms were again consulted. For continuous tracking tasks, the average was around 200-300 trials per participant, for example 216 in Künzell et al. (2017), and 300 in Wulf and Schmidt (1997), while in SRT tasks it has been as many as 800 for the original Nissen and Bullemer (1987) experiment. This is again where Hebb repetition learning was more analogous, as was mentioned earlier, due to measuring performance of entire sequences rather than individual stimuli. The average number of trials in that paradigm ranged between 20 and 30, which seemed more realistic for the sight-reading experiment. However, it became apparent in the pilot experiment that participant fatigue set in after an average of about five trials (i.e. 5 sight-reading pieces). Possible reasons for this phenomenon, and the implications thereof for this and future research will be discussed below, but it was nevertheless decided to run the experiment with five trials per participant.

## METHOD

This experiment was originally intended to be conducted with undergraduate music students from the Royal Holloway, University of London, in an on-campus music room, providing them with individual sheets of music for each trial, and using audio recording equipment to collect the data for analysis. Due to the global COVID-19 pandemic during 2020/21, with extensive restrictions on in-person meetings, the experiment had to be entirely reimagined to be conducted exclusively online, with no face-to-face contact. This did pose challenges in terms of technical difficulties, such as participants' internet connections being unreliable, intermittent, or slow, as well as software failures, and several other small issues that occasionally resulted in trials having to be rescheduled. However, this was also fortuitous, as it opened up the possibility of recruiting participants from a much wider pool of musicians globally, extending sample demographics from undergraduate music students alone, to international music students of different skill levels, as well as experienced professional musicians, strengthening the external validity of the results. The experiment was thus conducted at different time intervals, over several months during 2021 and 2022.

## *PARTICIPANTS*

Previous SRT experiments with similar test protocols and measurement criteria were analysed for their effect size in order to calculate the required sample size for this experiment. Nissen and Bullemer's (1987) SRT experiment was the closest in terms of test protocols and measurement, but due to the very large effect size, extensive trials (800 per participant), and a slightly different approach to statistical analysis than what was envisaged for the current experiment, it was decided to apply a conservative adjustment to the power calculations by halving the degrees of freedom, i.e. effectively halving the number of participants. This resulted in Cohen's $d$ = .557, and with a power of .95, the minimum required sample size was calculated at $n$ = 26.

Considering the risks of running the experiment entirely online, with the possibilities of technical failure, corrupt files, or inferior quality audio recordings, it was decided to recruit an additional 20%, for a total of 32 participants. Ultimately, one dataset had to be discarded due to an unusable audio file. Thus, a total of 31 musicians took part in the experiment, recruited from the United Kingdom, Ireland, Australia, and South Africa. The recruitment criteria were for musicians playing a pitched instrument, or singing, with a sight-reading ability of at least Grade 6 or equivalent in the standard music grading system. Proficiency levels ranged from intermediate to advanced students with no professional playing experience ($n$ = 6) to semi-professional and highly skilled professional musicians ($n$ = 25). The instruments played were violin (7), viola (1), cello (3), double bass (1), flute (3), oboe (1), clarinet (3), saxophone (1), bassoon (2), French horn (2), trumpet (2), tuba (1), voice (1), and piano (3). 15-minute experimental slots were scheduled online at times suitable to the participants' availability, with prior consent to record online sessions confirmed according to the ethical approval obtained from the ethics committee of the Royal Holloway, University of London.

## *APPARATUS AND MATERIALS*

Experiments were conducted online, and recorded utilising the free version of *Zoom* (Qumu, 2012). Audio files were kept for processing and analysis using the music production software *GarageBand* (Apple, 2021). Video files were discarded. Equipment required from participants was their instrument, and a screen large enough from which to comfortably read music notation. Each participant received the following five sight-reading trials, generated with *Finale* (Fig. 18-22):


**FIGURE 18:** *Sight-Reading Trial 1*


**FIGURE 19:** *Sight-Reading Trial 2*


**FIGURE 20:** *Sight-Reading Trial 3*


**FIGURE 21:** *Sight-Reading Trial 4*


**FIGURE 22:** *Sight-Reading Trial 5*

Trials were presented as portable document files (PDF) in *Acrobat Reader* (Adobe, 2020) to enable positioning them to fill the entire screen, with no distracting file headings or computer icons visible. The position was the same for each trial. An example trial, using the same measurements and position, but not including the repeated sequence or any material from other trials, was provided so that participants could adjust their screens or positions for comfort of reading and playing the music on their various instruments, before commencing with the experimental trials.

After the five experimental trials, participants were asked a series of questions about the material, starting with general questions about the experience, and narrowing down the focus gradually to determine any awareness that one sequence was repeated across the five trials. The questionnaire was based on the standard format as found in the majority of implicit learning experiments where sequence awareness is determined by participant interviews (Nissen & Bullemer, 1987; Pew, 1974; Shea et al., 2001):

1. What was your overall experience of the experiment? /Any general comments?
2. What was your impression of the music presented?
3. Was there anything interesting or peculiar about the sight-reading samples?
4. If you were to compare the samples to each other, would you say that they were very similar/very different/neither, just random?
5. *If answered "similar" to question four* – Would you say that they were so similar that there could have been repeated material between the different trials? (*If answered "different" or "neither", proceed to question nine*).
6. *If answered "yes" to question five* – Could you describe the elements that you felt may have been repeated? (*If answered "no", proceed to question nine*).
7. Do you have an idea where in the samples these repetitions occurred most frequently, i.e. beginning, middle, end, or all over? *If answered "beginning", "end", or "all over", proceed to question nine.*
8. *If answered "middle" to question seven* – Do you think you could sing or play any of the repeated material?
9. If you were told that the middle line of every sample was an exact copy in every trial, would you gauge this to be true or false?

## *DESIGN*

Each participant received five trials in succession, each with three musical sequences, equal in length, with the first and third line in each randomly generated, and the middle line repeated for every trial. Participants were subject to a repeated-measure design, with both baseline and test performance occurring within each trial. This would mean that there would be no need for a control group, since each participant's performance on the non-repeated material would serve as internal control for the performance on the repeated material. There was therefore also no between-participant comparison necessary. Time measurement commenced from the onset of the first note of the first trial, and ended after the last note of the final trial. Processing of the data to measure the time of each individual sequence will be discussed in the results below. The factors tested for were the dependent variables of response time, measured as the total time taken to sight-read each line of music as per the definition set out earlier, and accuracy, measured as the correct production of pitch and duration for every note per line. The independent variable was the exposure to the repeated sequence over five trials. An awareness measure was conducted after the completion of the final trial, to gauge participants' consciousness of the repeated line of music.

## *PROCEDURE*

Participants were sent electronic links to join the researcher online via *Zoom*, at times scheduled according to the participants' availability, with pre-obtained consent for the recording of the video meetings. Participants were instructed to complete the task in a quiet space such as a practice room, with a good internet connection, and a screen large enough from which to comfortably read music notation. Upon joining the online experiment, they were informed that ethics approval had been obtained from the ethics committee of Royal Holloway, University of London, and that all data would be kept completely anonymous, that only audio files would be retained for data processing and analysis, and that they were free to withdraw their participation and recorded data at any time. Participants were then required to give verbal consent of their participation in the experiment. The instructions for the experiment were read to the participants, informing them that the music notation samples they were about to see would be random and atonal, with no key signature or performance indications, and that they should simply “play what they see”. It was explained that they would be given an example trial on screen so that they may adjust the size and their playing positions for comfort and ease of reading and playing. Special attention was given to the instructions that: a.) there would be no time allowed to read through or silently practice the material before playing, b.) that the guideline for tempo was more or less 60 – 80 beats per minute (as per standard metronome markings, which musicians are very familiar with), but that they should play at a comfortable tempo within that range, allowing for maintained consistency throughout all the sight-reading samples, and c.) that they should not stop to correct mistakes, but continue playing from the beginning to the end of each sample, without interruption. Participants were then given the opportunity to warm up or tune their instruments if required, also serving as a sound test for recording levels before commencing with the trials.

Participants assumed a “ready” playing position before the first trial was presented onscreen, and started playing as soon as it appeared. The five prepared trials, in the appropriate clef for the instrument played by the given participant, were displayed on screen, one at a time, and the computer mouse was used to click through the different screens in such a way that it would appear that only the specific notes were changing, whilst the field they were presented in remained stationary. Participants played through the trials, without pausing in between for any longer than necessary for the next trial to be presented (1-2s). At the end of the fifth trial, participants were requested to answer questions regarding the sample material. The prepared questionnaire was followed, while still allowing participants the freedom to comment as much or as little as they wished. The total experiment time per participant averaged around 15 minutes.

## RESULTS

Preparing the data for analysis, audio files recorded in *Zoom* were imported to *GarageBand*, and sent to an independent music and sound production specialist, where the following procedures were followed according to strict, predetermined guidelines. Trials were isolated and divided by splicing the wave file of each trial from the onset of the first note of a line of music to the offset of the last note, except when a line ended in a rest sign, in which case it was spliced from the onset of the first note of that line, to the onset of the first note of the next line. In the case of the final line of a trial ending in a rest, the pulse of the music, as detected by the software, was followed to splice the file at the exact point where the next bar of music would have started, had there been another line of music. It is important to note that splicing was not done according to the visual demarcation in the wave file alone, but also by careful listening to where the pitch of one note changed to another, especially in cases where lines followed straight on from one another, with very little wave demarcation visible. This procedure resulted in segmented wave files, such as in the example below (Fig. 23, with the wave compressed for demonstration purposes):


**FIGURE 23:** *Processed Audio File in GarageBand*

The audio file of each participant thus contained three segments per trial (A, B, and C), for five trials, for a total of 15 segments per participant.

To measure response time, the metadata of each segment, as seen in Figure 23, was accessed to obtain the exact length of each sequence in seconds, accurate to three decimal places. For the accuracy measurement of the sight-reading, two separate and independent professional musicians compared each segment to the printed music as well as to the computer-generated music file containing the correct pitch and note duration, and recorded the number of errors made by each participant for each segment. The data were entered into a spreadsheet, showing 15 performance times and 15 accuracy scores per participant, grouped according to segment, i.e. 1A-5A, 1B-5B, and 1C-5C, where A is the first line of each trial, B the second (repeated) line, and C the third line. The first and third lines of each trial were combined and averaged to provide data from two distinct experimental conditions, repeated (B), and non-repeated (A+C), for subsequent statistical analysis.

Following the lead of several studies from the Hebb repetition learning paradigm, it was decided to employ regression analysis, in particular, analysis of the slope of regression, which can also be called the “gradient of learning”. This has been found to be a sensitive measure for predicted learning that describes the learning effect directly, and is less interfered with by statistical "noise" from the data than standard parametric tests (Page et al., 2006; Parmentier et al., 2008; St-Louis et al., 2019).

## *RESPONSE TIME*

For each participant, the gradient of learning was calculated for each condition, employing the above method of analysis. Figure 24 demonstrates this as the gradient of the change in response time for the repeated and non-repeated sequences across the five trials of the experiment:

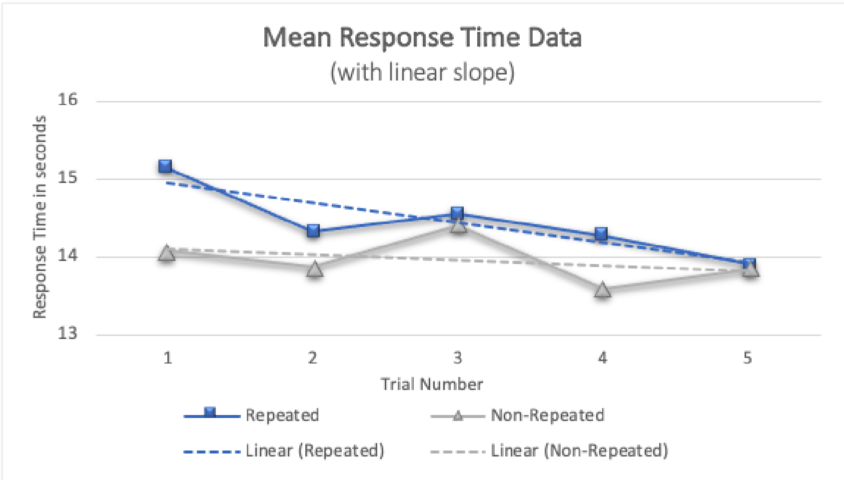


**FIGURE 24:** *Gradient of Learning – Faster Response Time*

The resulting data, being the gradient of improvement for each participant in each condition, were then analysed. The mean decrease in response time was compared between the two conditions through a paired sample t-test, showing that the response time decreased at a significantly faster rate for the repeated material, with $t(30) = -3.95$, and $p < .001$, as indicated by the steeper slope of the linear regression of the repeated condition above, than for the non-repeated condition, i.e., significant learning of the repeated sequence had occurred.

## *ACCURACY*

For accuracy, the standard of measurement was not as straightforward as using a basic timescale. If every line of music in the trials were identical, or even contained an equal number of notes and rhythms throughout, one could simply count the number of participants' performance errors per line and compare the raw data in the same way as for response time above. However, due to the random generation of pitch and rhythm in every line, apart from the repeated sequence, the number of pitch and rhythm errors that could occur varied across the trials. To further complicate matters, it is possible to play a note for the correct duration, but on the wrong pitch, or vice versa. For example, for Line 1 from Trial 1 (Fig. 25), there were 16 distinct pitches, and 18 rhythms (16 note durations plus the two rest periods at the end of bar 1 and 2). This constituted a total of 34 possible errors for this specific line:

**FIGURE 25:** *The Notes and Rhythms of Trial 1, Line 1*

Therefore, the total possible error score for each line was calculated (Table 3), and performance accuracy was scored as a percentage correct of that total score in each case.

**TABLE 3:** *Total Accuracy Scores Allocated for Each Trial Segment*

| Segment | 1A | 2A | 3A | 4A | 5A | B(all) | 1C | 2C | 3C | 4C | 5C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Possible Score | 34 | 32 | 40 | 27 | 34 | 38 | 33 | 38 | 28 | 32 | 30 |

Auditory analyses of the segmented wave files were conducted and compared to both the score, and the computer-generated sound file, with any clear deviation from the exact parameters of pitch and duration counted as an error, and the number of errors per line subtracted from the total possible error score for that line. Each participant's accuracy data was thus recorded as percentage correct for every segment of every trial. For binary comparison between the repeated versus non-repeated condition, the mean percentage points for segments A and C were again calculated, and the gradient of improvement was determined for each participant in each condition, using the same slope equation as with the response times (Fig. 26).

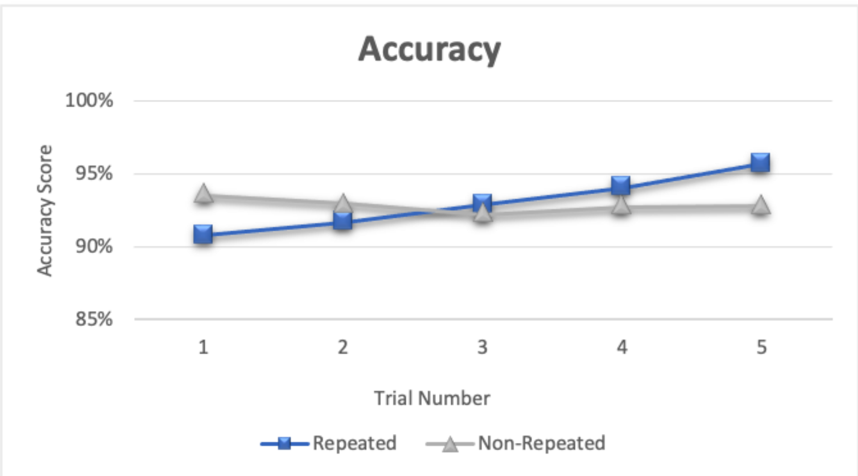


**FIGURE 26:** *Gradient of Learning – Improved Accuracy*

Note that regression lines were not added to the visual representation of data in this graph, as they were virtually indiscernible from those of the mean data. Comparing the mean change in accuracy between the repeated condition and non-repeated condition in a paired sample t-test, found that accuracy improved significantly for the repeated sequence, but not for the random sections, with $t(30) = 9.54$, and $p < .001$.

## *ANOMALOUS FEATURES*

From the mean response time data (Fig. 24), two unexpected deviations of this data from the linear slope were immediately visible, and could not be ascribed to random noise. Firstly, the response time of the repeated material seemed to be slower than the random material throughout the experiment, starting out at more than 1s slower in the first trial, and, due to the steeper slope of learning for the repeated material, ending up more or less equal to the non-repeated material by Trial 5, but never surpassing it. Secondly, Trial 3 seemed to be more difficult than the surrounding trials, as demonstrated by the slower response time in both conditions.

When the number of notes per trial were counted for the calculation of the accuracy scores, it became evident that there may be a correlation between the apparent difficulty of particular sections of the material and the number of notes that they contained. Due to the random number generation used to “compose” the trials, the absolute number of notes per line of each trial was not controlled for, as it was not predicted to have any effect on response times, as long as the lines were of equal length (4 bars) and played at a fairly consistent tempo. Yet, it could be seen that the higher the number of notes per segment, the slower the response time was. By simply looking at the number of notes per trial (Table 4), it became immediately clear why Trial 3 seemed more difficult, with 81 notes, as compared to the surrounding average of 72, and similarly, the repeated sequence contained 27 notes, as compared to the average of 23 in other segments.

**TABLE 4:** *Number of Notes per Trial*

| Trial | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Number of Notes | 72 | 75 | 81 | 70 | 72 |

Testing this confirmed a positive correlation between response times and number of notes per segment, with $r(13) = .49$, and $p < .05$, and further testing confirmed that the response times for Trial 3 were significantly slower than other trials, with $t(30) = 3.12$, and $p < .01$.

The accuracy scores did not reflect these anomalies, since the way they were calculated, as a proportion of the possible errors per line, already normalised the data for this effect, as was seen in a correlation test with the number of notes per line, with $r(13) = -.170$, and $p = .273$. The response time data were therefore proportionally corrected for an average cognitive load (i.e., having the same number of notes per line), using the following formulae:

$$\overline{CL} = \frac{\sum_1^x N_i}{x} \quad \text{and} \quad N_{i\propto} = \frac{N_i}{\overline{CL}}$$

Where:

- $\overline{CL}$ is the average cognitive load
- $N$ is the number of notes per line
- $i$ is the index (location) of any line
- $x$ is the maximum number of lines
- $\sum_1^x N_i$ is the sum of all notes in line 1 to line $x$
- $N_{i\propto}$ is the proportion of $N_i$ to $\overline{CL}$

And:

$$\overline{RT}_{CLi} = \overline{RT}_i + (\overline{RT}_i(1 - N_{i\propto}))$$

Where:

- $\overline{RT}_{CLi}$ is the proportionally corrected mean response time for the given line
- $\overline{RT}_i$ is the mean response time for any line
- $N_{i\propto}$ is the proportion of $N_i$ to $\overline{CL}$ for any line

The abovementioned anomalies were thus eliminated, as can be seen when the data were plotted once more (Fig. 27), and the implications of this will be discussed below.

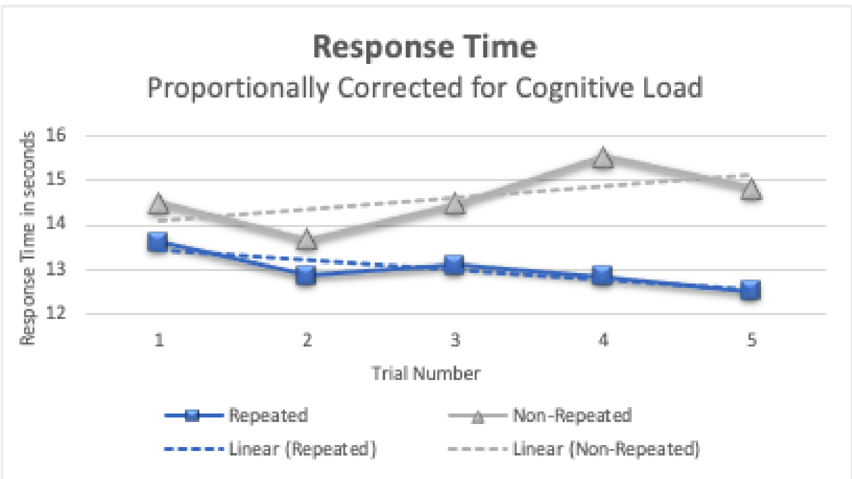


**FIGURE 27:** *Proportionally Corrected Response Times*

## *AWARENESS OF SEQUENCE REPETITION*

The answers to the sequence-repetition awareness questionnaire are shown in Table 5:

**TABLE 5:** *Questionnaire Responses on Sequence-Repetition Awareness*

| Question | Responses | | N |
|---|---|---|---|
| **Q4:** *If you were to compare the samples to each other, would you say that they were very similar/very different/neither, just random?* | Similar | | 31 |
| **Q5:** *Would you say that they were so similar that there could have been repeated material between the different trials?* | Yes | | 9 |
| | No | | 19 |
| | Not Sure | | 3 |
| **Q6:** *Could you describe the elements that you felt may have been repeated?* | No | | 3 |
| | Vague Description | "some" rhythmic and melodic elements felt like they occurred more than once | 3 |
| | Specific Description | final two notes of the sequence, both pitch (D-sharp/D-flat) and rhythm (quaver/semiquaver), indicated that they thought there were more instances, but could not immediately recall | 1 |
| | | G/F-sharp/G-sharp semiquaver pattern (repeated sequence, bar 1), but not the following A that is still part of the group of four | 2 |
| | | semiquaver group as above, without specific pitches, thought that it may have been only a rhythmic repeat, on different notes | 1 |
| | | large interval jump (repeated sequence, bar 2-3), from B-flat to middle C | 2 |
| **Q7:** *Do you have an idea where in the samples these repetitions occurred most frequently, i.e. beginning, middle, end, or all over?* | All Over | | 4 |
| | Middle | | 2 |
| **Q8:** *Do you think you could sing or play any of the repeated material?* | Yes | Sings last bar of the sequence fairly accurately, asserts that there was more repeated material before that, but not confident enough to sing it | 1 |
| | No | | 1 |
| **Q9:** *If you were told that the middle line of every sample was an exact copy in every trial, would you gauge this to be true or false?* | True | | 1 |
| | Not Sure, Possibly True | | 2 |
| | False | | 28 |

These data suggest that the majority of the sample (*n* = 28, ~90%) did not become aware of the repeated middle line and that the performance improvement of that line was due to implicit sequence acquisition. Of the three remaining participants, one clearly and immediately knew that the middle line was at least fairly similar, if not identical, on every trial. The other two demonstrated partial awareness. One expressed that they had a sense of something being very familiar on each trial but could not pinpoint what that may have been, until Question 9 of the questionnaire elucidated it. The final participant was recorded in the experiment itself, at the beginning of the middle line of the second trial, saying quietly "I think I've seen this before". Despite this, by the time the questions were posed, although they gave an accurate description of the semiquaver grouping at the start of the repeated sequence, they could not pinpoint the location (beginning, middle, end), and determined that the final statement was false. It was unclear whether they were only referring here to the three semiquavers at the start of the repeated sequence when they said they had seen it before, or to the entire middle line. Erring on the side of caution, this participant was classified as having become aware of the repetition of the middle line.

All data were subsequently checked, by comparing the performance changes between the repeated and non-repeated conditions with paired sample t-tests. The first comparison was for the sample that would remain without the three participants who had become aware of the repeating nature of the middle sequence ($n$ = 28), with $t(27) = -3.64$, and $p = .001$ (response time) and $t(27) = 8.565$, and $p < .001$ (accuracy). Secondly, the same comparison was made with only those participants that reported no awareness of any repeated material ($n$ = 22), with $t(21) = -2.46$, and $p < .05$ (response time), and $t(21) = 7.66$, and $p < .001$ (accuracy). In both cases the same pattern of results was seen as with the full complement of 31, and it was thus determined that neither part nor full awareness of the repeated material affected the results in any significant way.

## DISCUSSION

The main statistical analyses and findings were presented in the preceding Results section. However, in cases where additional calculation and analysis was necessary for the interpretation and understanding of the results, it will be reported at the appropriate point within the current section.

The results of this experiment, investigating implicit sequence learning in a sight-reading task, indicated that participants displayed both significantly faster response times and increased accuracy of repeated, as compared to non-repeated, musical material while sight-reading. The implicit nature of the learning was confirmed, as far as is possible, through testing participants' awareness of the repeated material. In a recapitulation of the objectives of replicating an implicit learning experiment for music, namely, to confirm the applicability of the experimental protocol to a music context, and to demonstrate that the learning mechanism operates in relation to musical material, it would seem that these were successfully met. However, the objective to demonstrate that it can produce commensurate advantages for music learning specifically, still needed addressing.

In this discussion, the observations and findings discovered in conducting the experiment and by interpreting the results, will be considered independently, and conclusions about their beneficial nature will subsequently be drawn.

## *RESPONSE TIME AS PERFORMANCE MEASURE IN MUSIC*

A fundamental issue that needs to be clarified prior to any further discussion, is the use of faster response times as an indicator of musical performance improvement, even when taking into consideration its redefinition for this experiment. In standard SRT studies, the instruction is typically to react as quickly and as accurately as possible to the presented stimuli. Observing a decrease in reaction times across trials are a common result, as participants are actively trying to perform the task as quickly as possible, and the only question is whether they did so in a significantly different way in the repeated versus non-repeated conditions.

The musical context in this case necessitated a different approach. To assess sight-reading as a skill, the criteria for evaluation are adherence to the performance indications on the page, an appropriate and consistent tempo, and as few errors in pitch and rhythm as possible. Accordingly, measuring any improvement in the skill would require improvement of any or all of these elements. This led to an incongruous condition where participants were instructed to play at a comfortable tempo, as consistently as possible throughout all trials, and yet the prediction was that faster response times would be observed. It would seem that a.) if the instruction emphasised consistency, then learning would yield fewer deviations from the mean tempo, and any faster response times could be construed as a deterioration of the skill rather than an improvement, and b.) obtaining a reliable difference between repeated and non-repeated conditions would be less likely if participants were deliberately attempting to do the opposite (remain consistent) of what was expected (faster response times). It could indeed be seen from the results that the higher the musical proficiency of the participant, the more consistent the tempo was, and fewer deviations were detected in individual segments from the mean response time of all trials. It was, however, considered in designing the experiment that even if response time measurement could potentially be difficult to interpret, the measure of accuracy would still yield the necessary evidence of learning, being a non-time-measured variable, with a higher probability of improvement under consistent-tempo conditions than if participants were attempting to play as fast as possible. This was evidenced by testing consistency, measured as the range in trial completion times per participant, against the mean accuracy score of each participant, and finding a positive correlation of $r(29) = -.767$, and $p < .001$, i.e., the smaller the range in completion times across trials, the more consistent the tempo, and the higher the accuracy. It is unclear whether this was due to higher skilled performers being able to apply a consistent tempo, as well as being more accurate in their playing, or whether higher accuracy was a result of the consistent tempo application, but it could be argued that if participants intended to accelerate their performance rather than apply a consistent tempo, accuracy would likely have suffered.

The important qualification here is that the consistent application of an overall tempo requires the conscious control of motor responses by the performer (Kihlstrom, 1987), whereas the processing speed of a visual stimulus is an essential, involuntary cognitive function (Owsley, 2013). If we consider the pioneering distinction between response time (RT) and movement time (MT) as two discrete motor responses to a stimulus (Breen et al., 1969; Fitts & Peterson, 1964), where MT is the duration of the motor response, and RT is the time it takes from the perception of the stimulus to the onset of the motor response, then tempo would be the deliberate control of the duration of playing, with response time the interval between reading a note and playing it. The length of this interval depends in part on the speed of the subconscious processing of the visual stimuli. If processing speed is inversely proportional to cognitive load (Barrouillet et al., 2004), and implicit learning bypasses at least the cognitive load imposed on working memory (Maxwell et al., 2003; Yang & Li, 2012), then the logical inference is that implicit learning will result in faster processing speed. It is suggested, then, that the benefit of implicit learning for sight-reading lies in the faster processing of the musical information on the page, as indicated by the significant decrease in response time for the repeated segments seen in the results.

Although it may seem contradictory, the improvement in response time for individual segments, led to an enhanced ability by participants to apply a consistent tempo throughout the trials in the experiment. A comparison of the mean total time of completion for every trial showed that the variation in completion time across all trials was around 1s, which is a remarkably consistent application of tempo, considering it took around 42s to complete each trial on average. Even more notably, this was evident despite significant savings in response time for the repeated sequence across the five trials. It can thus be concluded that the savings in processing time, i.e., faster response times, allowed performers to execute the task with fewer variations in the overall tempo.

## *COGNITIVE LOAD*

When plotting the mean response times, it was expected that a relative amount of noise would be observed in the data, i.e., the change in response time as a function of learning would not be linear across the trials. Fluctuations may occur due to any number of factors, such as nerves, the particular difficulty or ease of any musical elements throughout the trials, fatigue, errors, and more. However, the two specific anomalous features as discussed in the preceding Results section, namely the slower response times for the repeated section overall, and for both conditions in Trial 3 specifically, were found to be due to the presence of a higher number of notes than in the surrounding material.

As discussed, response time and the control of tempo involve distinct motor processes, and segments of equal length played at a consistent tempo are not in fact a guarantee for a consistent rate of change in response time, as the latter is a measure of processing speed rather than speed of performance. The number of visual stimuli per segment seemed to be a stronger predictor of response time than overall length and tempo. Reasons for this could be the difference in processing speed of visual stimuli of differing magnitude (Li & Cai, 2014), such as the different individual note appearances (e.g. semiquaver vs. minim), or the serial processing of individual stimuli in a visual field (Töllner et al., 2011), i.e., the total number of consecutive note appearances per line. Simply put, the more notes in a bar/line, the higher the cognitive load, the slower the processing speed became.

Significantly, the repeated segment showed an overall improvement of 1.235s, from 15.142s in the first trial to 13.907s in the final trial, despite having a higher cognitive load (more notes) than the surrounding non-repeated segments in nearly every trial. This may be a valuable finding for this area of cognitive research since, as far as can be ascertained, no other implicit learning experiment has demonstrated in the same instance the detrimental effect of increased cognitive load on processing speed, as well as the fact that implicit learning seems relatively unaffected by the increase in load. However, more research is needed to measure the differences specifically between the learning of repeated higher- and lower-load musical sequences to make any such claims.

## *FATIGUE*

In the decision to have only five trials per participant in this experiment, as mentioned in the introductory part of this chapter, the motivation was the apparent fatigue reported by participants in the pilot trials. Further to that, in conducting the experimental trials, the same phenomenon was observed. Although the general reaction to the experiment was favourable, it was clear that participants found the material to be difficult, and the task challenging. A majority expressed that they experienced mental fatigue by the end of the five trials, some commenting on this as early as the end of Trial 3.

One possible reason that could be suggested for this is the increased overall complexity of an experiment using these specific musical parameters and skill testing. There is currently no standard statistical measure for comparing different experimental conditions (Martens, 2021), but for the sake of demonstrating the difference in complexity, a simple means of estimation has been employed here. It can only include those variables that are known and quantifiable, but it may still allow us to roughly approximate parity between otherwise heterogenous elements of two experiments.

Using the Nissen and Bullemer (1987) SRT experiment again as example in Table 6 below, by setting the complexity of a variable in the traditional SRT experiment as a standard value of 1, the equivalent variable for the sight-reading experiment can be calculated as a multiple or fraction of that value. For example, in the first line of the table, it can be seen that the stimulus in the SRT experiment had one possible surface feature, being an asterisk of 0.35cm in diameter in every case, whereas each individual stimulus in the sight-reading experiment had 20 possible variations in surface features, awarding it the value of 20 times the complexity of the same variable in the SRT experiment.

**TABLE 6:** *Relative Comparison of Standard SRT and Sight-Reading Trials*

| | Nissen and Bullemer | CS* | The Sight-Reading Experiment | CS |
|---|---|---|---|---|
| Stimulus Features | Asterisk, 0.35cm in diameter | 1 | Music notes of four different duration types, with four different possible variations (no accidental, natural, sharp, flat), and four different rest symbols | 20 |
| Number of Possible Locations on Screen | 4 locations | 1 | 756 locations[20] | 189 |
| Stimulus Recurrences per Trial | 100, standard for every trial | 1 | Variable in separate trials, for an average of 74 | 0.74 |
| Individual Response Duration | One short press of a button | 1 | Duration of every response determined by the surface appearance of the note | 4 |
| Continuous Stream Y/N? | Yes, no interruptions in stimulus presentation | 1 | No, some stimuli (i.e. rest symbols) require silence (no motor response) for a set duration as determined by the surface appearance of the rest symbol | 4 |
| Total Score | | 5 | | **217.74** |

*Complexity Score

There are many more variables that could be included, but assessing the difference of complexity in a few examples that are easily quantifiable can demonstrate the argument sufficiently. Thus, continuing in the same way, the SRT experiment receives a total complexity score of 5, while the sight-reading experiment receives a score of 217.74. If we represent this as a ratio (217.74/5), we can then see that the sight-reading experiment, for these selected variables, may be nearly 45 times more complex than the standard SRT experiment. This not only speaks to the cognitive load of the musical material as discussed above, but also to general task difficulty, and explains the fatigue experienced by

[20] For every bar of music, the maximum number of possible notes is 16, for the shortest note duration of a semiquaver (sixteenth note), and the minimum is 2, for the longest duration of a minim (half note), therefore the average possibility of horizontal locations is 9. However, for every possible horizontal location, there are 7 possible vertical locations from middle C up to the B before the one octave range is reached. This results in 7x9=63 possible locations per bar, thus 63x4=252 possible locations per segment, and 252x3=756 possible locations per trial.

participants after an average of only 3.5min of active sight-reading. This is an important consideration for any future experimental designs, when deciding upon the skills and variables to be tested and measured, and the number of trials necessary to observe the desired effect.

Interestingly, although not statistically significant, a slight deterioration in performance was observed for both the accuracy scores, and the corrected response time data (e.g. see the linear trendlines in Fig. 27). This may be a visible indication of the fatigue as discussed here, but more importantly, both accuracy scores and response times continued to improve for the repeated material, providing evidence that implicit learning of the repeated sequence was not adversely affected by mental fatigue or task difficulty.

## *INDIVIDUAL FINDINGS*

Certain phenomena were observed on an individual participant level, which may not allow for any statistically meaningful inferences, but were interesting enough to warrant discussion here.

SPEED/ACCURACY TRADE-OFF. In a few isolated cases (*n* = 3), there was a definite deterioration (slowing down) of response times over the course of the experiment. This could possibly be attributed to a reduction in initial stress levels, leading to a lowered arousal state and slower but more controlled motor responses (Acharya & Morris, 2014), as evidenced by the fact that slower response times were offset by increased accuracy in every case, as can be seen in Figure 28:

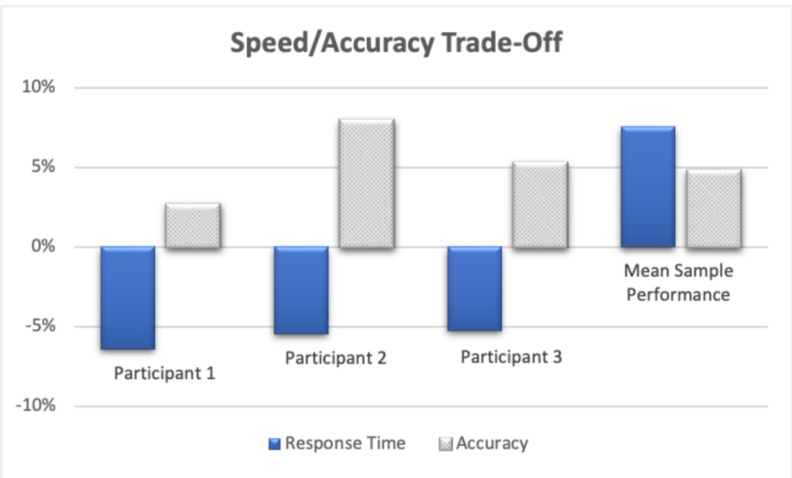


**FIGURE 28:** *Individual Differences in Results (Response Time/Accuracy)*

ERROR LEARNING. Another interesting finding on an individual level, was repeated errors, as has also been observed in Hebb learning (Couture et al., 2008; Lafond et al., 2010). As could be expected from the random nature of the non-repeated material, errors were also random, with no discernible pattern or frequency. However, in some cases in the repeated material, once a participant was committed to an error, they would repeat that error in every subsequent trial. This could be argued to be more evidence of implicit learning, albeit in an undesirable way, but it does pose important questions for the future development of material and methods incorporating incidental acquisition for students, and how teachers apply these for increased accuracy, as we know that, in this case, practice does not always make perfect, since errors can be practised too.

SEQUENCE-REPETITION AWARENESS. A final individual insight would of course have to be those participants that showed part or full sequence-repetition awareness, becoming independently conscious of the repeated material, either over the course of the trials, or after the fact. By comparing the sample with and without these participants, firstly without the three individuals who were deemed to have become aware of specific sequence repetition, and secondly without any individuals who suspected repeated material to any given level, the results displayed the same pattern as for the full complement in both cases. This indicates that the same learning gradient was still evident (although incidentally acquired rather than implicitly), independent of awareness, and likely not altered by it. Therefore, unless the subject is explicitly informed of the repeated material and the expectation of improved performance before commencing the task, there is no reason why the implicit/incidental distinction should preclude a learner from any performance gains obtained in the process of skill acquisition.

A possible way to test this hypothesis would be to repeat the experiment with as many trial blocks as necessary for every participant to become aware of the repeated sequence, as it is believed they would, due to the repetitive musical qualities in the auditory modality, the repetition of the visual material, the repeated motor movements on musical instruments that participants are closely familiar with, or all of the above. Continuing the trials past the point of awareness in all participants can potentially demonstrate whether the nature and amplitude of improvement is in any way affected by awareness or not (Musfeld et al., 2022).

## *FUTURE RESEARCH*

As far as future research in this area is concerned, there are additional arguments for repeating the same experiment with refined parameters other than examining the effect of sequence-repetition awareness, such as controlling for cognitive load, i.e. the same number of notes per segment, or indeed comparing repeated sequences of varying load to test the preliminary findings mentioned above, regarding implicit musical learning being resistant to higher load.

It could also possibly be useful to recruit a sample of the same skill level, since the data of the learners in this sample may have skewed results and necessitated a different approach to statistical analysis. These participants, despite having the required Grade 6 level in sight-reading, in general took much longer to complete each trial, showed a reduced ability to apply a consistent tempo, and often felt compelled to stop and correct mistakes, despite being instructed not to. It is noteworthy that the ability to continue playing regardless of errors, as can be seen in highly skilled musicians, is a direct result of experience in orchestral or ensemble playing. In such settings, the group will not stop to allow any individual to correct their playing, and the skill of uninterrupted performance thus becomes inevitable. On the other hand, due to the lower skill participants' reduced ability to apply a consistent tempo, it could be seen that they reaped a greater benefit from the implicit acquisition of the repeated material, as it improved not only their response time and accuracy to a greater extent than seen in the highly skilled cohort, as can be seen in Figure 29, when the learning gradients for both measures (response time and accuracy) are averaged, but their application of consistent tempo also improved for the repeated material at least, if not overall.

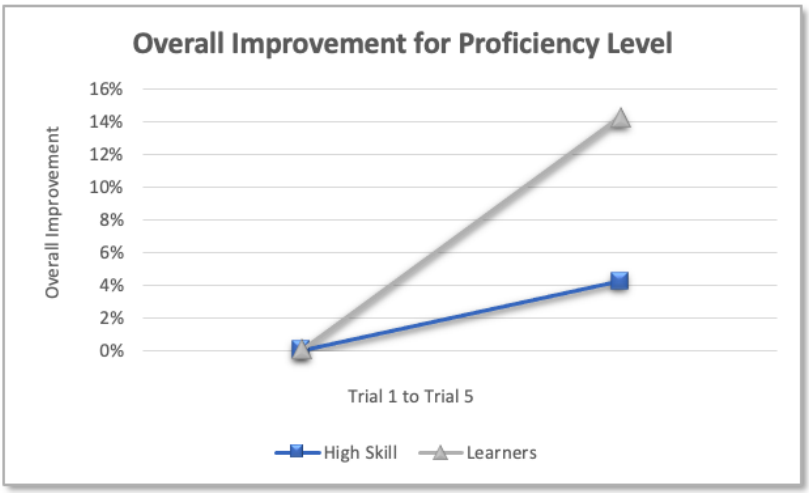


**FIGURE 29:** *Performance Gains per Skill Level*

This is an encouraging sign for possible future applications in pedagogy, as the learning environment seems the most receptive to the measurable effects.

If, for any of these mentioned reasons, a repeat of this experiment was to be undertaken, it would be advantageous to have a larger number of trials, to obtain more data and possibly additional insights. Despite the assertion in the design phase that five trials would likely be sufficient, and despite successfully obtaining the anticipated evidence of significant learning, it could be seen from a linear projection of the original mean data, without having to correct for cognitive load (Fig. 24), that conducting more trials could have provided stronger and qualitatively different results, if we consider questions like the threshold of improvement for the repeated material, and conflicting findings of skill deterioration for the non-repeating material, that could not be seen in the response time gradient over five trials (Fig. 30).

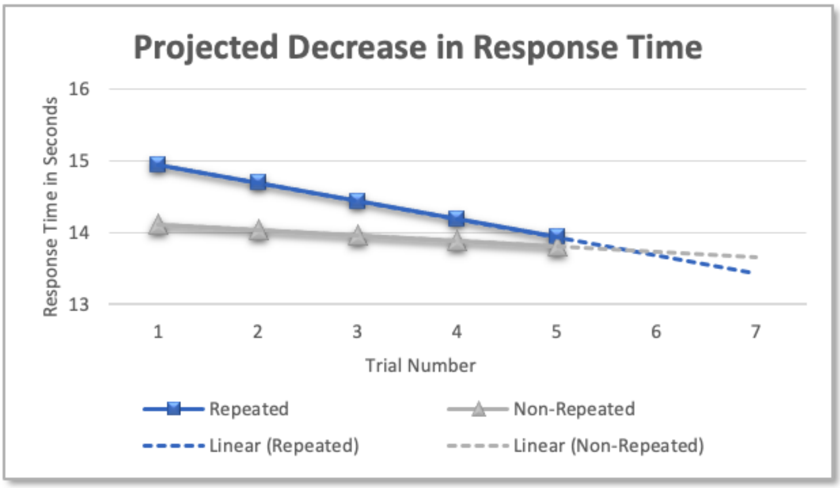


**FIGURE 30:** *Projection of Results with Increased Number of Trials*

VARIATIONS. To strengthen the evidence for implicit learning, participants could be required to make note predictions within the repeated sequence, or to perform retention tests after a predetermined time interval. The issue of participant fatigue could be addressed by presenting a higher number of trials in separate trial blocks, with rest periods in between, and the higher risk of sequence-repetition recognition could be mitigated by considering alternative sequence designs. For instance, it does not have to be presented as one distinct line of music but could be offset by starting in the middle or near the end of one line and continuing in the next, as long as the overall segment lengths are equal. Further modifications to the repeated sequence for increased obscurity from a musical perspective might also be considered.

Variations on the experiment may include the introduction of distractions, such as flashing a coloured dot on the screen or presenting an incongruous sound at different intervals, to examine the robustness of implicit learning in the face of distraction (Lavie, 2005; Vékony et al., 2020). The findings regarding increased cognitive load might also be tested further by adding a concurrent task, although this would be a challenging design considering the level of engagement necessary for sight-reading music on an instrument.

STRESS. One possible avenue for future exploration is the reliability of implicitly acquired musical knowledge and skill under stress conditions. Studies have shown that the stress of perceived public or social evaluation results in a deterioration of motor skill (R. Masters, 1992; Yoshie et al., 2016), which is concerning when one considers the already high prevalence of music performance anxiety (MPA), colloquially known as “stage fright”, amongst music students and professional musicians alike (Kenny, 2011). However, studies have also demonstrated that implicit learning is particularly resilient to stress conditions, not only in relation to social evaluation, but also in the presence of other stressors like financial incentive and time constraints (Lam et al., 2009; Masters et al., 2008). These benefits may have key implications for music if they can be transferred.

Of the 31 participants, only two displayed positive or neutral attitudes towards sight reading as a musical skill. The remaining participants all conveyed varying degrees of aversion, stress, and anxiety over the fact that the experiment involved a sight-reading task. One participant, an accomplished professional orchestral musician, even expressed fear, and confessed that they only agreed to take part out of curiosity and because they knew there would be no audience to judge them. This is remarkable when considering the importance and universality of this skill for classical musical learning and performance, as was explained in the reasons for choosing it as a skill to be tested in this experiment in the first place. As was indicated, students are expected to perform sight-reading as part of their graded music evaluations globally, but even more than this, professional classical musicians are required to sight-read on a regular basis at work, for example in the first orchestral rehearsal of new musical works, or when recording newly composed music in studio. It is of great concern, then, that such a necessary and unavoidable skill should be the cause of so much stress.

There are different approaches that could be taken when investigating the resilience of implicit learning to stress in a musical context. The stress already present in the sight-reading experiment could be continuously monitored through physiological measures such as heart rate variability and galvanised skin response (GSR), which are the current accepted standards for stress monitoring in MPA (Thurber et al., 2010; Williamon et al., 2014). Levels could then be compared to discover whether there are any significant differences between the repeated and non-repeated material, as well as under aware and implicit conditions. Considering the available array of wearable devices (Kim et al., 2020), this may be the most unobtrusive way of stress monitoring. Another approach may be to induce additional stress and compare the deterioration of performance in both repeated and non-repeated conditions. For the online version of the experiment, the virtual meeting could be joined by more people, even if these are dummy accounts with no real human presence, simulating the perception of social evaluation. Other options include using virtual performance environments, such as the performance simulator at the Royal College of Music (RCM, 2022), or even hiring real people to act as an audition panel. It has to be noted, however, that the typical musician who would volunteer for such an experiment would probably not be one to experience the most stress in either sight-reading or evaluation, but finding meaningful results with such participants will hypothetically produce similar or increased results with a more stress-prone sample.

Related to this discussion is the possibility of implicit learning applications to reduce the level of stress around sight-reading as a skill in the acquisition phase, rather than addressing it after the fact. Although the overarching aims of this experiment was to demonstrate implicit learning of musical material, identify possible benefits of implicit learning in a music-specific context, and make the case for the transferability of findings in related experiments, the potential for specific application of implicit learning for sight-reading cannot be ignored. In a simple conceptualisation of such an application, when we teach sight-reading to our students, identified musical elements that are commonly recurrent in the standard test material could be embedded in the practice material. In this way we can be fairly certain that, when these elements are encountered in future, the mechanism of prior implicit learning will result in faster processing speed and increased accuracy.

## THE BENEFIT OF IMPLICIT LEARNING FOR MUSIC

The present experiment demonstrated a marked improvement in both response time and accuracy for the repeated sequence in the sight-reading material, beyond any general practice effect or task familiarity effects. One could ask what the difference would be between learning a line of music through deliberate (aware) repetition, and learning it in the way participants did here, in other words, how was this beneficial? The most important distinction in answering this question, is that sight-reading is not a learning task, but an immediate motor response to the visual stimuli presented in the notation, especially in this format, where no time was allowed for visual pre-scanning or silent practice. From extensive experience, it can be confidently stated that any highly skilled musician who deliberately attempted to learn the middle line of these samples, would have done so with relative ease, and would have been able to reproduce it at a later time without the notation. However, they did not “learn” it in the musically accepted sense of the term. The vast majority of the sample had no awareness that there was even any repeated material that could be “learnt”, let alone reproduce it. Yet, they still demonstrated faster response times and increased accuracy of the musical skill of sight-reading, and therein lies the significance.

To explain further, consider the discussion in Chapter 3 of how teachers may facilitate the incidental acquisition of the various complex biomechanical steps of a musical motor skill through the appropriate application of a single metaphor, as has also been seen in the implicit, errorless learning of a motor skill in sport, such as golf putting (Maxwell et al., 2001). Skill automation, and the accompanying reliability and robustness, is achieved much sooner than through the countless hours of rote repetition and skill practice traditionally needed. This experiment provided empirical evidence of that fact, where the advantages of deliberate practice were observed, but without the deliberate practice.

Specifically observed benefits, as discussed here, were that faster response time translated to faster processing speed of musical notation, regardless of the cognitive load, which aided in improved motor control, as seen in the enhanced ability to apply a consistent tempo. The increased accuracy of performed notes and rhythms is a benefit in and of itself, but added to this, both faster response time and increased accuracy seemed resistant to mental fatigue and task difficulty, as the decline that was evident in the non-repeated material, could not be detected in the repeated condition. Also of interest, is that these advantages were observed in both that part of the sample that showed no awareness of sequence repetition, i.e., the "implicit" group, as well as in those that became aware, i.e. the "incidental" group, confirming the earlier conjecture that the incidental/implicit distinction is of secondary importance when it comes to the inherent benefits of the process of learning.

In conclusion, it would seem that the aforementioned objectives of the experiment were adequately addressed. It was clear that implicit learning occurred for musical material, as evidenced by the significant improvements in both response time and accuracy for the repeated condition. This provides strong motivation for the transferability of findings from other implicit learning experiments, or at the very least, for replicating further experiments in the paradigm for music, and establishing the called-for cross-cultural validity between music and the cognitive sciences (Rohrmeier & Rebuschat, 2012).

The challenge now is to determine whether these findings, that were for all intents and purposes obtained under "lab" conditions, have any real-life validity and applicability. In the next chapter, such an application will be conceptualised and tested under everyday teaching conditions, to discover the viability of further such developments.

⌘

# CHAPTER 5: FROM THEORY TO PRACTICE

Through the observation of everyday instrumental lessons and surveying teachers about their use of methods that may facilitate incidental learning for students, it was demonstrated in Chapter 3 that incidental, and implicit, learning processes are widespread and occur frequently in various aspects of music instruction. However, it remained unclear how such naturally occurring and utilised processes could be deliberately induced in order to deliver a specific and intended outcome. In Chapter 4, an experiment under controlled conditions showed that these learning processes and their benefits can be identified and measured in a musical context. As promising as this may be, such conditions are artificial and do not resemble a normal, real-life musical learning environment. For the aims of the present thesis, any positive experimental outcomes would only be of theoretical and academic value if they cannot be transferred into practice. Moving "from the lab into real life" thus becomes the main challenge to the viability of any further research in the area. Investigating whether this can be achieved to any significant extent therefore becomes essential. In this chapter, the results are reported of a study that sought to explore whether incidental or implicit learning could be induced, observed, and measured under natural learning conditions.

In the summer of 2021, a local youth centre required provision of a music programme for children, for two hours per day, over four days, with the following brief:

- Introduce enrolled children to orchestral instruments and basic musical concepts.
- Allow them to experience playing an instrument (even if at the most basic level).
- Deliver enjoyable and engaging activities to promote an ongoing interest in music.

With official permission from the centre management, ethical approval from the Royal Holloway, University of London, as well as parental consent to report the findings here, this programme was chosen to pilot the concept that a set of teaching methods could be designed and applied to achieve discernible and measurable instances of incidental and implicit learning to the benefit of the musical learners. The challenge of this would be to deliver the required enjoyable and engaging programme whilst incorporating research elements, with controlled experimental protocols and measurable outcomes, without affecting the natural learning environment in any adverse way.

The focus in the literature on game-based learning in general, and implicit learning specifically, has been mainly on digital gaming (Ciavarro et al., 2008; Rowe et al., 2017; Schwartz, 2017; Vinter et al., 2022). Some studies have however considered game-based learning from a broader perspective, for its potential to increase learning and facilitate the acquisition of knowledge and skills, including the role of the teacher in achieving this (Taylor et al., 2012), and evaluating the necessary design and implementation aspects of effective instructional games (Garris et al., 2017).

In the music domain, recent interests have also focused on digital gaming, considering the usefulness of existing music video games for educational purposes (Gower & McDowall, 2012; Hein, 2014; Khoo et al., 2008), and the use of advanced technology and serious gaming to improve learning and practice conditions for advanced students (Margoudi et al., 2016). However, there is a considerable body of evidence regarding the nature and prevalence of physical, non-digital musical play, including the oral tradition of singing games (Marsh & Young, 2006). These may include language, music, and movements such as clapping, skipping, ball bouncing, imitation, counting out or elimination, and are typically performed outside of formal learning hours, in pairs, circles or lines. In formal education settings, beginner musicians may be discouraged by the simultaneous challenge of both the cognitive elements of music notes and theory, combined with the motor learning elements of unfamiliar instruments and techniques (Harwood & Marsh, 2012). Introducing musical games such as these mentioned above, may lessen this burden, not only for the learners, but also for the delivery by teachers (Hein, 2014).

Another important benefit of musical games within the formal education setting, is the development of empathy and pro-social behaviours, as was discussed in the Motivation and Affect section of the potential benefits of implicit musical learning in Chapter 2. Rabinowitch et al. (2013) tested this concept by engaging children in long-term musical group interaction. The year-long music programme consisted of musical games that incorporated various embedded empathy-promoting musical components, such as motor resonance, imitation, and entrainment, that may promote empathic concepts such as shared intentionality and intersubjectivity. They found that the children displayed an increase in empathy scores from their pre-programme baseline, as well as higher scores than children from control groups. In the limited scope of the current proof-of-concept study it would not be possible to measure the implicit acquisition of any extra-musical elements beyond basic sequence and visual context learning, but if successful in doing so, it may pave the way for further research incorporating such valuable contributions of musical learning through gameplay.

If we also finally consider, in addition to empathy and cooperation, evidence of other essential skills that children may acquire through music, such as spatial, linguistic, and mathematical capacities (Schellenberg, 2001), or the incidental acquisition of language through music and song (Akbary et al., 2018; Maneshi, 2017; Pavia et al., 2019), we can see the benefit of combining games and music in providing an ideal real-life “lab” for observing the incidental learning of musical elements (and potentially related skills in future research) through gameplay.

# METHOD

## PARTICIPANTS

On day one of the programme, before commencing with the learning sessions, eight of the original twelve enrolled participants arrived at the youth centre. This was an immediate reminder of the challenges of the natural learning environment, and that course content and delivery were the only variables that could be controlled. The sample ($n$ = 8) was thus self-selected and not specifically recruited for the research, consisting of children between the ages of eight and sixteen, previously unknown to the researcher (except for two learners who were existing regular attendees of various term-time youth centre activities). As much relevant information as possible was collected to determine sample characteristics:

- Age (8, 9, 9, 11, 12, 12, 14, 16yrs)
- Previous musical learning experience ($n$ = 2)
- Instrument and level attained (piano, Gr. 3 and Gr. 5)
- Any learning disabilities or medical conditions (dyspraxia, $n$ = 1, autism spectrum disorder, $n$ = 2)

## APPARATUS AND MATERIALS

The instruments belonging to the youth centre were prepared for the musical games by placing blue, red, and green stickers in the positions of the notes the participants would learn (Fig. 31). As a point of interest, it was decided to have the stickers on the violin and cello run across all the strings, even if only the A-string would be used for the required notes. This is in keeping with the teaching principle of learning the position of the hand for all the strings, rather than individual notes on separate strings.


**FIGURE 31:** *Prepared Instruments*

Also, it was planned that the group would perform a song together for their parents at the end of the programme, for which they would need to be able to play new notes on different strings, the learning of which would be greatly facilitated by already knowing the correct position of the hand for all the strings.

Each instrument was marked with a sticker bearing the name of the learner to whom it was allocated, minimising the need for constant cleaning and sanitising (especially in the case of the woodwind instruments), nevertheless, an adequate supply of cleaning materials was always at hand. Apart from these instruments to be allocated to the learners, a small hand drum was also used for providing a beat for any games that would require it.

In addition to instruments, several items to facilitate the explanation and playing of games were used, such as flipcharts, coloured and black markers, and coloured chalk. Paper squares (*post-it notes*) in red, green, blue, and black were used for the sequence prediction tests on the third day, and various sheets of music were used for the visual context learning experiment on the last day. The nature and features of these tests and experiments, and the sheet music used, will be discussed and described in the design and procedure sections below.

## *DESIGN*

Teaching young musical novices in a group setup, without the benefit of individual tuition, to play an instrument that they have never attempted to play before, in eight hours over four days, would be a monumental task under any circumstances. Added to this was the fact that the youth centre does not own enough of any one specific instrument for all enrolled children to receive identical tuition, e.g., a group violin lesson. This presented a further complication in that some of the available instruments were transposing instruments in different musical keys (B-flat clarinet, E-flat alto saxophone, cello in bass clef C, violin in treble clef C)[21]. Considering this, it quickly became clear that the traditional format of instrumental music lessons would not be fit for purpose, and something unique would have to be designed especially for this programme.

The first step was to find a set of notes that would sound the same when played on any of the above instruments and would simultaneously be easy to learn and play on any one of them. After trying out various combinations, the researcher settled on B-flat, C, and D on the violin and cello (concert pitch),[22] which transposed to C, D, and E on the clarinet, and G, A, and B on the alto

[21] Transposing instruments play a different sound than what is written in their notation, e.g. when a clarinet reads and plays its middle C, the sound it produces sounds the same as the B-flat below middle C on the piano, which is why it is called a B-flat clarinet.
[22] Concert pitch refers to the notes audible to the listener, i.e. sounds of the same frequency (with A=440Hz usually) even though the written note to produce the same frequency may differ between instrumental notation in the printed parts (see transposing instruments above).

saxophone. This unfortunately provided a possible source of confusion for the learners, with the same "sounds" having different note names on the different instruments. For this reason, it was decided to rename the three notes on every instrument as colours (blue, red, and green, respectively, in each case), which would then be the same for every instrument (Fig. 32). It was also decided that musical rests, where needed, would be represented by the colour black. The instruments were then prepared for ease of learning the given notes, as described in "Apparatus and Materials" above (Fig. 31).

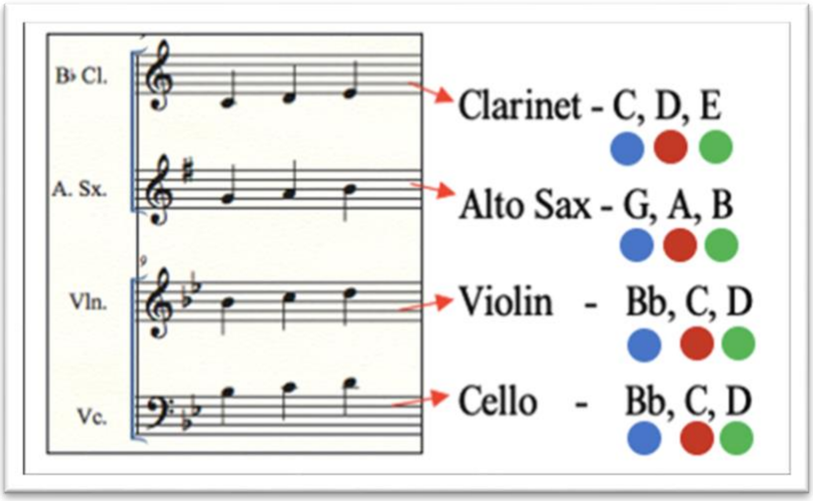


**FIGURE 32:** *Notes as Corresponding Colours*

After determining the distinct pitch of the notes to be learnt, the next question was how to present the different note durations, seeing as traditional notation, where the different note lengths are indicated by the shape of the notes and rests, would not be used. It was decided to simply use numbers to represent the number of counts each sound or rest would last for, presented in the colour of the note (or rest) to be played (Fig. 33).

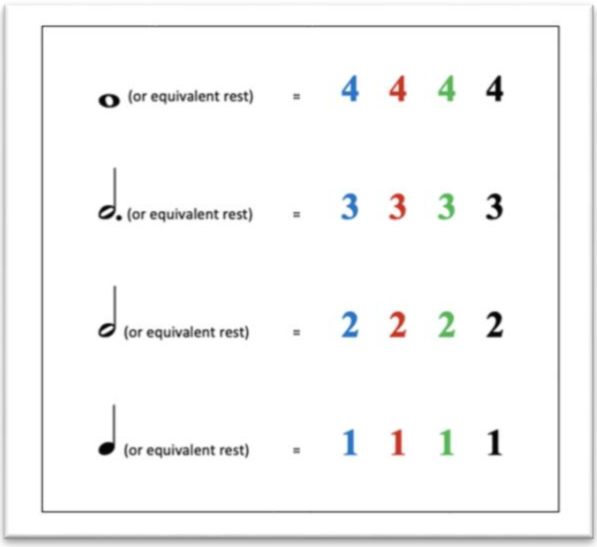


**FIGURE 33:** *Representation of Note Duration*

With the variations in pitch and duration decided, these had to be presented in a way that would facilitate incidental learning, to a clearly observable and measurable level. Due to the unpredictable nature of the real-life learning environment, two separate methods of assessment were incorporated in case of unforeseen circumstances and variables outside of the researcher's control. Simply, this would be a once-off opportunity that could not be rescheduled or repeated if something did not go as planned. Therefore, if anything interfered with the learning, test, or measurement in one condition, there would still be another to fall back on. To this end, two existing implicit learning paradigms were chosen on which to scaffold the design of the experimental protocol for the study, namely implicit sequence learning, and visual (spatial) context learning. These were specifically chosen for their relative simplicity, and for the potential for the generic application of their basic elements to any other specialised context.

**IMPLICIT SEQUENCE LEARNING.** For the first incidental learning assessment, a hidden musical sequence would be embedded within the musical learning games and activities. The learning of the sequence would then be tested through a prediction task, and a set of questions would be asked to gauge whether any of the participants had become explicitly aware of the sequence during the games or test. Although only of secondary and theoretical interest, this might indicate whether the learning was implicit, and would add a fun "guessing game" to the programme. Verbal confirmation of awareness, or the lack thereof, is argued to be one of the most appropriate measures of explicit knowledge of a hidden sequence (Rünger & Frensch, 2010). As an added measure, a free-generation task was included in the case of positive awareness responses (Schwarb & Schumacher, 2012), i.e. any participant who indicated that they thought there was a repeating phrase would be asked if they could sing or play that phrase, or any part thereof. This could indicate, especially in the case of young learners, who may not be entirely truthful when they are trying to impress their peers or teachers, what the extent of sequence awareness might be.

With the selected learning material (pitch and duration), it would be possible to use four variations in pitch and silence (rests) multiplied by four different durations, with a resultant maximum of sixteen possible items in the sequence. However, accurate learning of duration would be dependent on each attempt at the sequence being played at a consistent tempo, which would complicate the execution of this part of the study, as well as limit the scope of games that could be played for sequence exposure. It was therefore decided to only use the pitch distinctions, as indicated by the colours blue, red, green, and black, but not the numbers indicating the durations.

Traditionally there have been three identifiable types of sequences used for implicit learning experiments (Cohen et al., 1990):

- Unique, where each item can be reliably determined by its relation to the previous item (e.g. ADBCADBC, where A is always followed by D, is always followed by B, etc.),
- Ambiguous, where the appearance of an item provides no information about the following item, and
- Hybrid, which, as the name implies, is a combination of the first two.

Although there has been a lot of debate over the last few decades as to the structure and characteristics of different sequence types, and how they affect the learning task, the consensus seems to be that a unique sequence is easier to learn and needs less focused attention for implicit acquisition to take place (Stadler & Frensch, 1998).

Given the limited time available for sequence exposure, and the young age of the participants, it was decided to create a unique sequence in accordance with the above information. However, when played on an instrument, it became apparent that any unique sequence resulted in a repeating and memorable melodic phrase, with a risk of explicit sequence memorisation due to its musicality and auditory repetition, as was explained in Chapter 4 in the design of the sequence for the controlled experiment conducted previously. Some adjustment and modification led to the creation of a sequence that did not completely fit within any of the definitions, but it was hoped to be both easy enough to learn and obscure enough not to be noticed or memorised. If the note colours blue, red, green, and black were represented as A, B, C, and D, respectively, the eight-item sequence BDCACDBA would form a palindromic loop (connected by a singular A), in other words, it could be played backwards or forwards and would seem continuous either way. This would make it quite suitable for musical games, and flexible enough to be applied in various different guises throughout the material presented to the participants. Also, in keeping with traditional sequence requirements, every item would appear twice, but never consecutively.

VISUAL CONTEXT LEARNING. The Cleeremans Connectionist Model (1993) seeks to explain how we implicitly acquire information from the learning environment and use such information to inform behaviours and decisions, as well as effecting successful learning outcomes, with many studies manipulating the visual and spatial context of learning to measure the extent and nature of such learning. To my knowledge, no music-specific studies have attempted similar manipulation of the visual context to measure the resultant learning, despite the importance and natural occurrence of visual context learning directly impacting performance elements and memorisation of music. It was therefore decided to attempt such a study, manipulating the visual context of the learning material, as the second assessment of incidental learning in this programme. The learned elements of pitch and duration (colours and numbers), that the participants would have learnt through initial games and activities, would then be presented within a previously unknown visual context of traditional music notation, since none of the participants would previously have seen notation for the instruments they would learn, if any at all. No instruction or information would be provided about the novel elements in the learning material. After sufficient exposure, a test would be run to see the extent of acquisition of previously unknown information from that visual context.

All of the elements of this study design as discussed here, would be presented as fun and engaging games and activities, the nature of which will be described within the next section reporting on the procedure of the programme as it happened over the four-day period.

## *PROCEDURE*

The first activity was to allow each learner to try out every instrument available, in order to find a "good fit". Learning a new instrument will always be facilitated by choosing one for which there is a natural aptitude, and where the physical intricacies of holding the instrument properly or producing a clear sound do not become the overwhelming focus of learning. This resulted in a collection of chosen instruments consisting of two cellos, one alto saxophone, two clarinets, and three violins. The participants were then divided into three groups according to their chosen instrument, with the researcher and two assistants each teaching the woodwind-, cello-, and violin players respectively, to hold the instrument, produce a clear sound, and play the three coloured notes as indicated by the stickers on the instruments. When sufficient attainment of this had been achieved, they were reconvened as one group, ready for the first learning session to start.

SESSION ONE. The sole purpose of the first learning session was for the participants to become comfortable with their new instruments and gain familiarity with the new coloured notes they had learned to produce. Several games were played in group context to achieve this goal:

- Basic Musical Concepts

  The group was introduced to the musical elements of dynamics, tempo, duration, articulation, rests, and expression through simple instructions such as *"play your blue note for as long as possible; play lots of short green notes; when I say black, keep perfectly still and be as quiet as a mouse; play the red note as loud/soft as you can; play the blue note as if you're very happy/sad/angry",* etc.

- "Pass the Ball"

  The group was arranged in two opposing lines, with the goal of passing musical notes between each other. One player would start by playing a note of their choice, the next player across would then respond. The rules were as follows:
  - Responding with a different note – pass the ball to the next player
  - Responding with the same note – pass the ball back to the previous player
  - Responding with a rest (silence) – the next player skips a turn

- "Conductor Says…"

  This game proved to be extremely popular and would be requested as a warm-up game in every subsequent session. It basically followed the same rules as "Simon Says", but with a musical twist, i.e. "play whichever note(s) in whichever way the conductor says, and *only* when the conductor says, or you're out", until only one player would be left.

SESSION TWO. On the second day, the purpose was to introduce the group to the concept of specific duration, rather than just "long" or "short". The research team demonstrated how notes could be played for a specific number of beats, to a steady tempo provided by a hand drum. Examples were then written on a flip chart, incorporating numbers for the number of beats (1,2,3, and 4) in coloured markers to represent the colour note or rest to be played (blue, red, green, and black), as previously demonstrated (Fig. 33). After ensuring that everyone understood the principle, it was then applied in various games:

- "Route March"

  Big, coloured numbers were drawn in chalk all over the floor of the youth centre sports hall, with arrows pointing from one to the next. Participants were then tasked to follow the route one by one (each starting as the previous player reached the next number) and play the correct colour for the correct number of "steps" whenever they landed on a number, before following the arrow to the next number. A comfortable walking pace tempo was again provided by the hand drum. It was intended that this combination of duration with movement would provide an embodiment of rhythm and tempo, much like Dalcroze Eurhythmics, which teaches embodied musical knowledge through movement (Juntunen & Hyvönen, 2004), rather than it remaining an intellectual concept of counting alone.

- "Musical Race"

  Two parallel lines of chalk numbers were drawn on the floor, seemingly of the same length, with an equal number of items per line (Fig. 34).

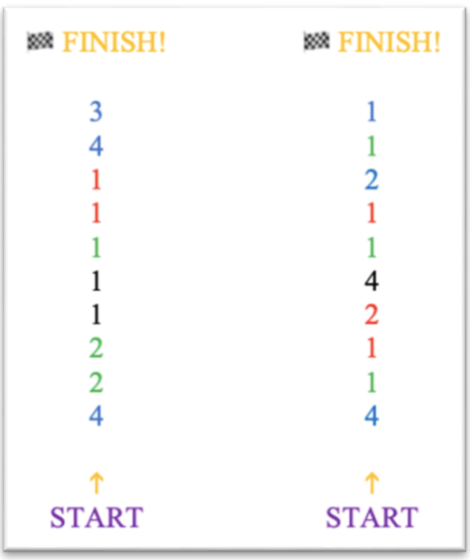


**FIGURE 34:** *Plotted Course of "Race" Game*

Unbeknownst to the participants, one line contained 20 beats, while the other had only 18. The group was divided into two, one group at each line, and tasked to race each other from start to finish. The rules stated that they had to play the correct number of beats, and could not do so faster than the provided drum tempo. After the first round, the two groups switched lines and raced again. They were then collectively asked to work out why the team at the left-side line would always win. The object of this game was to further consolidate the colour-duration association in a fun and engaging way.

- Canon Playing[23]

One line of coloured numbers was again drawn on the floor, according to the following simple composed melody, but presented as coloured numbers as before (Fig. 35 & 36).

**FIGURE 35:** *Composed Phrase for Canon (clarinet part as example)*


**FIGURE 36:** *Composed Phrase Represented as Coloured Numbers (all instruments)*

One player would start walking and playing the phrase, accompanied by the drum, and when the number indicated by the asterisk was reached, the next player would start. When a player reached the end of the phrase they would have to return and join the back of the line again, for a continuous canon to be played. The aim of this game was to further consolidate the colour-number association, but also to develop general musicianship and listening skills, introducing participants to the idea that the numbers and colours were not just abstract noises arranged in time, but could be used as coherent sounds to make music.

SESSION THREE. By the start of the third session, it was determined that the group had gained sufficient command over the skills learned, and a good enough understanding of the application of the colours and numbers for the first measurable research, being implicit sequence learning, to be conducted. It would however first be necessary to obtain a baseline score for the participants' accuracy in sequence prediction. To this end, each participant was given four small, coloured squares of paper in blue, red, green, and black. They were then instructed to listen to a sequence of notes and guess which note (or rest) they think would be played next, indicated by

[23] A canon in its most basic form is a type of musical composition, where a melody is played/sung by one person/instrument, and then exactly imitated after a specified time interval by another. This often happens four times in succession, but any number of voices or imitations are possible, and the first voice usually starts again when it reaches its end, allowing for a perpetual round of the same melody.

holding up the corresponding-coloured paper square. The results would be independently tallied by two research assistants for verification purposes, with the process repeated for a total of seven sequences. To arrive at this total, five random sequences were created by associating the colours with the numbers one to four and using a random number generator to produce eight-item strings, containing no consecutively repeated items. For the remaining two, the predetermined experimental coloured-note sequence, as described earlier in the implicit sequence learning design (henceforth referred to as the target sequence), was then also included twice in the baseline test, to ensure that it was relatively homogenous to the random sequences, and that there were no peculiar surface characteristics that would interfere with the learning of the target sequence in either a positive or negative way.[24]

The learners were given no information as to the nature or purpose of this test, other than being told that it was a guessing game, and that the research team was just curious to see how good they were at guessing. They were also told that the game would be repeated later to see if they got any better at guessing during the day. At this point they were asked to pick up their instruments and "warm up with a refresher from the previous day" – coloured numbers written on the flipchart, but secretly in the order of the  target sequence – for their first exposure to it. Subsequently, several games were played using only the target sequence to ensure repeated and adequate exposure:

- "Play the Colour Not the Word"

  This game had only one rule – as the name suggests, to play the colour seen (presented in the order of the target sequence) and not the word written, e.g. whether the chart said RED, BLUE, GREEN, or BLACK (all written in the colour red), they would have to play a red note, with the same going for any of the other colours. Anyone playing a wrong note would be "out", until only one person was left.

This game is an example of the Stroop effect (Stroop, 1935), which describes the tendency to struggle with naming a presented colour when it is used to spell the name of a different colour. A Stroop test would thus evaluate a subject's ability to process one surface feature of a stimulus in the simultaneous presence of another incongruent or interfering surface feature (for an overview, see MacLeod, 1991). In the context of the present study, it was chosen as a challenging but enjoyable game, which would occupy the participants' attention while they were being repeatedly exposed to the implicit target sequence.

[24] Both iterations of the target sequence happened to be exactly equal to the baseline mean, as will be discussed later in the data analysis.

- "Who Can Go the Fastest?"

  In this game, the researcher would call out the colours in target sequence order, each to be played by the entire group. For the first round, each note would be held for four counts, also called out by the researcher, at a relatively slow and relaxed pace. For the second round, each note was still held for four counts, but at a faster pace. For each subsequent round, the number of counts would be reduced by one – three counts per note for the third round, two counts per note for the next, and one for the next. Finally, the pace was increased for every round, with each note played for only one count, until it would become too fast for anyone to play – to the amusement of all those present.

Unfortunately, this game was interrupted by parents requiring their child's presence elsewhere. The child in question requested to play the guessing game once more before they left, which led to the decision to run the target sequence learning test, despite concern that an adequate level of implicit exposure may not yet have been reached. A repeat of the morning's prediction test was run, but this time using five iterations of the target sequence, with two random sequences in between to reduce the likelihood of explicit repeated sequence recognition.

SESSION FOUR. On the morning of the last day, it was decided to run a salvage attempt on the sequence learning experiment by running one more round of target sequence exposure games, and repeating the test once more, before commencing with the planned programme for the final session. This was an exact repeat of one round each of "Play the Colour Not the Word" and "Who Can Go the Fastest?", as well as the same sequence learning test, containing five iterations of the target sequence, interspersed with two random sequences. After doing so, the participants were asked post-measure questions to determine the level of explicit awareness of the repeated sequence, if any. After this, session four began in earnest, focusing on the second incidental learning measure, namely visual (spatial) context learning. As a baseline score for this experiment, a short, composed phrase was placed in front of each participant (Fig. 37). They were then asked if they thought they might be able to play, or would like to guess, what was on the page.

**FIGURE 37:** *Composed Phrase for Visual Context Experiment (violin part as example)*

As expected, the two participants with previous musical learning experience both easily recognised standard sheet music, and were quite willing to attempt playing the presented phrase. The other participants, who by their own accounts had never seen music notation before, except perhaps in a passing manner, such as in a class music setting at school, were very reluctant to play the phrase. With gentle reassurance that there would be no judgement, and telling them that it would be very interesting to see what they thought the symbols on the page meant, all except one did make an effort to play the phrase in some way. The results of this baseline test will be discussed below.

After a short break and a warm-up game of "Conductor Says" for distraction, the participants were then presented with the (by now well-known) colours and numbers, on a field (visual context) of traditional notation (Fig. 38).


**FIGURE 38:** *Colours and Numbers as Traditional Notation 1 (alto sax part as example)*

The group was given no information or explicit instruction as to the shapes or placement of the colours and its relation to the numbers. In fact, they were instructed not to concern themselves with any of the "new things" on the page, as it was just made that way to look neat and "pretty", and all they needed to remember was their colours and numbers, and to "just play what you see". They were then presented with several similar four-bar phrases to play together, starting from the very simple phrase above, and gradually becoming more varied in pitch and duration, up to the final phrase as seen here (Fig. 39).


**FIGURE 39:** *Colours and Numbers as Traditional Notation 2 (cello part as example)*

When it seemed clear that the group in general was comfortable with playing the colours and numbers even when presented in this format, the black-and-white traditional notation from earlier that day (Fig. 37) was placed in front of them again. It was striking to witness the sudden comprehension on most of the learners' faces when they realised that they now understood what the symbols on the page meant. When asked again if they would like to play or guess the phrase, this time, every single participant felt confident in attempting to play it, and did so. The results of this test will also be discussed below, and the before-and-after attainment scores will be compared for statistical significance.

For the final half an hour of the last session, the group divided into instrumental sections again, where each instrument group was taught two new additional notes, using the known colour-notes as reference points, and adding these to the sheet music for the children's song "Mary Had a Little Lamb". Utilising a combination of colours, numbers, and their incidentally acquired notation reading skills, the learners were then able to perform this song in four-part harmony, in ensemble, in a concert performance for their parents. The fact that they could do so after a mere total of eight hours of group tuition on new instruments, with no previous music education (for the most), is a testament to the power of the incidental learning processes undergone, as accessed through engaging games and activities in this case, rather than traditional explicit instruction.

## RESULTS

Before reporting the results of the two incidental learning assessments, in the wider debate about the importance of the provision of music education for children with special educational needs, as well as the previous mention of the potential of implicit learning benefits for this area, it is important to discuss the learning outcomes of the participants that were identified with learning disabilities at the beginning of the programme. Special consent for discussing these details here was obtained from the parents of the relevant participants.

Firstly, the child with dyspraxia had difficulties with the movement games, as could be expected.[25] However, they had no trouble with the fine motor co-ordination necessary for holding an instrument and producing a sound. With some minimal assistance on some of the movement games, they ultimately achieved a normal rate of learning as compared to the group average.

Of the two participants on the autism spectrum, one child presented with fluctuations between extremes of distraction and hyperfocus. It is believed that with dedicated individual attention this learner could attain the same level of musical skill acquisition as any of the others. However, in the group learning context necessitated by this programme, it was unfortunately impossible for them to maintain focused attention on the task at hand, as they would become fixated on physical objects such as the instrument, music stand, or chair. As an example, with the sequence learning test, the object of fixation was the coloured paper squares used for prediction, and one or

[25] Dyspraxia, also known as developmental co-ordination disorder (DCD), a neurological condition affecting physical co-ordination, delaying developmental milestones, and causing children to appear clumsy and perform less well in daily activities than others their age.

several would be held in the air before the playing of a sequence had finished, or sometimes even before the next sequence had started. These could hardly be classified as responses, let alone be admissible in any credible research. Although the learner seemed to enjoy the activities and learned enough to take part in the performance for the parents, no usable data could be collected from them, or included in the analysis, under the circumstances.

In the final case, also a learner with ASD, they initially struggled to produce the specific notes on the clarinet, which was identified as the instrument they could most easily produce a basic sound on. It seemed that the hand position necessary for closing the finger holes properly was problematic, with either the thumb slipping off the back, or the front three fingers moving out of place. A solution was quickly found by plugging the thumb hole at the back of the clarinet, allowing for the learner to concentrate on the front fingers alone and produce the notes as required. After this, a normal rate of learning was attained as compared to the group average. This is of particular interest, as it has been suggested that musical potential is often overlooked in children with learning disabilities, and specifically autism, unless savant-like talent surfaces naturally (Heaton, 2009). Furthermore, this is in keeping with recent findings that musical prediction abilities remain intact in individuals with ASD, even when other prediction faculties are impaired (Zhao et al.). The results of the two participants who attained skill acquisition in line with the group means were included in the data analysis, ($n$ = 7), which will be discussed here.

## *IMPLICIT SEQUENCE LEARNING*

On the third day, a baseline test was conducted to determine the participants' ability to predict items in novel, unfamiliar sequences. This was followed by games and activities that would expose them to the repeated target sequence, after which the prediction test was conducted again, once on day 3 and again on day 4. Differences between the two conditions were analysed, according to the scores as recorded in Tables 7, 8, and 9:

**TABLE 7:** *Sequence Prediction Test 1 - Baseline Score*

| Participant No. | Random Sequence Trial No. | | | | | | | Total Correct/Participant |
|---|---|---|---|---|---|---|---|---|
| | RS1 | RS2 | RS3 | RS4 | RS5 | RS6 | RS7 | |
| 1 | X | √ | X | X | X | √ | X | 2 |
| 2 | X | X | X | X | X | X | X | 0 |
| 3 | √ | X | X | X | X | X | X | 1 |
| 4 | X | X | X | X | √ | √ | X | 2 |
| 5 | X | X | X | X | X | X | √ | 1 |
| 6 | X | X | X | X | X | X | X | 0 |
| 7 | X | X | √ | X | X | X | X | 1 |
| Total Correct/Trial | 1 | 1 | 1 | 0 | 1 | 2 | 1 | 7 |

**TABLE 8:** *Sequence Prediction Test 2 - Learning (first attempt)*

| Participant No. | Proper Sequence Trial No. | | | | | | | Total Correct/Participant |
|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | |
| 1 | √ | X | X | X | √ | X | X | 2 |
| 2 | √ | X | X | X | √ | X | X | 2 |
| 3 | X | X | X | √ | X | X | X | 1 |
| 4 | √ | X | X | √ | X | X | X | 2 |
| 5 | X | X | X | X | √ | X | X | 1 |
| 6 | X | X | √ | X | X | X | X | 1 |
| 7 | X | √ | X | X | X | X | X | 1 |
| Total Correct/Trial | 3 | 1 | 1 | 2 | 3 | 0 | 0 | 10 |

**TABLE 9:** *Sequence Prediction Test 3 - Learning (second attempt)*

| Participant No. | Proper Sequence Trial No. | | | | | | | Total Correct/Participant |
|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | |
| 1 | X | √ | X | √ | √ | X | X | 3 |
| 2 | √ | X | X | X | √ | X | X | 2 |
| 3 | X | X | X | X | √ | √ | X | 2 |
| 4 | X | X | √ | X | X | X | X | 1 |
| 5 | X | X | X | X | X | √ | X | 1 |
| 6 | X | X | X | X | X | √ | X | 1 |
| 7 | X | X | √ | X | X | X | X | 1 |
| Total Correct/Trial | 1 | 1 | 2 | 1 | 3 | 3 | 0 | 11 |

Regarding the inclusion of the target sequence in the baseline test for the implicit sequence learning assessment, it is important to note that at this stage any sequence, whether specifically chosen or randomly generated, would be novel for the participants, having had no previous exposure to it. The only thing that could affect the performance at this point would be if there was something peculiar about the nature or structure of a sequence that made it somehow easier to predict, which is why the target sequence was included in the first place, to check for any such irregularities. It was also considered whether any elements from the random sequences were similar to the target sequence, to the extent of possibly causing interference with learning. However, no significant overlap between any sequence elements, random or otherwise, was found. With large sample sizes and high numbers of trials, additional analysis may have been required, but with seven participants and seven trials it was immediately visible that the performance score on the target sequence (RS1 and RS7) was exactly equal to the mean of the performance score on the entire trial block ($\overline{X}$ = 1), with therefore no significant difference between the two. The same goes for the inclusion of random sequences in the learning tests (S2 and S6 in session 3, and S1 and S4 in session 4), seeing as the aim was to measure the overall improvement of prediction accuracy from the baseline test ($\overline{X}$ = 14.3%) to the learning tests ($\overline{X}$ = 22.5%), and not between single trials.

With such a small sample size, one would normally not expect to run parametric tests for any meaningful results. However, there was an interest in the direction of the effect for the potential prediction of a learning trend. Individual scores were therefore adjusted to proportion correct, with a normal distribution. A repeated-measure t-test was performed on the data from the first and last tests, with $t(6) = 1.65$, and $p = .143$. It could be argued that with no interruptions, and adequate levels of sequence exposure, the results could have been significant. However, the entire motivation for this study was to demonstrate the viability of incidental learning research in a real-life musical learning environment. Interruptions, time constraints, and many other unforeseen events are to be expected. These challenges cannot be mitigated, removed, or otherwise controlled for, and any desired outcomes need to be achieved despite their presence. Notwithstanding, it was clear that the circumstantial challenges were not as detrimental to the results as was the small sample size. The direction of the effect is in keeping with existing sequence learning studies, and all analyses seem to suggest that significant results would be possible if this study was to be repeated with a larger sample.

As mentioned in the design of the study, of secondary and theoretical interest, was to determine if the learning could be classified as implicit. Children were asked post-measure questions to determine the level of explicit awareness of the repeated sequence, if any. It is worth mentioning that the results from these responses may not be valid beyond any doubt, as they were elicited in group format, with the accompanying risks of peer pressure and conformity, especially with younger participants. Nonetheless, the responses were recorded as follows:

**TABLE 10:** *Post-Measure Sequence Awareness Questionnaire*

| Question | Participant No. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| What did you think of the guessing game? | Fun | Don't Know | Fun | Difficult | Fun | Fun | Don't Know |
| Do you think you got better at guessing from the first game to the last? | Not Sure | Yes | Yes | Maybe | Yes | Yes | Yes |
| If yes, why? | NA | NA | NA | NA | NA | NA | More Confidence |
| Do you think there was something different between the first and last games? | No | No | No | No | No | No | No |
| Do you think I played the same line of music more than once? | No | Yes | No | No | No | No | No |
| Did this happen in both games, or just one? | - | Both | - | - | - | - | - |
| Can you sing the line? Or a bit of it? Would you like to just try? | - | (After thinking for a bit) No, I don't think I remember it | - | - | - | - | - |

*NA = No Answer, - = not applicable*

Based on these responses it was judged to be unlikely that any explicit sequence awareness had occurred. The majority showed no awareness of any repeated material, and the one learner who thought they might have heard the same phrase more than once across both the baseline and final tests, despite not being timid and being eager to show knowledge of the phrase, could not remember what the repeated line sounded like when encouraged to try and sing (or play) it. Although the apparent implicit nature of the learning had no particular significance for the outcome of this assessment, the finding is promising for future research.

## *VISUAL CONTEXT LEARNING*

Of the two participants with previous musical training, with Grade 5 and Grade 3 piano respectively, the learner with the higher attainment was found to apply their existing knowledge of rhythm and melodic progression, to try and "find" the right notes on the saxophone, which they had never played before this programme. However, since they started on the wrong, randomly chosen pitch, every subsequent pitch was therefore also incorrect. Further to this, the considerable effort of trying to play the notes they could clearly audiate but not execute, caused a long hesitation in between every note, thereby rendering the specific note durations incorrect as well.

The Grade 3 piano student started with the correct note durations, but on the wrong string and pitch on the violin, then gave up after a few notes, exclaiming "I don't know where the notes are on this instrument!", and subsequently improvised the rest of the notes, seemingly according to their own imaginary rules, as no further attempts were made to adhere to any up or down movements of pitch, or specific note durations. The other five participants, despite initially being unwilling to even attempt playing any of the notes, were eventually convinced that it would be fun and interesting just to try. However, their utter confusion about what had been presented to them was obvious, as all attempts were "made-up" random noises on the various instruments. For the sake of distinguishing between genuine attempts, however wrong, as in the case of the first participant, and improvised, random sound, it was decided to mark the latter as "no attempt" for the specific pitch and duration of any particular note. Only one participant remained unwilling to attempt playing any of the notes in the baseline test, but did however take part in the learning test. They were given a 0-score for the baseline, in keeping with the majority of the sample. Individual scores for the visual context learning experiment were thus recorded as follows (Table 11 and 12):

**TABLE 11:** *Visual Context Learning – Baseline*

| Participant No. | Individual Note Scores | | | | | | | | | | | | | | | | Total Correct |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Note 1 | | Note 2 | | Note 3 | | Note 4 | | Note 5 | | Note 6 | | Note 7 | | Note 8 | | |
| | P | D | P | D | P | D | P | D | P | D | P | D | P | D | P | D | |
| 1 | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | 0 |
| 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 |
| 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 |
| 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 |
| 6 | X | √ | X | √ | X | √ | - | - | - | - | - | - | - | - | - | - | 3 |
| 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 |

**Key:**
P = pitch D = duration
√ = correct X = incorrect - = no attempt

**TABLE 12:** *Visual Context Learning – Test*

| Participant No. | Individual Note Scores | | | | | | | | | | | | | | | | Total Correct |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Note 1 | | Note 2 | | Note 3 | | Note 4 | | Note 5 | | Note 6 | | Note 7 | | Note 8 | | |
| | P | D | P | D | P | D | P | D | P | D | P | D | P | D | P | D | |
| 1 | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | X | X | X | 13 |
| 2 | √ | X | X | X | X | X | X | X | X | X | X | X | X | X | √ | X | 2 |
| 3 | X | X | X | √ | √ | √ | X | √ | √ | X | √ | √ | √ | √ | X | √ | 10 |
| 4 | √ | X | √ | X | √ | X | √ | √ | √ | √ | √ | √ | √ | √ | √ | X | 12 |
| 5 | X | √ | X | X | X | X | √ | √ | √ | √ | √ | √ | √ | √ | X | √ | 10 |
| 6 | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | 16 |
| 7 | √ | √ | X | X | X | X | X | √ | X | X | X | √ | X | X | √ | √ | 6 |

As before, the individual scores were adjusted to be proportion correct, and have a normal distribution through an arcsine transformation. The subsequent repeated measure t-test results were significant, with $t(6) = 8.33$, and $p < .001$. This is hardly surprising, looking at the scores above, when most participants initially did not even feel capable of attempting the baseline test, and when they did it was mostly random guessing, but every single one managed to score some correct notes in the learning test. As powerful as the effect of the visual context learning may seem, the sample was still very small, and the results are thus reported with modesty and caution. However, as far as the proof-of-concept focus of this chapter is concerned, they are exceedingly positive and promising. At the very least, these results show immense potential for further research in this area, and the protocol used lends itself to modification of the nature, volume, and structure of information, knowledge, and skills that can be incidentally acquired through visual contexts in musical learning.

## DISCUSSION

It has been stated in the introduction to this chapter, as it has been in the wider thesis, that incidental learning processes are innate and organic to musical learning. The theory and experimental findings strongly suggest that these are powerful cognitive learning mechanisms that can be harnessed and applied to the benefit of the learner, but thus far this has been merely hypothesis. Being presented with this opportunity at this time was incredibly fortuitous, as for the first time it could be attempted to take theory into practice.

It was always anticipated that the real-life learning environment would present unique challenges, such as not being able to recruit a homogenous sample according to specific criteria like attainment, ability, and previous experience, or even having the planned number of participants show up for the programme, with little to no scope for rescheduling or repeating any part of the research. However, these and any other unforeseen circumstances can be navigated and managed through careful planning and preparation. The importance of applying experimental findings in the actual environments where their impact may be the greatest, such as in education, should override any difficulties encountered in the research process.

With regards to implicit sequence learning, repeating the study with a larger sample and possibly obtaining significant results, may not only confirm that musical material can be acquired implicitly, but could also demonstrate that the phenomenon can be deliberately induced and employed for specific learning outcomes in real-life teaching contexts. It may also strengthen the argument that has been made in Chapter 4, for the transferability of findings in other types of implicit learning experiments to the everyday context of music instruction.

In the second experiment, the powerful effect of visual context learning was immediately obvious from looking at the data mean, but even more so from the first-hand experience of the participants' reactions to incidentally acquiring a skill that they had previously deemed "impossible" to perform. Nonetheless, even if the indications are there, we cannot see this as conclusive evidence of the usefulness of this method for teaching, as the small sample size would be a limiting factor to any such claims. What this experiment did provide, is the immense potential for exploring the different ways in which the visual context of musical learning might be adapted and manipulated to acquire various types of musical knowledge and skills, and discovering what the nature and extent of such learning might be through future research. The eventual development of teaching applications should ideally be a subsequent initiative.

It is hoped that any such future research will also contribute to the existing scope of learning theory in the field of psychology, and its applications in pedagogy, by adding to the body of research, and providing new insights from a musical context, especially since music forms an equally inherent part of the human social, cultural, and learning experience as does language. The importance of achieving such aims, and the implications they may have for our future understanding of musical and wider learning, will be discussed further in the general findings of the thesis in Chapter 6.

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# CHAPTER 6: EPILOGUE

In the wider context of music pedagogy and its influence on everyday teaching praxis, many contemporary debates and concerns have occupied scholars and teaching professionals alike. Important issues, such as diversity and inclusion, and the reflection of this in modern repertoire, as well as the lack of funding and support for music education, have been front and centre. The original inspiration for this research was rooted in these matters, specifically, in the accessibility of orchestral instruments and music for students from different backgrounds and of different abilities, and in the provision of a music education for all young learners.

In the first instance, it was in the pursuit of alternative ways of teaching than the traditional Western classical school methods, that could be more effective and deliver better outcomes for students, that the phenomena of incidental, and by extension implicit learning, were discovered. In the second, it was put to the researcher that anecdotal evidence of the efficacy of music for the enhanced mental and social development of children would not sway those with authority to provide the necessary funding. Instead, a vast amount of scientific evidence to that effect was needed. The combination of a scientific approach and a pedagogical perspective in examining musical learning evolved into this project, which will be summarised and evaluated here, and with the intention of continuing along this course, possible future avenues of research will be considered.

## SUMMARY

### *LITERATURE REVIEW*

Chapter 1 presented a brief historical overview of incidental learning and its characteristics, starting with its inception as a phenomenon for study in the late 1800's, to the development of seminal learning theories based on this phenomenon. From Dewey's learning from experience (1938), and Lewin's field theory (1951), to the considerable contributions of Leo Postman, spanning several decades. By the 1980's there were Bandura's social learning (1986), Kolb's experiential learning (1984b), and Schön's reflective practice (1983), and modern areas of research that are still concerned with the subject were considered, such as lifelong learning, learning in the workplace, memory and retention, musical enculturation, and the acquisition of language and vocabulary.

After this timeline of incidental learning, the focus turned on implicit learning specifically. The three main paradigms that have constituted the body of work in this field, namely abstract implicit learning, requiring participants to make an abstract judgement about a presented stimulus, perceptual implicit learning, measuring a participant's ability to perceive or predict a stimulus, and implicit motor learning, facilitating new or improved specific motor responses to presented stimuli, were explained according to these distinguishing features. In each case the most salient studies were discussed, with the addition of alternative examples in every paradigm.

A distinction was made between the different terms encountered in the literature, such as incidental, implicit, and explicit, with an explanation of the different meanings and specific applications within the field. It was clarified that the difference between implicit and incidental learning is that, in the former, the learner has no awareness that learning occurred, but in the latter, they do. It was then argued that, in the process of learning, the distinction was not of consequence, with evidence from the literature to substantiate this point.

The advantageous nature of implicit learning, as has been found in several areas of study, was then investigated. In the field of language learning, it was found that implicit learning facilitated faster learning, greater fluency, and improved vocabulary acquisition. In memory and retention studies, the implicit recognition of familiar contextual elements aided in better learning and recall, both in the short term, and after a time interval, and this learning was found to be resistant to concurrent tasks and increased cognitive load. For implicit learning in the context of neurological impairment, valuable findings of rehabilitative applications for patients with, for instance, Parkinson's disease, motor skill loss after stroke, and amnesia, were discussed. However, for learners with different learning needs, the evidence was contradictory, and it was determined that more research would be needed to reach conclusive findings. With regards to the implicit acquisition of motor skill, the field of sport psychology offered several advantages and applications, such as discovery and analogy learning, which may lead to injury prevention and an increased reliability of such skills under the pressure of sports performance.

These abovementioned areas were then compared as analogous to music learning, with potential equivalent advantages envisaged to have considerable implications for music students, teachers, and professional performers, such as the learning, fluency, memory, and retention, of musical material, the effective teaching of students with learning disabilities, and the acquisition of specialised motor skills needed for musical performance, as well as the reliability of such motor skills under the pressure of performance.

## *MUSICAL CONTEXTS*

In Chapter 2, incidental learning in general, as well as implicit learning specifically, were discussed, and considered within the context of music, reviewing the available literature, and conceptualising potential applications of the findings as discussed above. The absence of a comparable body of research as in other fields was noted, but the possibility that some musical phenomena had simply not been classified as incidental or implicit was contemplated. Such related areas of interest, as has been well-documented in musical (and other) research, but not from an incidental/implicit learning point of view in particular, such as cognitive structuralist research, enculturation, and statistical learning, were thus also considered for their relevance and applicable content.

Enculturation was found to be a ubiquitous musical process in all cultures, as the implicit acquisition of the traditional rules and practices of the particular culture. This was observed from a very young age, and was reported to be a life-long learning process, inherent to all human beings. Enculturation was demonstrated to be a form of statistical learning, which is an innate human (and cross-species) ability to implicitly perceive statistical regularities from the environment. Related to this, were the interesting findings that the same learning mechanism also functioned to acquire new and unfamiliar musical elements, regardless of age, or musical training. Musical training was, however, demonstrated to be a determining factor in the level of ability to learn statistically, or implicitly, in general.

The same areas as identified in Chapter 1 for their findings of inherent benefits of incidental or implicit learning, were again used as categories to consider similar potential findings for music. In music/language learning, the close relationship between these two areas were discussed, and it was hypothesised that if language could be learnt through song, then musical elements could be obtained through language. Examples of the rhythmic metre of spoken words were applied to musical rhythms to demonstrate this possibility. For the memory and retention of music, the importance of performing from memory was highlighted, and known memorisation strategies were compared to the evidence from implicit learning studies, with the conclusion that the benefits seen in one domain should be equivalent in the other. In musical applications of implicit learning in the context of neurological impairment, studies were found that demonstrate how patients had intact musical memory, and could acquire new music, even when other memory processes were impaired. It was also shown that music could be applied for the rehabilitation of walking, through the implicit process of entrainment, when two systems synchronise their rhythms. Three case studies were presented to demonstrate how music could be incidentally learnt by students with special educational needs, specifically in ASD, ADHD, and dyslexia. Finally, the acquisition and execution of the complex motor skills needed for instrumental performance in music, were considered for the possible applications of the benefits as was found in sport, such as prevention of injury, and the reliability under the pressure of musical performance.

What was clear from the assimilation of research on incidental learning in music, was that it is an integral part of music acquisition, just as it is for the areas identified in the cognitive research discussed in the previous chapter, and that the potential for applying findings in parallel could be transformative to music teaching.

## *INCIDENTAL LEARNING IN PRACTICE*

In Chapter 3, the first practical research phase of this thesis was reported, with the aim to observe actual everyday teaching praxis, to determine the context and prevalence of incidental learning, examine the role of the teacher in facilitating such learning, and identify any potential advantages thereof. Teachers who were willing to have their practice observed, and students (or parents in the case of minors) who gave consent for lessons to be recorded, were recruited and their regular lessons were attended by the researcher, for a total of 20 hours. Examples from the researcher's own teaching experience were also included. Transcriptions of the recordings were analysed to identify possible instances of incidental learning, and these were categorised according to either learning outcomes achieved through incidental learning, such as memorisation, or according to the methods used by teachers, such as modelling, and the use of metaphor.

In the categories of memorisation and modelling, both visual and auditory, individual case studies were discussed, and the incidental nature of the learning, as well as the possible advantageous attributes thereof were considered. For the category of metaphor, due to the magnitude of examples seen in observations, a detailed discussion of this practice was provided, considering how it constitutes incidental acquisition, and contemplating reasons for its prolific use. Two specific applications of metaphor were identified, being motor skill and expressivity, and several examples from the observations were used to demonstrate these applications.

In the final part of this chapter, 108 teachers responded to an online survey, providing information about their teaching experience, the age groups of students they mostly teach, the instruments they specialise in, and also giving examples of metaphor use from their own teaching practice, as well as their reasons for doing so. The data were analysed for teacher awareness of, and motivations for metaphor use, and common elements as inferred from this data were discussed. A specific mention was made of the fact that most of the literature pertaining to metaphor use focuses on expressive skills, whereas most of the examples given related to motor skill, which was identified as a gap in the knowledge base and an area for potential future research.

## *IMPLICIT SEQUENCE LEARNING IN A SIGHT-READING TASK*

Chapter 4 considered the knowledge obtained throughout the previous chapters, and the fact that implicit learning findings from other fields could not be directly transferred to the musical domain.

The importance of the cross-discipline application of findings, with reciprocal advantages, was discussed, and a solution proposed through the replication of an implicit learning experiment from cognitive science in a musical context. The rationale of the choice of experimental protocol and musical parameters to use was reported in detail, including the difficulties of designing an experiment that not only meets the rigorous standards of scientific testing and analysis, but is also ecologically valid, i.e. that it resembles a normal musical task.

31 Musicians were recruited from various parts of the world, with different proficiency levels, and playing various instruments, or singing. Each took part in an individual online experiment, where they played or sang through five pieces of custom-composed sight-reading, with a repeated musical sequence embedded in the middle of each piece. Participants were asked specific questions to find out if they had become aware of the repeating sequence, in order to gauge whether any performance changes that happened due to the repeating nature of the sequence were implicitly acquired. Their performances were recorded and measured for response time and note/rhythm accuracy.

The results, as analysed through credible statistical measures, demonstrated faster response times and increased accuracy for the repeated sequence, to an extent not seen in the surrounding random musical material. In the interpretation of these results, it was found that faster response times constituted faster processing speed, which allowed for higher accuracy levels, and increased motor control. Further findings demonstrated that more notes on the page equalled a higher cognitive load, but that the implicit acquisition of the sequence features was not influenced by this. The implicit process was also resistant to interference by task difficulty and participant fatigue. These benefits were observed equally for the large part of the sample that did not become aware of the sequence repetition, and for the few isolated cases where awareness did occur.

Proposals were made for future research stemming from these findings, with a particular focus on the level of stress that was evident in the great majority of participants, specifically related to the musical skill of sight-reading.

## *FROM THEORY TO PRACTICE*

Having amassed all of the above knowledge, Chapter 5 reported the first attempt at applying teaching methods that may facilitate incidental or implicit acquisition, and the associated benefits, in the practical setting of a real-life learning programme. In this proof-of-concept study, a small group of young learners, who enrolled at a local youth centre for a summer music programme, were provided with fun and engaging musical games and activities. Each was allocated an orchestral instrument, specifically prepared for the study, and offered the opportunity to learn to play, for as much as the time would allow (2 hours per day for 4 days).

The test material was designed with experimental measures in mind, and embedded in several games and learning activities for participation by the learners. The implicit learning paradigms of implicit sequence learning, and visual context learning were used to test the implicit learning of a hidden musical sequence, for the former, and to measure the acquisition of musical elements in the visual context of unfamiliar traditional notation (sheet music), for the latter. Notes were initially presented simply as colours, and subsequently as coloured numbers, to indicate duration. Several games were played to familiarise the participants with these concepts, based on traditional children's games, such as "Simon Says" and "Pass the Ball". In subsequent sessions, games were designed specifically to expose the participants to the hidden sequence, and they were tested for acquisition of this sequence by playing a guessing game, where they had to predict the missing note in the sequence. After this section of the research, the coloured numbers were presented as coloured notes on traditional music staves, without informing the participants of the reason or nature of the change in presentation. After repeated playing of the coloured/numbered notation, they were tested for their ability to play a new musical line in conventional black and white notation.

The results for the sequence learning were not statistically significant, but did show a positive trend, which may have been significant with a larger sample. The visual context learning results were significant and extremely promising. A further discussion was included regarding some of the learners who presented with developmental and learning disabilities, and their learning progress was, for the most, in line with the sample mean, which is a positive indication for the potential of incidental learning applications in special needs music education.

## *SUMMARY OF THE BENEFITS OF IMPLICIT MUSICAL LEARNING*

From the various discussions, there seem to be multiple potential advantages to the utilisation of teaching (or practice) methods that facilitate incidental and/or implicit learning. As mentioned earlier, these could have far-reaching implications for music students, teachers, and professional performers.

Some of the benefits as reported from the real-life lesson observations, as well as inferred from the answers by survey respondents, were the ease of acquisition of skills that would otherwise be difficult to explain, or even learning additional or peripheral skills through observation, either by watching a skill being performed, or by capitalising on the use of the sensory feedback loop, which allows for the continuous implicit adjustment of a motor skill until the desired sound or feeling is achieved. Metaphor, which is used extensively in music lessons, was demonstrated to be a powerful method of delivering complex information, biomechanical skills, and expressive tools incidentally through simple analogy.

Under controlled experimental conditions, implicit learning resulted in faster response times and increased accuracy levels. As mentioned earlier in the summary, these indicated improved processing speed of musical information, and led to the application of consistent tempo, as a function of motor control. The improved performance was resistant to cognitive load, task difficulty, and fatigue, but one of the most important findings was that participants displayed these performance improvements (the effects of practice) despite not being aware of learning or practising the musical material.

In the quasi-experimental conditions of the summer youth music programme, it was observed that musical skills that typically take a considerable amount of time to obtain, and are traditionally viewed as difficult, could be acquired to a significant extent, by employing the mechanisms of implicit learning, at an accelerated pace and with ease, by young learners of various skill levels and abilities.

## CRITICAL EVALUATION

The purpose of a critical evaluation is not only to point out errors, omissions, and areas for improvement, but also to appraise the positive facets of any work undertaken. With this in mind, the structure adopted here, was to first consider areas for improvement, and subsequently discuss the positive aspects. As a general point, this thesis was intended for a mixed audience, and to that effect, both basic musical concepts, as well as statistical and mathematical principles, were explained clearly where it was deemed appropriate. This measure was taken in good faith, to make the study accessible to practitioners of both disciplines (and any other interested parties), and it is hoped that this would not be perceived as patronising by either.

### *OMISSIONS AND CLARIFICATIONS*

In the comparison of the strengths and weaknesses of different research methods in the Methodology section of this thesis, it was stated that any literature review of a vast subject area such as incidental learning, risked narrowing the focus too much and missing important information in the process. In the case of this thesis, although an overview of incidental learning was provided, the attributes and examples of this type of learning could have been described in more detail, before launching into the focused review of the implicit learning literature. Another possible omission, may have been literature that is teacher-centred, rather than only focusing on the learning aspect. This may have provided valuable insight in the observation of isolated cases where, for instance, teaching resulted in a different (incidental) outcome than what was intended, or where teachers seemed unaware of employing certain teaching practices. There is also the question regarding the reciprocal nature of incidental learning in the music lesson, and considering what teachers learn incidentally about their own praxis. Understandably, there is always a limited scope and time for any research project, and a balance must be found between being comprehensive, and focusing on what is relevant and important.

Another caveat of reviewing the literature on a subject was pointed out, namely the risk of introducing confirmation bias, where only those sources are presented that confirm what we already believe about the subject, or that report results equivalent to those we hope to find in our own research. As was mentioned at various intervals throughout the thesis, the literature contains many criticisms of the implicit learning paradigm, in a long-standing argument about how learner awareness is measured, amongst other points of contention. However, individual examples of these were not presented or discussed at any great length in the literature review. The reason for this, is that the critique has been mostly concerned with the conscious or unconscious nature of claimed implicit learning, and not with the beneficial consequences that have been reported as a result of this learning. It was therefore stated that, as far as the benefits of implicit learning are concerned, they seemed to be inherent in the learning process, independent of learner awareness occurring at some point, or not, and that the critique was therefore not specifically relevant to the current research. Credible evidence was presented to illustrate this, and thus, at the most, the implicit/incidental distinction was not the primary concern.

Unfortunately, as a result of this decision, there was not a very clear distinction at all times between the use of the terms incidental or implicit, and it seemed as if they were sometimes presented as almost interchangeable. The difficulty of presenting a learning instance as implicit because the learner did not seem aware of the learning taking place, but not conducting any awareness testing and therefore not adhering to the textbook definition of the term, has been reported in other disciplines as well, such as in language learning (Rieder, 2003). Perhaps an effort could be made to find a third term, that encompasses both the incidental and implicit learning terms, which may be considered for future research to avoid this pitfall.

### *CULTURAL FOCUS*

As far as the music-specific literature is concerned, the discussion seemed to start with enculturation and modern musical practices. This neglected the aspect of the innate human propensity for the performing and understanding of music, dating back at least 40,000 years to the first examples of musical instruments found, as well as the invention of Pythagorean tuning, and the reasons why we prefer certain frequencies over others. It has to be noted that the subjects of the human neurobiology of sound processing and of the entire field of psychoacoustics are immensely complex, and any discussion included here would have barely scratched the surface, if not raising more questions than it answered. Nevertheless, there have been increasingly frequent contributions of compelling evidence of the evolutionary origins and nature of music, suggesting that the ancestors of modern humans were engaging in musical activities and technologies for a considerable span of time before the first known physical artefacts of 40,000 years ago (Killin, 2018). We could make the logical argument that if the predecessors of all humans were practising "music", and that some form of what we would call music today has been part of every known culture (Cross & Morley, 2010), then the universal human cognitive mechanism of implicit learning (as seen for language, and in musical enculturation) would be equally available across all cultures for the aspects of musical learning proposed in this project. As convenient as that may be, and despite the literature on incidental learning in music demonstrating that both own-culture and unfamiliar other-culture music can be acquired to some extent, the overall discussion (as partly necessitated by the location and participants of the practical research) was overly Western-centric. The balance of perspective, and the generalisability of the study, could have benefited from observational and experimental insights from the musical practices of various cultures, whether formalised, such as in the maqam of Arabic music and the rāga of Indian music, or in informal aural traditions.

## *FIELDWORK*

The observations of everyday music lessons could have been extended to include more teachers than the initial five, with a wider range of students and instruments. The recordings of lessons of the students that were observed could also have been augmented with more follow-up observations. It was indeed intended for at least twice the number of hours of recorded material to be collected, and to have post-observation interviews with teachers and, where possible, the students themselves. However, due to the global COVID-19 pandemic in 2020/21, which effectively halted all in-person teaching for a prolonged period of time, it was decided to analyse and discuss the limited data that had already been collected. As a result of this, only one case study could be presented in each of the categories of incidental learning of memorisation and modelling. The inclusion of additional case studies could have increased the likelihood of observing incidental learning instances, and would have strengthened the argument for any advantages perceived.

As it stands, although great care was taken not to let any teachers or students become aware of the purpose of the study, so as to avoid any deliberate attempts at showcasing incidental learning, it does not eliminate general behaviour modification due to the circumstance of being observed. No researcher engaged in ethnographic observation could therefore ever be certain that what they observed was entirely natural and a true reflection of daily practices. The question was also considered whether it would have been possible to subject students that displayed instances of incidental learning to further tests, such as the retention of acquired material or skills, their perception and awareness of the learning and its processes, or even fMRI in selected cases. Again, due to the circumstances during the pandemic, these issues were left by the wayside, but it is possible that following that avenue of research may have violated the principles of ethnographic observation in any case.

In the report of the findings of these observations, the link between metaphor and incidental learning was in some cases speculative, and not clearly demonstrated. Furthermore, examples referred only to the acquisition of motor skill and expressivity, but no particular attention was given to the role of metaphor in the acquisition of (theoretical) musical knowledge. In the survey of music teachers conducted after the ethnographic observations, it became clear that some of the metaphors provided by participants pertained specifically to this aspect, with examples such as note durations, rhythm, pitch variations, dynamics, and musical terms, all facilitated by the use of metaphor. It is therefore noted, in addition to the lack of literature on metaphor use for motor skill, that the same point should also be included for theoretical knowledge.

With regards to the survey, it was seen in hindsight that additional questions pertaining to awareness and teachers' value judgements of metaphor as teaching method may have been useful. The general critique of the weaknesses of surveys as research method as being limited and limiting were observed, in that the lack of face-to-face interview conditions with immediate feedback and follow-up questions, rendered the responses one-sided and sometimes unclear. Confidence levels in the responses were therefore less than what they would have been with interview responses. Further to this, having no control over the participants that chose to respond, it was seen that the sample was skewed towards higher experience, although this was not necessarily detrimental to the interpretation of findings.

## *EXPERIMENTAL MEASURES*

Despite the noted effort made to explain musical and scientific concepts clearly, the reader would have benefited from specific definitions of terms like learning, memorisation, sight-reading, and performance, earlier-on in the thesis. It is worth highlighting, should this not have been made clear in the discussion of the experiment, that there is a definitive distinction between learning and memorising music, in the way that this practice is viewed by musicians and music students, and the task of sight-reading musical notation and the concurrent performance of what is read. The use of the term "learning" may thus be interpreted differently by readers from a musical perspective, and those from a cognitive science perspective. In the latter, learning means the processing of information, influenced by various internal and external processes, as measured by (outwardly visible or measurable) modifications in behaviour. In the former, learning means the deliberate repetition and practice (often for an extended period of time) of the performance of a piece of music, either from written notation, or "by ear".

Aside from basic clarity, several aspects of the experimental design could have been modified to mitigate challenges found in the analysis of the results and interpretation thereof. Response time measurement was made difficult by the addition of rests at the end of musical lines, and the lack of control of the number of notes per line necessitated the normalisation of data due to the increased cognitive load. The design of the musical series for use with the random number generator could have been more intricate to avoid these phenomena, and a more rigorous number generation method in itself may also have contributed to increased control of such outside variables. It was prudent that the experiment included the second dependent variable of accuracy, as this was not affected by these sequence characteristics, and would have demonstrated positive results even if the response time measure failed to produce usable data, which fortunately it didn't.

The requirement of Grade 6 sight-reading was thought to produce a fairly homogenous sample, but did not take into account the skill of professional musicians to continue playing at a consistent tempo despite errors and distractions. The tendency of the less skilled participants to vary their tempo, and on occasion briefly pause after errors, produced outlying data that complicated statistical analysis, necessitating a different approach altogether. It would have been preferrable to have two distinct samples, one with highly skilled professional musicians, and one with less skilled students and learners. Ideally, had the scope and time allowed for it, the experiment could have been repeated with these and other above-mentioned adjustments in place.

Some of the discussions of reported results included interpretations that were not based on statistical evidence, whether due to the number of participants involved being too few to compare, or due to speculative inference. This would normally not be acceptable in credible, robust scientific exploration, but disclaimers were made to that effect, and it was decided to include such discussions for their relevance to daily teaching practice, and for the implications they may have for future research.

## *PRACTICAL APPLICATIONS*

The first impression of the quasi-experimental proof-of-concept study was that it was slightly chaotic, although this may have been more apparent in person than from the subsequent report. It was, in general, a very enjoyable and rewarding endeavour, and it could be argued that by its very nature of being a first "prototype" conceptualisation in a real-life learning environment, nothing should have been altered in any way. However, objectively speaking, it was clear that the intentional recruitment of a larger sample, with a more homogenous distribution of age and ability, would have provided better, or at least less noisy (statistically speaking) results. Further to this, more time and fewer interruptions would also have been ideal. It is debatable to which extent the natural environment could or should be controlled, but it is an important consideration for any future research and applications.

## *POSITIVES*

The above recommendations and elements of critique notwithstanding, it was assessed that the overall study produced more positive features than negative ones. The literature review, in both the general and music-specific contexts, was as comprehensive as possible, transparent, and informative. The envisaged implications for music were logical and realistic, and clear parallels were drawn to demonstrate the importance and relevance of the theoretical survey to the practical research.

The flow of practical research was well-planned, with observation of existing practice first, experimental testing of the findings from observations next, and the combination of the two in conceptual practical application as the logical culmination. Research elements of both the scientific and interpretive paradigms were employed, with the appropriate use of relevant methods, and an innovative combination of both for a pragmatist, mixed-method design. All foreseeable efforts were made to avoid the introduction of bias, both from the researcher's and participants' point of view. Research protocol was clearly laid out, organised, and followed in as rigorous a way as possible, whether for ethnographic study, experimental measures, or the novel applications of the proof-of-concept study.

The data collection methods, as well as methods of analysis, were clearly explained and demonstrated, and credible statistical analyses were conducted and presented. The results were reported objectively, as a true representation of the research undertaken. The writing of the research report in this thesis was conducted as clearly and logically as possible, without detracting from the focus and progression. Most importantly, the hypothesized benefits of incidental and/or implicit learning for musical skill acquisition were demonstrated and evidenced in a convincing and clear manner, with clear implications and recourse for future research and the development of targeted applications.

## PROJECTIONS FOR FUTURE RESEARCH

From a wider perspective of cognitive science research that has its focus and application directly in the musical domain, and musical research that employs scientific methods in its investigations, any subsequent projects will contribute to the body of evidence for such an approach, and bring the two disciplines closer to a mutually beneficial cross-cultural validity. This will widen the available pool of literature for future students and scholars.

In the ethnographic observations and teacher survey, it was recommended that research should be conducted to fill the knowledge gap for metaphor use in music instruction for more than only expressive skills, but also including metaphor for motor skill, and for the acquisition and understanding of theoretical music knowledge. Further investigations about the incidental nature of metaphor use may also be of great value, as this aspect was not always easy to discern.

For future experimental research, the possibilities are numerous. Firstly, there is the indication for the replication of other implicit learning experiments across all the different subject-specific paradigms as discussed. This will not only strengthen the validity of the current research and the general direction taken, but may also produce entirely new knowledge and insights not previously thought of, which in turn will suggest further avenues for future research again. The specific experiment conducted in this project may be repeated with several adjustments and added elements, such as more trial blocks, more difficult musical sequences in different locations and orientations, the addition of concurrent tasks or deliberate distractions, and the important measure, as mentioned, of stress monitoring under implicit learning conditions. Future experiments may also endeavour to test various different musical skills or elements, in various applications of independent measures and the measuring of dependent ones.

The highlight of this project was seeing the findings applied in real life, and observing positive results for the benefits of the incidental acquisition of musical skills as was observed organically in the lessons, manipulated artificially in the experiment, and finally conceptualised as practical application. It would be the ideal outcome if further research gained momentum towards applying specific teaching methods that facilitate incidental and/or implicit learning for students, allowing them to reap the benefits of faster learning, reliable memorisation, access to music education otherwise denied due to learning disability, prevention of injury due to bad posture and technique, and experiencing less anxiety and stress in musical performance.

It is hoped that any such future research will also contribute to the scope of learning theory in the field of psychology, and its applications in pedagogy, by adding to the existing body of research and providing new insights from a musical context, especially since music forms an equally inherent part of the human social, cultural, and learning experiences as does language. The theory, observational, experimental, and practical findings strongly suggest that incidental and/or implicit learning are powerful cognitive learning mechanisms that can be harnessed and applied to the benefit of the learner. The importance of achieving such aims, and the implications they may have for our future understanding of musical and wider learning, are numerous and diverse.

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# CONCLUSION

Music and cognition are inseparable. We could not produce, understand, appreciate, or enjoy music, if not for the cognitive abilities to do so. Likewise, the representation of the cognitive realm of a human being would be incomplete without music, to the same extent as it would be incomplete without language, creativity, emotions, or behaviour. Yet, the two disciplines of music and cognitive science have taken very different views and approaches to the investigations, reports, and descriptions of the characteristics of their respective fields. The latest publication of a definitive meta-review on the field of implicit learning, *The Cognitive Unconscious: The First Half Century* (Reber & Allen, 2022), includes chapters on diverse topics, such as the neuroscience of implicit learning, neurological disorders, implicit learning in everyday life, language, aging, motor skill, social cognition, and emotions, amongst others. However, there is no chapter for music.

Bringing the two worlds together will take more than one doctoral thesis. Nonetheless, this one has attempted to add a small building block to the bridge between the two. More than just with abstract theoretical reason, it has attempted to do so with positive implications for both fields. In cognitive psychology, the demonstration of the various aspects that can be explored through musical parameters in traditional experiments should be promising, and should open up new avenues for the modalities and stimulus features that can be utilised in novel ways for future research. In music, the understanding of the neurological and cognitive elements of certain ways of learning and acquiring musical skills should provide insights into the practices we employ to teach and perform music.

Specifically, the advantages that were found to incidental and/or implicit learning in the field of cognition can be tested in musical contexts, and applied to musical learning, as has been done here. These findings may be valuable to music performance professionals, and if they have applications in that setting, that would be a welcome enrichment to existing practices. However, the ideal use for these findings would be in the education of future generations of amateur and professional musicians, so that they may learn faster and more effectively, regardless of whether they are neurotypical or neurodivergent, avoid the injuries common in professional musicians due to issues with posture and technique, and experience less stress, and more enjoyment, of this inescapable part of being human that is music.

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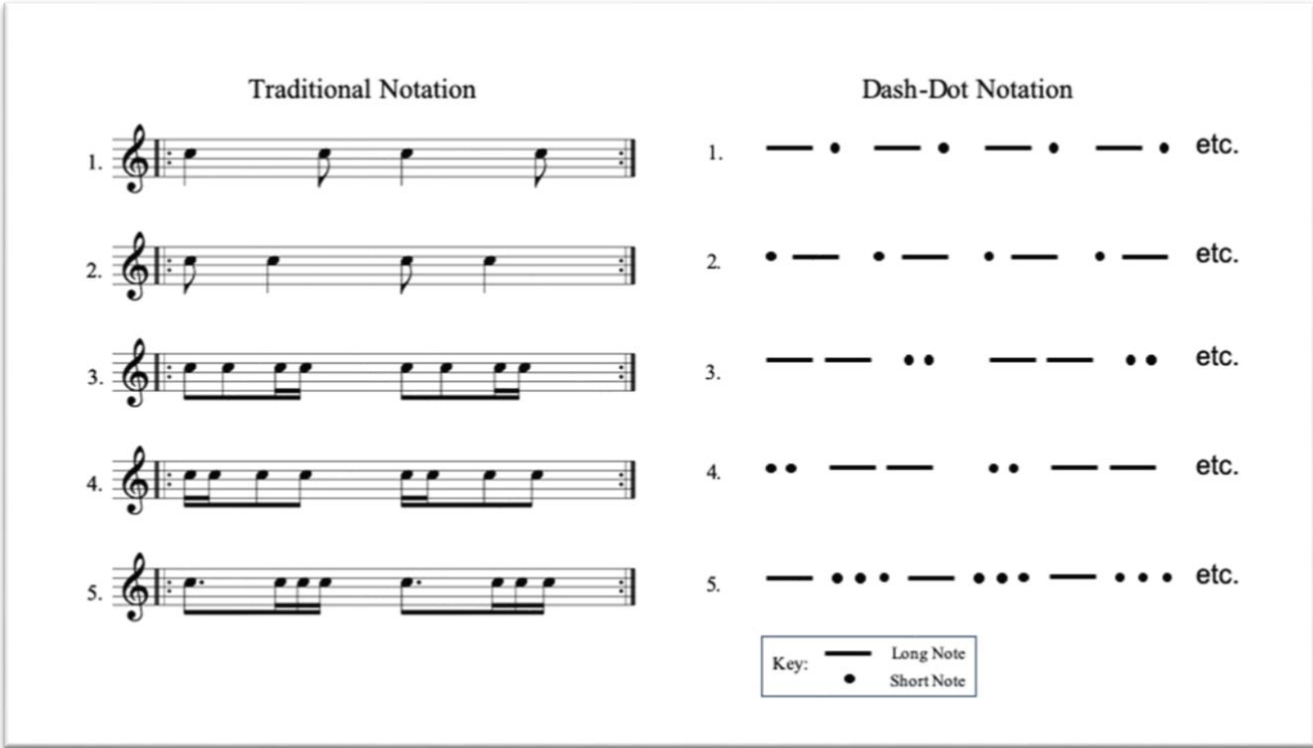
# APPENDICES

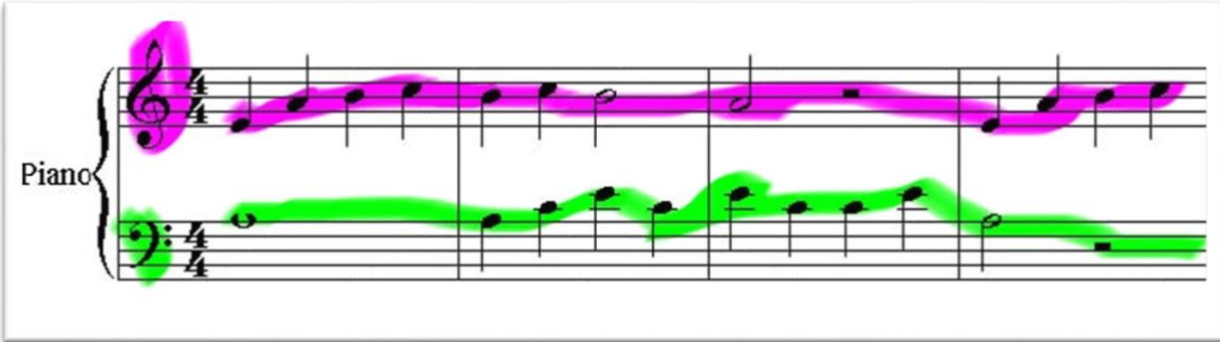
## APPENDIX A:

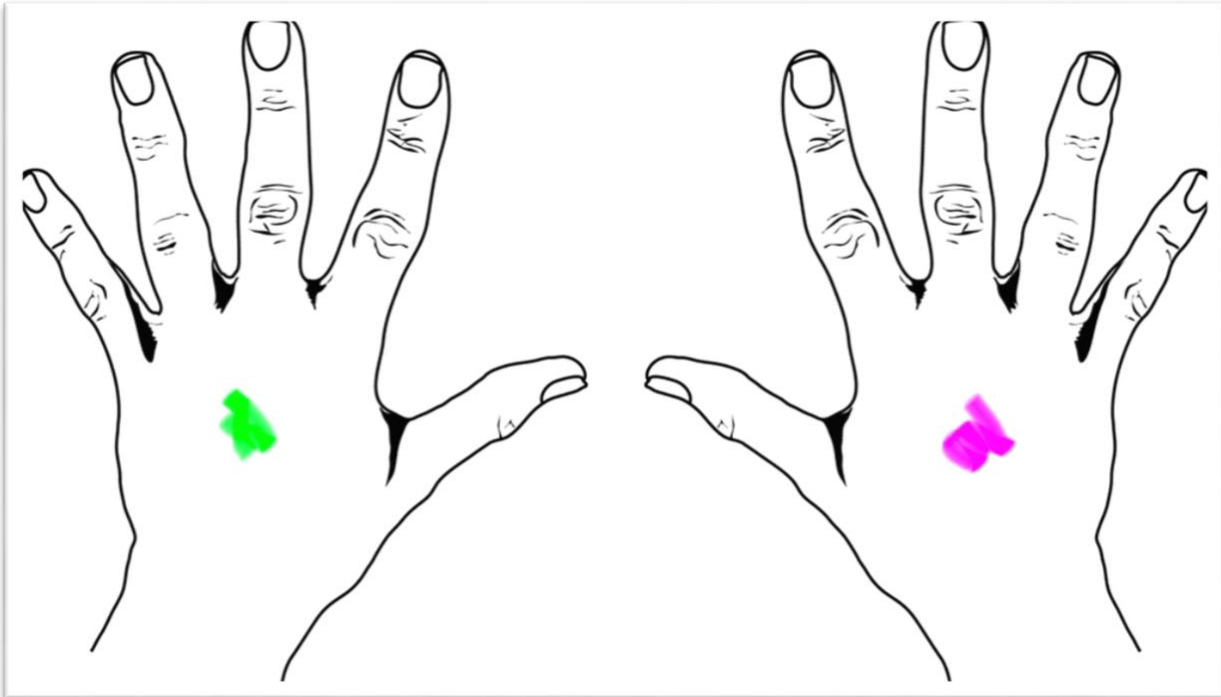
### MORSE CODE-LIKE RHYTHMIC NOTATION FOR INFORMAL MEMORISATION EXPERIMENT



# APPENDIX B:

## THE IRLEN COLOUR OVERLAY METHOD, AS ADAPTED FOR A PIANO STUDENT WITH SUSPECTED DEVELOPMENTAL DYSLEXIA



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