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THE RHYTHM OF LIFE:

The Perfect Rhythm of Morse Code

Cassandra Mohapp

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Declaration

I, Cassandra Mohapp, hereby declare that this submission is my own work and that it contains no material previously published or written by another person. This thesis contains no material that has been accepted for the award of a higher degree.

Ethical approval has been granted for the studies presented in this thesis from the University Human Research Ethics Committee. Participants were required to read an information document and informed consent was given individually prior to the collection of data. Each participant had the choice to withdraw from the project at any time, but with the knowledge that the contributions they had made up to that point, and data collected up to that point, will not be erased after commencement of the project.

Signed: _____Date: _____

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Abstract

Morse code is a unique exemplar of the inherent complexities of rhythm. Learning Morse code in wartime presented challenges to expedite skill acquisition. This thesis explored the strategies used to teach and learn Morse code in the second World War and investigated the resourceful techniques used by the WRANS in an empirical study.

The first study investigated the teaching and learning strategies of wartime telegraphists to learn Morse code. Five WRANS described a series of techniques to learn Morse code, including rote learning and repetition, visualisation and pattern recognition, intoning and mnemonics, and music. Music provided effective training for the fundamental teaching and learning of Morse code by matching the rhythmical properties of Morse code to music. Music equipped Morse code operators with a unique approach to Morse code instruction. Learning Morse code with music was described as a way of making sense of the 'rhythm' and 'shape' of the Morse code letters and proved an invaluable aid to learning and teaching Morse code.

The second study examined the effectiveness of learning Morse code with the aid of music. Novices formed two groups, Control Group (no music aid) and Music Group (with music aid). Results confirmed the effectiveness of music training in three Morse code letters, *Q V,* and *A* in two experiments, the first with known Morse code letters (Q V A) and the second with unknown letters. The Music Group accurately identified 90%

of known and unknown Morse code letters compared to the Control Group who identified less then 50% of known and unknown Morse code letters.

This thesis explored the transferable attributes of rhythm perception in music as a teaching and learning mechanism for Morse code. There is extensive research on the complex learning and retention of Morse code but the studies in this thesis have indicated that the ground-breaking wartime strategy of music and Morse code is a powerful duo. The investigation of learning and teaching strategies of the WRANS showed that musical rhythm influenced the skill acquisition of Morse code and the perceptual test suggests that current work in rhythm perception extends beyond music pedagogy and has further implications for all cognitive function.

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1 ABOUT THIS THESIS

This thesis investigates the teaching strategies and learning methods of music and Morse code. Music educators such as Emile Jaques-Dalcroze, Carl Orff, Zoltan Kodaly and Shini'chi Suzuki will provide the framework for teaching and learning strategies in music, and the wireless telegraphists from the Women's Royal Australian Naval Service (WRANS) who served during the Second World War and Post-War, will provide the teaching and learning methods for Morse code. This thesis will investigate the learning strategies for Morse code used by the WRANS and apply these strategies to novices.

1.1 The researcher and the researched

From my fortunate position as a current serving member of the Royal Australian Navy, access to military history and the ex-service associations is within reach. My employment as a military musician, however, provides unique opportunities to work closely with ex-serving military associations and this is how I have come to know the WRANS. These women, now aged in their 70s, 80s and 90s, report on their time in the military services with historical accuracy, skill and sentiment. The women served in the Royal Australian Navy with great pride and until now, little is known about the immeasurable contribution the women have made to Australia's military history. Furthermore, until now, little is known about the important parallels in their teaching and learning strategies of Morse code and how this resembles teaching and learning strategies in music.

My partner's mother Judy Saunders (nee Alley) was one of the first WRANS who served during the Second World War as a wireless telegraphist. Judy passed away at the

age of 89, but still had an extraordinary memory for Morse code. My regret is that I did not hear all of Judy's stories before she passed away, but she left me with this gift; her incredible ability to sing Morse code. Judy had a fine singing voice. She had no formal music training, but sang Morse code with all the musical elements of phrasing, pitch, contour and rhythm. There is no pitch, contour or melody in Morse code transmissions; however, to Judy, Morse code was like a symphony in her head. This is extraordinary when the 'real' transmissions of Morse code are metrically measured and irregular complex patterns.

There is something quite marvelous about Morse code in that even with this metrical and complex structure, that after listening to Morse code for the past few years I have started hearing Morse code as music, with pitch, contour and rhythm. I have had no training in Morse code yet I find it very musical. I have had over twenty years of formal music training, so the newfound musical interest in Morse code raised more questions than I can answer. To learn more about wartime Morse code, I joined the New South Wales Branch of the Ex-WRANS Association in 2010 and invited the women to take part in my research on music and Morse code. The women of the New South Wales Branch form the sample population of WRANS who participated in this research. A majority of the members of the Ex-WRANS Association are Morse code operators, senders and receivers as well as teachers and students, and were very keen to assist with my research.

1.2 Research questions

My research questions draw from the information, knowledge and expertise in Morse code and wireless telegraphy from the WRANS as well as capturing their unique stories

and history. The main research questions are based around the strategies the WRANS used when learning and teaching Morse code. What techniques did they use in teaching Morse code? Were there any shortcuts or 'tricks' to expedite their learning? Can novices learn Morse code using these same methods?

1.3 The Chapters

The chapters are outlined with four sections in mind. The first section reviews an analytical approach to understanding what rhythm is, how rhythm is learned, and the strategies used to remember rhythm. This section also investigates the current methods drawn on to teach and learn rhythm in music, and the strategies used to teach and learn Morse code. The second section outlines Project 1 and investigates methods used by the WRANS in teaching and learning Morse code. The third section is the follow-on study with further investigation of themes emerging from Project 1. The third section, Project 2, provides further investigation of the findings from Project 1 and tests these findings of teaching and learning Morse code with novices, and the final section discusses future implications and further study for music and Morse code.

To begin with, I look at rhythm perception. More specifically, what is rhythm and how is it understood? Do humans have a capacity for rhythm and if so, can this be used to learn complex information quickly? Can our capacity for rhythm be used to achieve a desired outcome? The first chapter will address these questions and give a brief overview on how rhythm is learned and the methods used to teach rhythm in music.

2 SECTION 1: RHYTHM IS EVERYWHERE

We all have a capacity for rhythm. Rhythm is evident in our heartbeat, our sleep patterns, suckling and walking (Bolton, 1894; Fraisse, 1982). The action we make when we chew and swallow food generates rhythm in the same way as when we drink and swallow fluid. The way our heart pumps blood around our body generates rhythm; as does our pulse (Bolton, 1894). Rhythm is part of our every day and our brain controls these rhythms in the same way as our brain controls our rhythm in singing, speaking and movement (Clayton, Sager & Will, 2005). This is how we all have a capacity for rhythm.

2.1 WHAT IS RHYTHM? – RHYTHM IN MUSIC

So, what is rhythm? Well there are several definitions of rhythm and depending on the multi-disciplinary perspective, rhythm can be defined in different ways. This thesis focuses on rhythm from a musical perspective. Rhythm in music is defined as the temporal hierarchy of sub-skills necessary for musical rhythmic behaviour (Bispham, 2006; Brochard, Abecasis, Potter, Ragot & Drake, 2003; Overy & Turner, 2009; Povel, 1984). In other words, researchers have investigated how the human brain measures musical rhythmic information, such as meter, accents, beat and pulse, to make sense of rhythm. Research in temporal rhythmic processing has evolved from general intensities of two or more groups of sound - one strong and one weak - like the ticking of a clock (Bolton, 1894; Brochard et al, 2003), to the phenomenon of subjective accenting of isochronous sequences (Bolton, 1894; Brochard et al, 2003; Overy & Turner, 2009; Povel 1984). The two important terms here are subjective accenting and isochronous sequences.

The first term, subjective accenting, refers to the unique human ability to hear beats and accents when there is no meter or pulse (Bolton 1894; Povel 1984). The second term, isochronous sequences, refers to repeated tones of the same pitch and equal duration (Brochard et al, 2003; Povel 1984). This means that researchers have experimented with repeated tones of the same pitch and duration (isochronous sequences) to make sense of how the human brain perceives musical rhythm (Brochard et al, 2003; Fitch & Rosenfeld, 2007; Overy & Turner, 2009). Subjective accenting and isochronous sequences form the basis of extensive research on how musical rhythm is understood and will appear throughout this chapter as the rhythm in music is explored.

2.1.1 Finding the beat

The process of finding the beat in rhythm begins from infancy (Phillips-Silver & Trainor, 2005). Infants develop a rhythm by learning to suckle for feeding, finding their individual rhythm of crawling and walking, clapping their hands at a very early age, and later moving in time to the music (Fraisse, 1982; Phillips-Silver & Trainor, 2005). In their research, Phillips-Silver & Trainor (2005) demonstrated the ability for infants to discriminate between rhythmic pulses and build rhythmic tendencies by bouncing infants on different beats of music. Using isochronous rhythm patterns for a two-minute duration, the infants were bounced on the second or third beat implying a duple and triple time. Phillips-Silver & Trainor (2005) were examining the abilities of seven-month-old infants to encode rhythm patterns to movement and their research revealed that infants preferred to listen to the beat pattern they were bounced to, as opposed to the beat pattern they were not bounced to, and would show their preference for a particular beat by turning their head away (losing interest) when the opposing beat

pattern was heard. Phillips-Silver & Trainor (2005) propose that movement may influence what we hear and in a second experiment, Phillips-Silver & Trainor (2005) blindfolded the infants to rule out the influence of visual information. This resulted in the same effect; demonstrating that visual stimuli did not influence, nor hinder, the infant's preference to particular beat patterns, suggesting that unique strategies of building layers of rhythmic information to understand rhythm are formed from infancy (Phillips-Silver & Trainor, 2005).

Finding the beat when the beat is silent has been referred to as the mind's rhythm, or our internal clock (Tecumseh-Fitch & Rosenfeld, 2007). The mind's rhythm describes the human ability to hear what is not physically audible and has been researched with syncopated rhythms (Tecumseh-Fitch & Rosenfeld, 2007). In their research, Tecumseh-Fitch & Rosenfeld (2007) used a computer-generated program to design a 4/4-meter of non-tonal clicks of 20 milliseconds (ms) duration. Thirty rhythms were created all consisting of varying complexities of syncopation. An underlying bass drum sound was used to give a low-frequency steady pulse and a woodblock sound was used to generate the syncopated rhythms. Tecumseh-Fitch & Rosenfeld (2007) also report that no prior musical training was necessary for humans to frame strong and weak beats and that, in their research, there were underlying musical events present where participants would generally tap along to strong pulses, or pulses that were "on the beat" (p.45). Conversely, research in the human ability to modify syncopated rhythms to align with an internal tempo, has revealed that syncopated rhythms elicited tension in listeners (Tecumseh-Fitch & Rosenfeld, 2007).

One example of this is where our individual ability to keep time, or the timing of the imagined beat, triggers mechanisms in our brain to hear beats in the silent parts of syncopated music when syncopated rhythms are used (Iversen, Repp & Patel, 2009). Iversen et al (2009) conducted brain research using EEG studies revealing that the brain responds differently in syncopated rhythms when perceived strong and weak tones are predicted and when these tones are omitted completely (Iversen et al, 2009). Iversen et al (2009) investigated how the brain responds to exogenous stimuli (such as the beat of a drum), and endogenous stimuli (such as heartbeat or pulse), and how the human brain consciously interprets and measures those stimuli. Interestingly, Iversen et al (2009) found that the brain activity in all participants, of whom all had had some music performance experience, responded with the same heightened activity when the beat was present, and when it was omitted. The beat was perceived, regardless of whether the physical sound was present.

2.1.2 Measuring rhythm

Rhythmic patterns are measured psychologically in milliseconds (ms) and are measured musically by beats per minute (bpm) (Krumhansl, 2000). Table 1 shows the breakdown of measurement between beats per minute and milliseconds where 60 bpm is equal to 1000 ms (or 1 second), 120 bpm is equal to 500 ms (or half a second), and 240 bpm is equal to 250 ms (or one quarter of a second). This information is important as rhythm perception is influenced by speed and tempo (Krumhansl, 2000).

Table 1: Comparison Chart of Beats per Minute and Milliseconds (after Krumhansl, 2000)

Beats per Minute	Milliseconds
60	1000
120	500
240	250

Krumhansl (2000) describes rhythm perception by how rhythm is organised to form patterns and is influenced by time perception and rhythm in tempo (Krumhansl, 2000). Krumhansl (2000) is referring to the sound duration of the rhythmic units where rhythm is perceived according to the space or silence between sound durations. For instance, when sound durations are less than 100 ms, the rhythm is heard as one continuous single event (Krumhansl, 2000). This means the focus is directed at the silence between the sound durations as opposed to the duration of the sound itself. It is the space of the silence that generates the perception of rhythm. Generally, the faster the tempo, the more tones are grouped (Krumhansl, 2000). For instance, Krumhansl (2000) reports that when participants are required to tap rhythmic elements at a speed of 420 ms (approximately 70 bpm) rhythmic elements are grouped in three. Speeds of 370 ms (approximately 80 bpm) resulted in rhythmic elements grouped in four.

2.1.3 Internal tempo and movement

The human ability to keep time is unique and is influenced by our preferred rate of lifestyle; for example, speaking, gestures, walking and movement, are all influenced by our internal tempo (Bispham, 2006; Boltz, 1994; Clayton et al, 2005). This is linked to

many activities such as walking, rocking and heartbeat to spontaneous tapping, which all coincidentally occur between 500 ms (120 bpm) and 1000 ms (60 bpm) (Krumhansl, 2000). In Table 2 below is a comparison of milliseconds and beats per minute outlining these reported ranges of tempo for every day activities. The interesting factor here in Table 2 is the measurement for tapping. The average person will spontaneously start finger tapping at a speed between 68 bpm and 77 bpm, which is approximately the same speed as our heartbeat, or our internal tempo (Bispham, 2006; Boltz, 1994; Fraisse, 1982; Krumhansl, 2000; Patel & Daniele, 2003).

Table 2: Comparison Chart of Beats per Minute and Milliseconds for every day activities (after Krumhansl, 2000)

Activity	Milliseconds	Beats per Minute
Finger tapping	380 - 880	77 - 68
Walking/rocking/heartbeat	500 - 1000	120 - 60

There is rhythm in movement and the human ability to move rhythmically and synchronically is a phenomenon known as entrainment (Bispham, 2006). Entrainment is the human capacity to move rhythmically as a result of external influences and tempo (Bispham, 2006, Merker, Madison & Eckerdal, 2009), in other words, the beat of a drum. Bispham (2006) proposes that rhythm and entrainment is unique to humans in that while humans have the capacity to move rhythmically, it is the entrainment of movement (the external timekeeper like beating a drum) that implies a musical rhythmic behaviour. Entrainment presents a phenomenon where, after a period of time, synchronous human rhythmic behaviour can occur (Merker et al, 2009). For instance,

troops marching to the beat of a drum, all in step and sustaining a common rhythm and common movement (such as swinging arms in synchronous gestures). Entrainment and musical rhythmic behaviour is also exhibited in tribal and indigenous spiritual dancing, known as 'welcome to country' ceremonies by Aboriginal people and Maori spiritual dancing such as the 'Haka'. Both examples involve the perception of pulse.

Entrainment also occurred when internal rhythm, (pulse) synchronised with external stimuli such as music, fast heart-beat when "happy" music was heard and a slower heart-beat when "sad" music was heard (Khalfa, Roy, Rainville, Dalla Bella & Peretz, 2008, p.18). Khalfa et al (2008) experimented with the effects of music such as the *Adagio* from Albinoni and *Eine kleine Nachtmusik* from Mozart, to portray sad and happy music. The tempi for these two excerpts were approximately 40-69 bpm and 110-154 bpm respectively. Khalfa et al (2008) discovered that although happy music has a tendency to be a faster tempo and in a major key, and sad music has a tendency to be a slower tempo and in a minor key, that in whichever way it arouses a response, psychophysiological responses to rhythm are mostly dependent on other melodic characteristics of the music, such as pitch and contour.

The important aspect here is the human ability to correct individual rhythmic behaviour to allow for synchrony. When masses of people are marching to the beat of a drum, in military marches for instance, error correction mechanisms allow for adjustments in keeping in time with the beat of the drum (Bispham, 2006). These error correction mechanisms can be different for individual people and involves self-correction mechanisms to maintain group mind and synchrony (Bispham, 2006). However,

research suggests that there is a common pulse or internal tempo that is defaulted to naturally, a preferred rate of speed (Bispham, 2006; Boltz, 1994; Fraisse, 1982; Patel & Daniele, 2003) and when required to modify our natural internal tempo participants to external stimuli, the commonly reported favoured tempo was 600 ms (approximately 75 bpm) (Krumhansl, 2000).

Movement is an integral part of rhythm perception that defies multicultural boundaries spanning from tapping our feet to an internalised pulse or external beat, as part of a group or individually (Bispham, 2006), to being rocked during infancy (Phillips-Silver & Trainor, 2005). We all have a preferred tempo or internal tempo (Bispham, 2006; Boltz, 1994; Fraisse, 1982; Patel & Daniele, 2003).

2.2 LEARNING RHYTHMIC PATTERNS

Our brain forms rhythmic patterns based on pitch, duration, meter and accents (Fraisse, 1982; Povel, 1984). This section will investigate the different influences (beat, pulse, tempo, and speech) that help to frame rhythm into conceivable entities (Krumhansl, 2000; Povel, 1984), where each factor (beat, pulse tempo and speech) provides information that (when combined) facilitates the learning of rhythm, mimicking rhythm, and understanding rhythm into an entity we then recognise as rhythm (Fraisse, 1982; Iversen et al, 2009; Povel, 1984). Organising rhythms into conceivable units is the first step in identifying rhythmic patterns and forming rhythmic groups (Bolton, 1894; Fraisse, 1982; Iversen et al, 2009; Povel, 1984).

Humans are born with an internal pulse that sets the framework for our ability to understand and influence the beat or pulse of rhythmic patterns (Bolton, 1894; Povel,

1984; Tecumseh-Fitch & Rosenfeld, 2007). The human ability to form patterns is characterised by certain influences such as our internal pulse, the concomitant (concurrent) movements associated with listening to rhythm, and the ability to perceive a beat (Bolton, 1894). The location of the perceived beat is ultimately a cognitive interpretation that is influenced by accents, tempo, and concomitant movements (Povel, 1984). Grouping rhythm into conceivable patterns is crucial to developing the internal representation of the rhythm and is determined by temporal factors such as subjective accenting (Povel, 1984).

2.2.1 Framing rhythm into patterns – Subjective Accenting

The concept of subjective accenting/subjective rhythmisation is the mechanism the human brain uses to frame rhythms into patterns influenced by internal pulses, (our natural rhythm), perceived pulses (subjective accenting) and tempo (Bolton, 1894; Fraisse, 1982; Iversen et al, 2009; Povel, 1984). Internal pulses and natural rhythms are influenced by timing and tempo and this determines where the framing or subjective accents are placed. For instance, a faster tempo may result in more internal pulses and a slower tempo may result in fewer internal pulses (Bolton, 1894; Povel, 1984). These rhythmic patterns (framed by tempo and timing) are placed economically to achieve the most efficient coding of temporal intervals created in order to make sense of rhythmic information (Iversen et al, 2009; Povel, 1984).

In his research, Povel (1984) suggests that subjective accents provide the framework essential for the cognitive mechanisms of the human brain to organise musical rhythm. In other words, the human brain organises rhythmic information by making rhythm sequences fit within an existing framework of tempo or meter. Povel (1984) describes

this as metrical interpretation or the “temporal grid” (p. 320). The temporal grid is a mechanism that consists of several possible grids to frame rhythmic information into smaller rhythmic units that is easily understood (Povel, 1984). The choice of which grid to use is dependent on the individual, and influenced by elements such as tempo and in musical rhythmic passages, the temporal grid is what musicians use to frame beats into meter they can easily understand and manage (Povel, 1984).

Povel (1984) found that participants would re-structure the rhythm patterns they heard into a conceivable pattern they could then understand. Using isochronous tones, that is tones that are equidistant (same length) and equi-tonal (same pitch), Povel (1984) experimented with series of tones with varying durations and found that subjects would group these tones with differing results depending on the speed at which the tones were heard; the slower the speed, the more unstable the results. Improved results were shown in cases where subjects would organise the isochronous tones into a conceivable arrangement by placing emphasis on particular units (Povel, 1984). Povel (1984) argues that the way we perceive complex information and rhythm hinders our ability to accurately recall the information. To correct this, or to understand complex rhythmic information, we transform irregular rhythmic patterns or intervals into an understandable and recognisable entity. Povel (1984) reports that subjects recoded these complex irregular rhythmic patterns into a conceivable form. This means that importance of organising rhythms into conceivable forms is the first step in rhythmic grouping.

Temporal grids are formed as we try to group or chunk rhythmic passages into retrievable units (Fraisse, 1982; Povel, 1984). Grouping and chunking will be discussed later in this section, however, in this context it refers to the way we hear irregular rhythms or see irregular patterns and instinctively place a grid over it so we can process them according to our natural sense of the rhythm. It would be possible that compound or duple meters are the result of temporal grids. These grids are movable depending on the timing and tempo of the rhythm or pattern and the cognitive mechanisms we employ to understand rhythm (Povel, 1984). The grids are not only unique to each individual, but also unique to music meter and tempo.

Povel (1984) demonstrates this with a simple experiment. Povel (1984) used isochronous sequences of tones that were 50 milliseconds (ms) in duration and a silent space of 200 ms between each tone. In this study, participants reported as hearing the tones divided and framed into groups. The groups were perceived by the imagined accents or beats. These were imagined because each tone was the same pitch and the space between each tone was the same distance. There were no accents or beats yet participants still formed borders from the isochronous tones. Participants reported as being able to hear accents and from the isochronous tones and form groups according to these perceived accents.

Further to this, Iversen et al (2009) experimented with perceived beats and how our brain interprets these beats into rhythmic sequences. Iversen et al (2009) explored how the location of the perceived beat was movable in terms of where it was emphasised with a rhythm. In a similar method to Povel (1984), Iversen et al (2009) used repeated

sequences of two tones, 45 ms duration of 200 ms intervals and a tempo of 100 beats per minute (bpm). Every third tone was omitted. The addition of the tempo measurement of beats per minute ensured a common reference for the placement of where the participants perceived the beat within the sequence (Iversen et al, 2009). Interestingly, participants imagined a conscious interpretation of the rhythm that was framed by the omitted tones. In other words, participants grouped individual rhythmic patterns based on silent beats. Iversen et al (2009) refer to this concept as the "temporal anchor" (p. 58) as it serves as an anchor point to which other tones are organised and framed.

Musicians interpret and measure musical rhythm by the interaction of grouping and meter and frame musical rhythmic sequences with accents and pulses, to form musical rhythmic groups (Jackendoff & Lerdahl (2006). Jackendoff & Lerdahl (2006) investigated the ability of the human brain to measure the interaction of grouping and meter on rhythm by examining the influence of tempo on grouping rhythmic information. Jackendoff & Lerdahl (2006) reported two levels of tempo influences, macro (generated by the composer with tempo, rhythm and dynamics) and micro (generated by the performer in interpretative nuances). Jackendoff & Lerdahl (2006) suggested that macro level implied basic quick-slow tempo and micro level implied "getting the feel of the musical style" (p. 68). Macro and micro levels influence how musicians perceive tempo and rhythm and affect how musicians hear the beat (Jackendoff & Lerdahl, 2006). Beats are typically associated with where one perceives pulses to tap their foot and clap their hands, which is typically the strongest pulse or beat of the bar (Jackendoff & Lerdahl, 2006).

There is an alternative cognitive mechanism known as the "stress grid" (p. 42) (Jackendoff & Lerdahl, 2006). The stress grid aligns more with poetic stresses that appear in speech and rhymes than musical rhythm (Jackendoff & Lerdahl, 2006), however is worth mentioning in this context as it relates to rhythm syllables. For instance, the length of a vowel can imply spoken stresses in the same way the length of a beat can imply volume (Jackendoff & Lerdahl, 2006). This is due to the location of stress syllables in spoken language (the heaviness of where one places stresses in speech) and this corresponds with the preference of where musicians perceive longer or louder beats in music (Jackendoff & Lerdahl, 2006).

Irrespective of the terminology, the temporal grid, temporal anchor and stress grid, all provide a basis for understanding rhythm. As humans, we all hear things differently and we all hear the beat differently in our mind's ear. We perceive rhythm by means of framing what we hear with existing structures and patterns we understand. These patterns are formed by the interpretation of the imagined beat and we form these patterns under the framework of subjective accenting.

Temporal grids and subjective accenting so far have accounted for the ability of the human brain to respond to rhythmical and metrical structures phenomenally where listeners created a conscious choice to have strong and weak beats (Brochard et al, 2003; Povel, 1984). Longer sounds were interpreted as more intense and vice versa (Krumhansl, 2000). Fraisse (1982) explains that when listeners were presented with sequences of repeated patterns, elements such as duration, volume and silence generate rhythmic framing. In other words, participants perceived a long pause as the end of a

rhythmic group. The impact of duration affects the intensity of rhythmic patterns where the longer the duration of sound, the more intense the rhythmic pattern was perceived (Fraisse, 1982). Duration and pauses in rhythmic patterns strongly influenced the human capacity to perceive and categorise rhythm where grouping three units of the same duration together, will suggest a triplet musical rhythmic pattern. This triplet will then be converted or chunked into one conceivable unit of three smaller elements. Rhythmic grouping and chunking is the next step to understanding rhythm.

2.2.2 Rhythmic Grouping and Chunking

Rhythmic grouping refers to the identification of various fragments of rhythmic information that belong together or that share similar properties, such as meter, pulse, tempo and duration (including silence) for classifying the fragments as one unit for memorisation (Povel, 1984). Investigations into rhythmic grouping and how sequences of sounds are processed in the human brain have led to two distinct rhythmisations subjective and objective (Fraisse, 1982; Krumhansl, 2000). Sequences of identical sounds (isochronous tones) are grouped as subjective rhythmisations, and sequences of non-identical sounds (changes in pitch or duration with longer pauses between events) are known as objective rhythmisations (Fraisse, 1982). These subjective rhythmisations are also influenced by tempo with the impact on the number of elements being formed; hence, a larger amount of elements are being formed with a faster tempo (Krumhansl, 2000).

Rhythmic grouping is also influenced by the inter-onset interval (IOI): that is, the time between events as opposed to the duration of events (Krumhansl, 2000). Research shows that both subjective and objective rhythmisations are used in coding and marking

the beginning and ends of events where lengthening a sound can act as either beginning or end (Krumhansl, 2000). Similarly, variations in pitch can also have the same effect (Brochard et al, 2003). Brochard et al (2003) found that participants would organise isochronous sounds based on rhythmic expectancies, the rhythmic patterns they expected to hear. Brochard et al (2003) generated 96 isochronous sequences with some sequences consisting of random deviations using softer tones. The deviations occurred on the strong beats (odd numbers of the sequences) and weak beats (even number of the sequences). Brochard et al (2003) reported that participants processed isochronous sequences with unequal auditory accents and perceived patterns of strong and weak beats when identical sound sequences were presented, suggesting that subjective accenting cannot be automatically achieved as an auditory process and that additional information (softer tones in this case) must be gathered. Brochard et al (2003) believe that higher cognitive mechanisms must be active in the auditory processing of rhythm perception and subjective accenting, and that the human internal pulse provided physiological evidence for this.

The human internal pulse influences rhythm perception (Povel, 1984; Repp, 2001; Tecumseh-Fitch & Rosenfeld, 2007) and the irregular musical rhythmic patterns of syncopation have provided fundamental material for in-depth research. In their research, Tecumseh-Fitch & Rosenfeld (2007) reported that a "racing heart", normally linked to tension and anxiety, was typically associated with participants as they tried to understand syncopated rhythms (p. 54). In order to overcome the anxiety associated with the irregular rhythm patterns of syncopation, participants re-organised their perception of the irregular rhythms into less complex rhythms, (that is, hearing "off

beat" pulses as on beat) and subsequently reduce their anxiety and heart rate (Tecumseh-Fitch & Rosenfeld, 2007, p. 43). As Tecumseh-Fitch & Rosenfeld (2007) have shown, participants re-heard the syncopated rhythms with a less-syncopated framework, to decrease tension.

We maintain a unique human ability to modify the location of the internal pulse or perceived beat when working with highly complex syncopated rhythms (Tecumseh-Fitch & Rosenfeld, 2007). Tecumseh-Fitch & Rosenfeld (2007) revealed the natural tendency for humans to reorganise their internal pulse in relation to pulse tracking (maintaining a steady beat by tapping along as syncopated rhythms were heard), rhythm reproduction (reproducing the syncopated rhythm to a computer generated pulse) and rhythm recognition (recognising the syncopated rhythm after a delay of 24 hours). From this research, results showed that participants were able to reproduce the syncopated rhythms that were at a faster tempo, reporting more error with slower tempi, and were able to more accurately recognise the rhythms after a 24-hour delay, than immediately after the experiment. Participants were able to encode the less syncopated patterns more easily and still heard beats in syncopated rhythmic phrases, even though the beat was missing. The missing beat was inferred through cognitive representations, also referred to as the phenomenon of subjective accenting.

In a similar way to rhythmic grouping, "chunking" refers to linking units of information into a single concept that can be labelled (encoded) and stored in memory for easy retrieval (Dowling & Bartlett, 1981, p. 31). Dowling & Bartlett (1981) experimented with chunking rhythmic patterns and melodic contour patterns in Beethoven's String

Quartets where participants were asked to listen to short excerpts of Beethoven's String Quartets (approximately 2 and 8 seconds of music) and to recognise these short excerpts in similar melodies of varying genres, such as Thelonious Monk and John Coltrane. This experiment proved too difficult due to the difficulty of encoding aspects of the music stimuli (Beethoven String Quartets).

The outcome of Dowling & Bartlett's (1981) experiment, suggested that for effective encoding or chunking of information into retrievable data, deeper cognitive layers must be made active (Dowling & Bartlett, 1981). Dowling & Bartlett (1981) conducted an additional, and more successful, experiment where the participants were required to write down words associated with the stimuli, using words such as "bubbly" (p. 37).' It appeared that when participants encoded information with words that represented meaning, retrieval of information was more accurate. The results of this additional experiment implied that chunking or schemas assisted with grouping and encoding musical rhythmic information so it could be remembered and recalled when needed (Dowling & Bartlett, 1981). Dowling & Bartlett (1981) also noted that the most familiar example of this type of chunking was in the opening movement to Beethoven's *Fifth Symphony*.

Chunking was influenced by tempo, particularly in rhythm reproduction experiments of syncopated rhythmic patterns (Tecumseh-Fitch & Rosenfeld, 2007). Using three tempi, 75 bpm or 800 ms *(andante),* 90 bpm or 667 ms *(moderato)* and 105 bpm or 571 ms *(allegro),* Tecumseh-Fitch & Rosenfeld (2007) experimented with thirty syncopated rhythms to examine the human ability to re-organise irregular rhythm patterns into

regular pulses and beats. Tecumseh-Fitch & Rosenfeld (2007) conducted three experiments in their study. This first experiment was a pulse-tracking task that required participants to tap the beat and keep the pulse of 30 randomised computer-generated rhythmic patterns (15 known rhythms and 15 unknown rhythms some syncopated and some non-syncopated rhythms at the three tempi discussed earlier). The second experiment was a rhythm reproduction task where participants were required to tap the rhythm that was just played to them (with tempo accuracy as well as rhythmic accuracy). The third experiment involved immediate recognition tasks. The known rhythms were played back at identical tempi to the previous two experiments, and the unknown rhythms were played back in randomised tempi. Fitch & Rosenfeld (2007) reported the influence of tempi as having a minor effect on participants who showed a tendency to report more accurately on faster tempi than slower tempi. Results also revealed that participants reported difficulties in tapping and maintaining a regular pulse when they were presented with syncopated rhythms, and instead corrected their pulse to reflect "off-beat" pulses as evident in the syncopation (p. 43).

2.2.3 Rhythmic grouping in speech - mnemonics

When learning new rhythmic information, a novice would refer to concrete words or information as a strategy for making this new information more familiar (Shehan, 1987). Mnemonics help us chunk and group new rhythmic information, as well as encode defining attributes of the particular rhythmic information for storage in memory (Shehan, 1987). The earlier a person was exposed to rhythmic education, through chanting, singing, tapping and rhymes, the more familiar these rhythms become (Shehan, 1987). The new dimension of adding spoken language to speech syllables of rhythmic sequences enhances rhythmic learning and memorisation (Shehan, 1987).

In the early stages of music instruction, mnemonics facilitate an avenue for novices to learn new rhythmic information (Shehan, 1987). This process leads to encoding of information so the novice could store it in the brain for retrieval when necessary. Shehan (1987) designed a study using experimental rhythm patterns and mnemonic sequences, where participants were required to memorise and reproduce rhythmic patterns. Participants were presented with audio and visual stimuli, firstly the notation cards were presented along with audio, and then the participants were asked to reproduce the rhythm pattern with the visual stimulus removed. The visual notation included mnemonic syllables to which the participants were told was secondary to the task and not important to remember. Participants were given mnemonic syllables such as t*an-te-ka-ton-ton* to replicate *crotchet-quaver-quaver-crotchet-crotchet*. The results showed that participants, all beginner musicians, reported enhanced results with audio and visual stimuli suggesting that the acoustic properties of mnemonics may be influential in learning and reproducing rhythmic patterns (Shehan 1987).

2.2.4 Rhythm and tempo in speech

Rhythm and tempo are two aspects of music that arouse psychophysiological responses to how we understand speech (Patel, 2008). This means that there was natural rhythm in speech and it was this natural rhythm that left an imprint on the brain (Patel, 2008). The way we speak, the pauses and inflections and the changes in these two dimensions can effect meaning, add humour and generate emotion (Patel, 2008). For example, when a phrase was spoken such as 'I will see you on Monday' it has different meaning when certain words were emphasised or exaggerated. 'I WILL see you on Monday' implied a different meaning to 'I will see YOU on Monday'. Iversen, Patel, & Ohgushi (2008) investigated the presence of any bias to stressed syllables relating to fifty common

disyllabic words (words that have two syllables). Iversen et al (2008) investigated the relative syllabic duration, the duration of each syllable of each spoken word, to reveal any tendency for syllabic stresses. They were interested in whether one syllable was more commonly stressed or accented, than the other. In this research, Iversen et al (2008) found that words (English words that is) had a strong bias towards short-long duration. For example, words such as *be-FORE* and *be-CAUSE* are considered short-long duration and words such as *MO-ney* and *MAY-be* are considered long-short duration.

Iversen et al (2008) proposed that there were cultural differences in speech rhythm. In their research, Iversen et al (2008) investigated the differences between words stresses in languages between native English speakers and native Japanese speakers. There were 20 stimuli in total. Participants were required to report preferred groupings of long-short or short-long tones (durational sequences), or loud-soft and soft-loud tones (amplitude sequences). All tones were recorded at a frequency of 500 Hz (Hertz) and 150-250 ms (milliseconds) in duration. The amplification was increased by 1.25 to 3 times greater. The two tones had a gap of 20 ms and formed sequences that were presented in random order. In the first instance, results revealed a similar response from both English and Japanese speakers in relation to a preference for amplitude sequences. However, results revealed a marked difference in durational sequences with English speakers preferring short-long groupings and Japanese speakers showed a preference for long-short groupings. This result suggested that there was a cultural difference in the approach to rhythmic grouping and perception and that language experience was the reason for the differences.

2.2.5 The Mind's Ear – Hearing Musical Rhythm in our Head

Our ability to hear things in our head when physical sound was omitted was often referred to as hearing things in our mind's ear (Jackendoff & Lerdahl, 2006; Repp, 2001). In other words, this was how our brain hears musical imagery, such as rhythm, tempo, meter and pitch, when there was no music present. Jackendoff & Lerdahl (2006) proposed that from infancy, musical activity was embedded in the human brain by circumstances such as listening to music, performing music, singing a lullaby to a child or hearing subliminal film music, these situations all set the foundations for a unique capacity for hearing music in the mind.

There is a hierarchical perception to how rhythmic patterns are encoded (Krumhansl, 2000). A neurological link that results in the encoding of text and melody in the brain suggests that text will cue melody and that melody will cue text in memory (Sacks, 2007). Episodic memory can also influence recall of text and melody, as Sacks (2007) offers possible explanations to veteran's memories of the Second World War and other significant events at the time. These triggers influence rhythm memory where, although no melody exists, tonal patterns are still added. However, the ability to delete these tunes from memory was virtually impossible (Sacks, 2007). The reason it was nearly impossible to remove music from the auditory memory was due to the difficulty in separating important components such as timbre, rhythm, melody and repetition (Levitin, 1994). These timbral cues (timbre, rhythm, melody and repetition) have qualities that assist with memory representation of the actual pitch, particularly if lyrics are missing (Levitin, 1994).

Repp (2001) experimented with musical imagery and the human ability to replay familiar music with timing nuances and expressive intentions of a performance in the mind's ear. Repp (2001) used the score of the opening bars of Chopin's Etude in E Major No. 10 to demonstrate the expressive timing in the mind's ear. Figure 1 shows an extract of Chopin's Etude in E Major No.10.

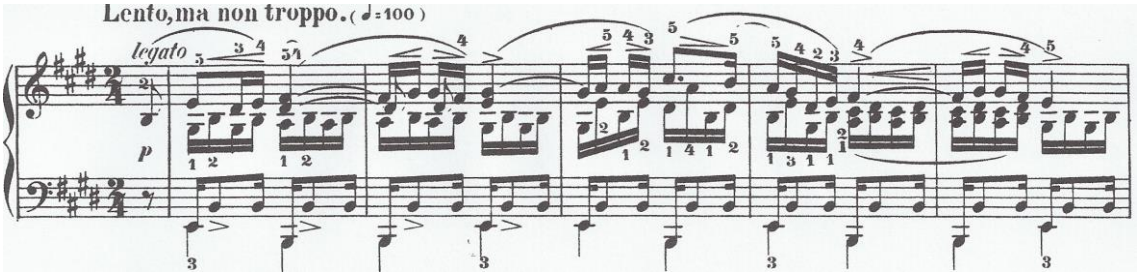

Figure 1: Chopin's Etude in E Major No. 10 (after Repp, 2001).

Repp (2001) experimented with pianists tapping semi-quaver pulses to their own performances of Chopin's Etude, but without sound and a piano for visual reference. Some pianists performed the work with free expressive flair, and others performed the work with strict adherence to the metronomic structure. Repp (2001) demonstrated the variations in expressive timing when the pianists, who did not stray from the metronomic timing of the music, were more accurate in the finger tapping experiment. Repp (2001) proposed that the imagined music in the mind's ear influences the accuracy in producing a steady metronomic rhythmic pulse.

2.2.6 Summary

To summarise, rhythm is measured in milliseconds, beats per minute (Krumhansl, 2000) and our perception of how rhythm is grouped is influenced by tempo – more units of

rhythm are grouped with a faster tempo (Krumhansl (2000), and modify syncopated rhythms to suit familiarity (Tecumseh-Fitch & Rosenfeld, 2007). Rhythm is modified in response to sound in dance (movement) and the way troops march in squads (Merker et al, 2009), and the unique human ability to clap our hands and tap our feet to external stimuli (entrainment) (Clayton et al, 2005; Phillips-Silver, Athena-Aktipis & Bryant, 2010). The human ability to synchronise movement (or dance) to a common external stimulus is a phenomenon that occurs when the body is forced to regulate or correct movement to these exogenous (external) stimuli (Clayton et al, 2005) and incoming rhythmic information (Phillips-Silver et al, 2010). The incoming rhythmic information is referred to as the beat or pulse and entrainment occurs when coordinated movement in groups of two or more display the same gesture (Merker et al, 2009; Phillips-Silver et al, 2010). Rhythmic syllabic information is also evident in language where English speakers show a bias towards short-long disyllabic groupings. And finally, the integration of tempo, duration, movement, rhythmic syllables and mnemonics, provides the foundations for understanding key concepts of learning rhythm in music education.

2.3 LEARNING RHYTHM IN MUSIC

From the early 1900s, a philosophy surrounding the teachings and learning in music education was emerging among four main music educators: Emile Jaques-Dalcroze, Carl Orff, Zoltan Kodaly, and Shin'ichi Suzuki. There was no ultimate approach or definitive philosophy that was regarded as superior but the common thread that linked these viewpoints was the development of the inner ear (Jaques-Dalcroze, 1930; Kendall, 1986; Orff & Walter 1963, Sándor, 1969). It was the viewpoint of these music educators, and Gordon Edwin from a music psychology perspective, that developing the inner ear began in infancy with listening and movement, rote and repetition, audiation,

then verbalisation, and finally improvisation (Brink, 1983; Garner, 2009; Gordon, 1984; Jordan-DeCarbo, 1986; Sándor, 1969).

2.3.1 Listening and Movement

According to the view of Jaques-Dalcroze, "if children are capable of moving rhythmically, then a transfer to the accurate performance of musical rhythms seems likely" (Shehan, 1986, p. 29). Rhythmic movement engages the whole body where moving to music becomes the first stage to developing a relationship between rhythmic movement and sound (Jaques-Dalcroze, 1930). The Jaques-Dalcroze Approach to teaching and learning rhythm is based around rhythmic imagery (Seitz, 2005). According to Jaques-Dalcroze, this rhythmic movement is generated by duration, intensity and space (Seitz, 2005). Jaques-Dalcroze believed that the natural rhythm of the body evokes rhythmic imagery resulting in "rhythmic consciousness" (Jaques-Dalcroze, 1930, p. 183).

In music education, the first stages of musical comprehension involved rhythm games and exercises (Orff & Walter, 1963; Shamrock, 1986). Jaques-Dalcroze developed a philosophy of internalising rhythmic patterns in an informal environment through games and movement (Seitz, 2005), which was developed further by examining the natural play-like behaviours of children by Carl Orff in the 1930s (Orff & Walter, 1963). The Orff Approach engages a flexible philosophy of music education that embraces the natural behaviours of children; singing, dancing, playing, fantasy, games and chanting, to teach and learn music (Orff & Walter, 1963). The Orff Approach to learning music starts with simple rhythmic chants or songs that are short in length and familiar to children, and then longer phrases are added gradually (Shehan, 1986). Once

the rhythm is learned, it can then be transferred to non-melodic instruments (Orff & Walter, 1963; Shehan, 1986). The rhythm is the starting point and through spontaneous movement, children engage in creative "play" that then form patterns and musical structure (Orff & Walter, 1963; Shehan, 1986).

Guiding children through the Orff Approach is also referred to as "Schulwerk", and this "Schulwerk" saw the development of rhythmic and free movement (Orff, 1963; Shamrock, 1986). Rhythmic movement enhances rhythmic development and through creative approaches such as 'drawing' the sound in the air with high movements for high pitch and low movements to indicate low pitch, by dancing and drama, and miniature theatre pieces, a vocabulary of rhythm is established (Shamrock, 1986). Teaching rhythm through movement arouses an innovative approach to musical comprehension and a unique way of hearing and understanding rhythm where students are encouraged to recreate a story through movement (Garner, 2009). This creative rhythmic movement is where students are asked to hop on one foot as if there is chewing gum stuck to the bottom of their foot. The idea is unique and still maintains that learning occurs, fundamentally, as a result of play. The teaching styles of the Orff Approach are fun and playful whilst still maintaining the idea that learning is a secondary bi-product of play, as children play they learn (Orff & Walter, 1963).

The Kodaly Approach was established in the 1940s and, inspired by Jaques-Dalcroze, included rhythm-developing exercises in the form of walking in time to music demonstrating crotchets, running in time to music demonstrating quavers, and skipping in time to music by demonstrating dotted rhythms (Sándor, 1969). By altering the pace

of walking and skipping, catchy rhymes (of folk origin) and counting games, quick and slow tempi demonstrated rhythmic pulse and beat (Sándor, 1969). Children use play-movements that are innovative and make-believe in natural rhythmic movement and when rhythm and movement are combined with intense listening, spontaneous responses to sound occur (Jaques-Dalcroze, 1930; Orff & Walter, 1963; Sándor, 1969. Movement is closely association with audiation (Garner, 2009).

2.3.2 Rote, Imitation and Repetition

The concept of rote and repetition learning forms the basis of music education in the Suzuki Approach (Shehan, 1986). Referred to as the "Mother Tongue Method", children learn by repetition and by copying what is demonstrated (Kendall, 1986, p. 48). Children are given taped recordings of the music they are studying and through endless listening of high quality performances, children are encouraged to imitate what they can hear in these taped performances (Kendall, 1986). This vital part of the Suzuki Approach uses an exact model to learn and duplicate new repertoire, as well as more complex musical literature, to promote the concept that all children can learn music (Brathwaite, 1988; Kendall, 1986). Here, simple variations on rhythmic patterns engage intense listening where children basically repeat what they hear with no real understanding or consideration for what they are repeating (Kendall, 1986). Whilst this is greeted with mixed reactions amongst music educators, the Suzuki Approach provides an initial learning aid to developing music literacy.

Similar to the Suzuki Approach is the Yamaha Method, where children are encouraged to listen and imitate what they hear and see (Miranda, 2000). In the Yamaha Method, children sing and play music by ear and identify music notation with flash cards and

activities such as colouring-in music notes, resulting in a reinforcement of this new material by adding a visual representation to the stimuli learned (Miranda, 2000). The mastery of rhythmic patterns and ear training collectively forms a very important part of the Suzuki Approach where reading music notation is less important than aural memorisation (Brathwaite, 1988). Aural memorisation through movement, ear training and repetition form the basis of Suzuki pedagogy and is vital for developing audiation and the mind's ear (Shehan, 1986).

2.3.3 Audiation

Audiation involves mentally recalling the music that is in the mind (Gordon, 1984). Audiation is the ability to hear what was not physically present (Gordon, 1984) and the concept of audiation is the culmination of processes and techniques used in music education such as rote and repetition, imitation, echoing or repeating a musical rhyme back through speech, clapping or stamping a musical rhythm, or singing (Garner, 2009; Gordon, 1984). Audiation is a crucial stage in learning music as it draws together the important viewpoint from music pedagogues that music is sound first, then notation and music literacy (Garner, 2009; Gordon, 1984; Kendall, 1986; Orff & Walter, 1963; Sándor, 1969).

Children achieve audiation by labelling what they could hear with speech associations like onomatopoeias (literally sounds like it was heard), where a rhythmic pattern of "quaver, quaver, and crotchet" is labelled as "ti-ti-ta" (Gerard & Auxiette, 1988, p. 173). Children associate a literary effect with the meaning with the sound (Gordon, 1984; Orff & Walter, 1963; Sándor, 1969). Association requires linking words with meaning and consequently labelling new ideas in a format or sound that is meaningful

to the child. This is the method used by music educators as they encouraged children to identify what they heard with rhythmic syllabic words (Gordon, 1984; Orff & Walter, 1963; Sándor, 1969). Children auralised the words in their mind and then "played back" the words in their mind to understand musical rhythm (Garner, 2009, p. 46). Audiation is based on how they sound and its primary importance is to associate the sound with the meaning by using simple verbalisation (Garner, 2009).

2.3.4 Verbalisation

Development in the concept of audiation (inner hearing) is enhanced by the verbalisation techniques used in the Kodaly Approach. Kodaly uses influences from Jaques-Dalcroze and raises rhythmic awareness by teaching children to walk in time to music, speak and/or sing the words to the rhythm, and stress the accented 'beats' of the music (Sándor, 1969). The results of this rhythmic training, has children clapping rhythms of a song to which they sing in their minds (silent singing), identifying a song from its rhythm, and singing and clapping the rhythm of a song as they sing rhythmic syllables (ti ti ta) instead of the words (Sándor, 1969).

Rhythmic syllables form the first stages of verbalisation and are commonly used in music education. Jordan-DeCarbo (1986) reports the significance of a child developing a vocabulary of rhythmic words in the early stages of learning music by associating appropriate labels to rhythm. A sound must be given a name and by incorporating the rote and repetition process, and listening and movement, rhythmic patterns are learned (Jordan-DeCarbo, 1986). This is demonstrated with a simple verbal association rhythmic exercise where both teacher and child would speak in time to the rhythmic beat they are patting on their knees (Jordan-DeCarbo, 1986). Both teacher and child

chant rhythmic patterns using “du” and “de” (developed by Edwin Gordon) to establish a rhythmic context as verbal association awareness is developed (Jordan-DeCarbo, 1986, p. 40).

Kodaly found natural rhythm in his native Hungarian folk-songs and used these as the basis to teach music to children (Sándor, 1969). Kodaly’s method of teaching used melody and singing as the primary importance stressing that teaching songs by ear formed the basis of musical literacy (Sándor, 1969). In the Kodaly Method, songs are learned by ear and then the rhythm of the song is taught. This method embeds the melody, pitch, rhythm and duration in the child’s memory and by seeing the rhythm notated, children are able to hear the song they have just sung by simply reading the rhythmic notation with pitch, melody and duration (Sándor, 1969). The end product is a reliable accurate ability to hear musical constructs in the inner ear that consequently strengthen musical memory and precise hearing (Sándor, 1969). Zoltan Kodaly referred to musical learning as an order sequence where visual symbols, rhythmic language, melodic language and melodic learning form the framework for music literacy (Shehan, 1987).

2.3.5 Improvisation and Music Literacy

Improvisation is termed by Jaques-Dalcroze as the final stage of music training (Seitz, 2005). Improvisation is the combination of meter, rhythm, tempo and movement enabling individual musical expressivity as the final development of musical engagement (Seitz, 2005). Moreover, Orff used improvisation to define the end product of incorporating all elements of music learning (rote and repetition, imitation, audiation, and verbalisation) (Orff & Walter, 1963). Improvisation is considered the ultimate

embodiment of music learning where children have taken all the skills they have learned to spontaneously create or perform music (Orff & Walter, 1963; Shehan, 1986). Shehan (1986) describes improvisation as the ultimate aim of Orff's philosophy as children uncover their understanding of music concepts through speech-rhymes, spontaneous movement and creative play.

The final stage to music education is music literacy; that is, "the ability to read and write music with understanding" (Brink, 1983, p.1). This is termed by the prominent music educator, Edwin Gordon in his approach to a sequential and stepwise approach to teaching (Gordon, 1984). This approach embraces five components of learning: listening, rote and repetition, verbalisation, pattern recognition, and then aural recognition (Gordon, 1984). First, at the listening level the sound repertoire is formed by rote teaching. This is then followed by verbal association where labels are given to sounds, and additional building blocks such as taping are used to enhance learning. These are all reinforced through patterns and sequences at the next level and accumulated in aural recognition involving more complex patterns and higher order cognitive processing (Gordon, 1984). Gordon created a system where all rhythmic patterns are subdivisions of a common pulse and termed this macro or micro beats. Macro beats are referred to as the basic pulse, and micro beats are referred to as divisions of the pulse (Brink, 1983). The micro beats allow for subdivisions so that the meter of the rhythm patterns are subjective to how the beat or pulse is 'felt'. This process of 'feeling' the rhythm is unique to each individual and forms part of the human ability to encode rhythm patterns from a very early age. Jaques-Dalcroze (1930) describes the process of encoding rhythm patterns as the human ability to convert "the

sensations afforded by the natural rhythms of our bodies [to] strengthen our instinct for rhythm and create rhythmic consciousness" (p.183).

2.3.6 Summary

The studies of the natural behaviours in children provide a framework for the way in which music educators are teaching rhythm (Gordon, 1984; Orff & Walter, 1963; Sándor, 1969). There is plenty of information and discussion about the various music methodologies in which rhythm is taught; however, the methods are all fundamentally the same and they all share important concepts; movement, audiation and verbalisation (Dalby, 2005; Gordon, 1984; Orff & Walter, 1963; Sándor, 1969). There are many views on the methods used in teaching and the order in which new information is acquired. Whether it is learning through listening and movement, rote and repetition, audiation and verbalisation, these stepwise approaches to acquiring new information have extraordinary meritorious value.

In summary, rhythm resides in the body and is perceived in various ways (Dalby, 2005). In music, rhythm provides a metrical framework to which beats per bar are measured to form patterns. These patterns then represent various rhythmic germs associated with pulse; 2/4 for instance represents a 'march', 3/4 a 'waltz' and so forth. Rhythm is found by the research to be everywhere and every thing has rhythm. Rhythmic behaviour is in speech, movement, heart-beat, and pulse. Rhythm is ubiquitous.

2.4 METHODS FOR LEARNING MORSE CODE

Morse code is made up of two notations; 'dits' and 'darts', also known as 'dots' and 'dashes'. In the Morse code, a 'dart' is equivalent to the duration of three repeated 'dits'

without any silence in between. In other words, the ‘dart’ is three times the duration of the ‘dit’. The ‘dits’ and ‘darts’ form letters, numbers and punctuation. When Morse code is transmitted as a letter, the space between each ‘dit’ and ‘dart’ is equivalent to the duration of a silent ‘dit’. The space between each word is equivalent to seven silent ‘dits’. A ‘dit’ can also be referred to as a ‘dot’ and a ‘dart’ can also be referred to as a ‘dash’ (Allan, 1958; Bryan & Harter, 1899; Taylor, 1943). Both Morse code notations are in Figure 2 below.

Figure 2: This is a ‘dit’ or ‘dot’ followed by a ‘dart’ or ‘dash’.

There are many approaches to learning Morse code, and some are more successful then others. This thesis will focus on the teaching methods and learning strategies of Morse code prior to commencement of the second World War and these methods are learning simple letters first, the visual method, the phonetic method (sound patterns), the synthetic method (whole elements) and the Koch method. This next section will also discuss the different skills required for sending and receiving Morse code, reported errors and difficulties in learning Morse code, automaticity (when the Morse code became automatic process) and aptitude testing.

2.4.1 Simple Letters First

Investigative studies dating back to the 1890s suggest that acquisition of Morse code started with learning simple Morse code letters in the initial stages of Morse code training (Bryan & Harter, 1897). Interestingly, these ‘simple’ letters are considered those that consist of ‘dits’ or ‘darts’ (Bryan & Harter, 1897). For instance, alphabet

letters such as *E* consists of one ‘dit’ (**.**) and the alphabet letter *I* consists of two consecutive ‘dits’ (**..**). Another example is the alphabet letter *T* that consists of one ‘dart’ (**_**). Complex Morse code letters are considered as those letters that consist of a combination of ‘dits’ and ‘darts’; those that are not consecutive ‘dits’ or consecutive ‘darts’. For instance, *J* ‘dit-dart-dart-dart’ **(. _ _ _**) and *Q* ‘dart-dart-dit-dart’ (**_ _ . _**) were considered “complex” letters of Morse code (Bryan & Harter, 1897, p. 28). Complex letters of Morse code are also identified due to the infrequency of the letter used in plain language (Taylor, 1943). Certain Morse code letters such as *X*, *Z*, *Q* and *J* were considered difficult for this reason. In other words, the difficult letters are referred to as those that are least frequently practised from whole words or sentences (Taylor, 1943). Figure 3 shows a breakdown of simple and complex Morse code letters as described by Bryan & Harter (1897).

Simple		Complex	
Alphabet	**Morse code**	**Alphabet**	**Morse code**
E	**.**	**J**	**. — — —**
I	**. .**	**Q**	**— — . —**
T	**—**	**X**	**— . . —**

Figure 3: 'Simple' and 'Complex' Morse code letters (after Bryan & Harter, 1897)

It is important to note that there are three types of Morse code language; American Morse code, Continental Morse code and International Morse code (Taylor, 1943). The Continental and International Morse code are identical, whereas there are some differences in American Morse code, most particular in Morse code numbers (Taylor, 1943). In short, these differences are found in the combination of 'dits' and 'darts' that form Morse code letters, not the 'dits' and 'darts' themselves (Taylor 1943). The differences, however, are not important to this thesis and will not be discussed. The only Morse code that is mentioned in this thesis refers to International Morse code.

The characters of Morse code have been mentioned; however, it is equally important to note the terms used when measuring the speed of Morse code transmissions. Transmissions of Morse code are measured in words per minute, also known as characters per minute. Taylor (1943) describes the measurement of words per minute where "approximately five characters constitute a word" (p. 462). Accordingly, to measure the approximate speed of the transmission one counts the number of characters sent in sixty seconds and divides this number by five (Taylor, 1943).

In Figure 4 below, ‘words per minute’ is referenced against milliseconds and provides a comparison of measurement in transmission speed and time.

Words per Minute	Milliseconds
12	1000
20	500
50	250

Figure 4: Comparison between Words per Minute and Milliseconds

In the initial stages of learning Morse code, the spaces between the characters of Morse code need careful consideration (Bryan & Harter, 1897). This means that by using the Morse code letter *Q* as an example, the space between each character (dits and darts) needs particular attention. As mentioned previously, the characters for the Morse code letter *Q* is shown as ‘dart-dart-dit-dart’ **(_ _ . _)**. In the early stages of learning to receive this Morse code letter, the space between each letter is extended so that the focus of learning is on the characters of Morse code, not the speed of the transmission (Bryan & Harter, 1897). A learner would receive a transmission such as ‘dart-long silence-dart-long silence-dit-long silence-dart’ **(_ _ . _)**. As the learner gains confidence, the gaps between the characters are reduced so the letter of Morse code is heard in its entirety. For instance, ‘dart-short silence-dart-short silence-dit-short silence-dart’ **(_ _ . _)**.

The Morse code characters remain at the same duration or length, only the space between the letters change (Bryan & Harter, 1897). This means that during these early

stages of learning Morse code, the transmissions of the actual Morse code characters will be at 20 words per minute (wpm), but the silence between each letter is much slower, at approximately 2 wpm (Bryan & Harter, 1897). This generates sufficient silence between the Morse code letters for the student to think about what they had just heard, to then label this letter before the next Morse code transmission is heard (Bryan & Harter, 1897). Hence, the silence between the Morse code characters is decreased so that the whole letter emerges allowing the student to no longer think of the Morse code letter consciously; it becomes automatic as if reading printed material from a book (Bryan & Harter, 1897). The student then starts to build a vocabulary of Morse code letters and is able to recognise, and distinguish, frequently occurring words such as *the*, *and* and *is* before understanding other letters (Bryan & Harter, 1897). According to Bryan & Harter (1897), it would take between two and two and a half years to become an expert Morse code operator.

2.4.2 The Visual Method

During the visual method of learning Morse code, students are given printed Morse code notation on cards (Thurstone, 1918). These notations consist of letters of the English alphabet in the form of 'dits' and 'darts'. Students are then required to copy the letters down on a blank piece of paper until memorisation (Thurstone, 1918). Students learn the Morse code letters in the form of 'dits' and 'darts' as opposed to sound and rhythm (Thurstone, 1918). The popularity of the visual method sustained through to post second World War as it continued to be a very important 'first step' in learning Morse code (Taylor, 1943). In the visual method, charts of Morse code characters of 'dits' and 'darts' are given alongside their corresponding alphabet letters (Taylor 1943). (see Figure 5). This chart is then used for memorisation with regular practice of the

Morse code with meaningful material, (complete sentences) and then increasing the speed until the desired speed is reached (Taylor, 1943).

Letter	Morse code notation
A	· —
B	— · · ·

Figure 5: Visual Method Notation Chart

Post second World War, the visual method of learning Morse code provides an instant memorisation tool and this alone makes it a very useful learning tool (Allan, 1958). This method in learning Morse code also involves memorisation of Morse code letters where the student will hear the Morse code letters tapped out slowly by the instructor (Allan, 1958). The sounds are then matched up to what is on the card, with increasing speed until the desired speed (or reception) is reached (Allan, 1958). The speed involves slowing down the entire Morse code transmission, hence the duration of the 'dit' and 'dart' is scaled to reflect the metrical accuracy of Morse code transmissions. This slower speed is approximately 4 words per minute (Allan, 1958). This approach to learning Morse code focuses on the separate characters of 'dits' and 'darts'; however, Morse code letters are mostly represented by a combination of these characters.

Prior to the second World War, there were criticisms of the visual method that raised fundamental concerns with regard to learning what was essentially an auditory medium, without sound (Thurstone, 1918). To combat this, teaching and learning Morse code with sound was established by the introduction of the phonetic method.

2.4.3 The Phonetic Method – sound patterns

In the phonetic method, students refrain from any visual stimuli, but rather focus on the interpretation of the auditory patterns of the Morse code letters (Thurstone, 1918). These auditory patterns, or sound patterns, form the basis of the material for learning Morse code. Practice of the phonetic method requires a sender of the Morse code letter (as well as a receiver), so practice time for this is limited to the classroom (Thurstone, 1918). These practice times involve drill sessions where the primary focus is on sound and rhythm, and later on the interpretation of the auditory sound patterns (in other words, identifying the auditory patterns as Morse code letters) (Thurstone, 1918). The phonetic method was later established as the pattern recognition method, termed later as the Gestalten Method (Allan, 1958). The pattern recognition method starts with an auditory form of the Morse code letter and when the student hears the Morse code letter, they copy the letter name from the teacher's marking on the blackboard (Allan, 1958).

2.4.4 The Synthetic Method – whole elements

The focus of the Synthetic Method encapsulates the whole understanding of the Morse code letters, as opposed to the individual characters of the letters (Thurstone, 1918). The concept of the Synthetic Method involves learning a short list of words so that the student becomes familiar with the Morse code letters that create the words (Thurstone, 1918). As the student becomes more familiar with the words, additional words are added and the focus for the student is to differentiate between short words and practise recognising whole words, instead of the individual Morse code letters of the word (Thurstone, 1918). The Synthetic Method is also known as the Gestalten approach (pattern method) (Allan, 1958). It is mentioned here, although post second World War, to establish that leading up to the second World War the concept of the Gestalten

approach (whole elements) as the learning strategy for Morse code was formulating. The Gestalten approach considers the whole sound of Morse code and proposes that beginners of Morse code learn this whole sound approach in the first stages, as oppose to the analytical approach of single Morse code characters (Allan, 1958). The Gestalten approach also outlines that the transmission of Morse code characters should be at a faster speed, and slower speeds used between each Morse code letter, as opposed to the individual characters (Allan, 1958). For instance, the letter *A* consists of a 'dit' followed by a 'dart'. Therefore, it has two Morse code characters, a 'dit' and a 'dart'. At a slower speed, the space between the 'dit' and 'dart' will be shorter so that it is consistent with the whole letter. The slow speed comes after the 'dart', that is at the completion of the whole transmission of the Morse code letter.

Allan (1958) conducts an experiment to investigate the effectiveness of the analytical approach (single elements) to learning Morse code with 64 personnel from the Royal Air Force. At a speed of 20 words per minute, participants are taught the Morse code alphabet by the phonetic method (sound patterns). The intervals between each Morse code characters are seven seconds. The instructor writes Morse code letters on a blackboard as they are heard by both students and instructors, and the students copy these Morse code letters down on a piece of paper. Students are not permitted to memorise the Morse code letters from visual stimuli or study materials, rather they had to listen to the whole characters to establish an association between the Morse code sound and the Morse code letter (Allan, 1958). A control group is also established consisting of 71 participants trained by the analytical approach (single elements) to learning Morse code. Results show that the participants who learned from the phonetic

method (sound patterns) revealed a significantly higher success rate of learning Morse code than those participants who learned from the analytical approach (single elements).

Learning Morse code involves a hierarchical order of learning to identify letters of Morse code first, then longer elements of Morse code in the form of words, and finally in the form of sentences or phrases (Taylor, 1943). Students are initially given a visual chart of the Morse code with their corresponding letter in patterns of dots (dits) and dashes (darts) and are required to memorise the chart (Taylor, 1943). The Morse code chart included the English alphabet (letters), numerals (numbers), two and three-letter procedure signals (coded signals), punctuation (comma and full-stop) and procedure signs (with terms such as ‘repeat’, ‘erase’ and ‘negative’) (B.R 98 Boat’s Signal Book, 1935). An example of the Morse code chart used prior to the second World War is shown in Figure 6.

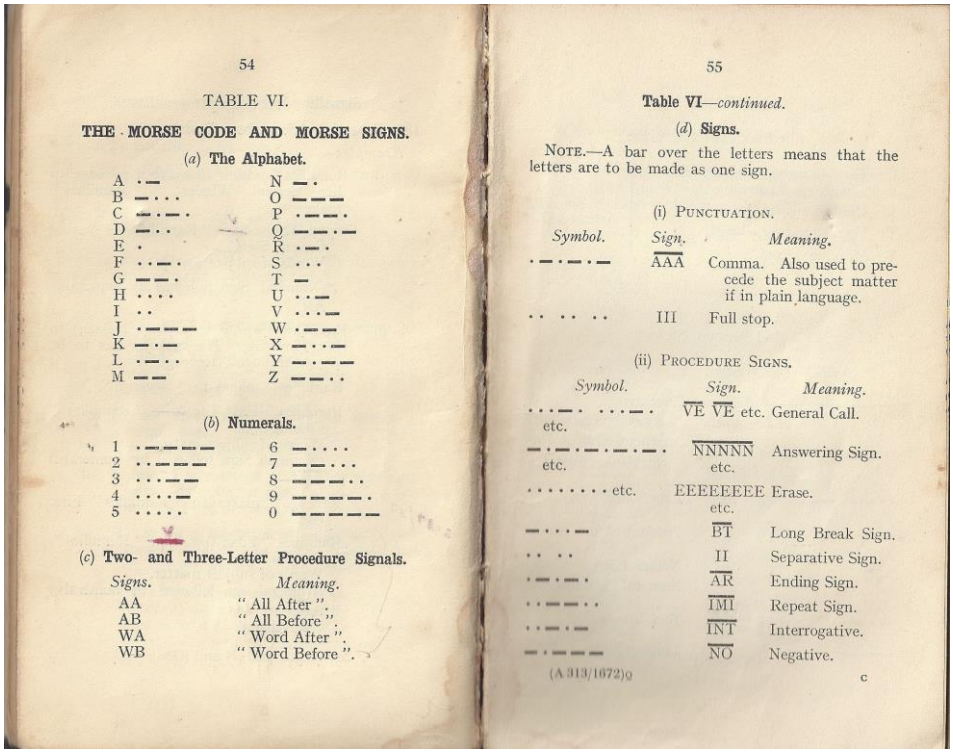

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TABLE VI.

THE MORSE CODE AND MORSE SIGNS.

(*a*) **The Alphabet.**

A	·—	N	—·
B	—···	O	———
C	—·—·	P	·——·
D	—··	Q	——·—
E	·	R	·—·
F	··—·	S	···
G	——·	T	—
H	····	U	··—
I	··	V	···—
J	·———	W	·——
K	—·—	X	—··—
L	·—··	Y	—·——
M	——	Z	——··

(*b*) **Numerals.**

1	·————	6	—····
2	··———	7	——···
3	···——	8	———··
4	····—	9	————·
5	·····	0	—————

(*c*) **Two- and Three-Letter Procedure Signals.**

Signs.	*Meaning.*
AA	"All After".
AB	"All Before".
WA	"Word After".
WB	"Word Before".

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Table VI—*continued.*

(*d*) **Signs.**

NOTE.—A bar over the letters means that the letters are to be made as one sign.

(i) PUNCTUATION.

Symbol.	*Sign.*	*Meaning.*
·—·—·—	$\overline{\text{AAA}}$	Comma. Also used to precede the subject matter if in plain language.
·· ·· ··	III	Full stop.

(ii) PROCEDURE SIGNS.

Symbol.	*Sign.*	*Meaning.*
···—· ···—· etc.	$\overline{\text{VE}}$ $\overline{\text{VE}}$ etc.	General Call.
—·—·—·—·—· etc.	$\overline{\text{NNNNN}}$ etc.	Answering Sign.
····· etc.	EEEEEEEE etc.	Erase.
—···—	$\overline{\text{BT}}$	Long Break Sign.
·· ··	II	Separative Sign.
·—·—·	$\overline{\text{AR}}$	Ending Sign.
··——··	$\overline{\text{IMI}}$	Repeat Sign.
··—·—	$\overline{\text{INT}}$	Interrogative.
—·———	$\overline{\text{NO}}$	Negative.

(A 313/1672)9 c

Figure 6: An extract of the Morse code Chart from the B.R 98 Boat's Signal Book (1935)

In the next stage, the students receive meaningful sentences, taken from a current magazine or similar literature, and then the speed of the transmission of these meaningful sentences is increased (Taylor, 1943). Due to an increase in unsuccessful Morse code operators, a change in methodologies is implemented where the learning of whole words and sentences is changed to learning individual characters, or single letters only, visual symbols are avoided and meaningful sentences are replaced by nonsensical written material (Taylor, 1943). This is established so that the students will focus on the individual letters and not their meaning (Taylor, 1943). The students will start with slower speeds, approximately 6 words per minute, but the duration of the dots and dashes are proportionately lengthened, thus altering the lengths of the Morse code

letters. As a result, students begin to process the Morse code letters more analytically, and incorrectly, by counting dots and dashes (Taylor, 1943).

Researchers then argue that students must be taught the Morse code letters as rhythm patterns from the very start where the duration of the dots and dashes remain the same; however the space between the letters is increased to assist with the slower speed at learning the Morse code (Taylor, 1943). Nonsense material is used to avoid students guessing what the next letter will be, and the individual characters are learned at 20 words per minute, whereas the overall nonsense message is transmitted at 6 words per minute (with more space between the words, not the characters) (Taylor, 1943). Therefore, the proficiency of Morse code characters are measured by the number of words an operator can send (or transmit), or receive, per minute (Taylor, 1943). Taylor (1943) describes the measurement of a word by five characters, in other words, the speed of the transmission was calculated by the number of Morse code characters sent in one minute, divided by five (Taylor, 1943).

2.4.5 Koch Method

Prior to the second World War, one of the most successful approaches in learning Morse code is the Koch method (Taylor, 1943). The Koch method starts with two characters and then once this is learned, a new character is added, and finally the student is given more characters until the entire alphabet is covered (Taylor, 1943). The outcome is that the student can confidently receive the entire alphabet of Morse code letters at 12 words per minute (Taylor, 1943). Koch implemented a strategy to assist with the organisation of the individual characters (‘dits’ and ‘darts’), so students could use pitch discrimination in learning Morse code characters (Taylor, 1943). Koch

constructed an automatic transmitting device for Morse code where the ‘dits’ and ‘darts’ are transmitted at different frequencies (different tones) and as the students become more confident with the Morse code characters, the closer in pitch the ‘dits’ and ‘darts’ would merge until ultimately, they are at the same frequency (Taylor, 1943). Koch also proposed that the most productive practice periods of Morse code is thirty minutes in the morning and thirty minutes in the evening (Taylor, 1943).

In his research, Koch experiments with four expert Morse code operators and tests the operators with nonsense messages (random letters) consisting of 30 Morse code characters at varying speeds ranging between 5 – 20 words per minute (wpm) (Taylor, 1943). Surprisingly, the expert Morse code operators are unable to identify all Morse code characters on the slower speed (5 wpm), reporting only 5 – 8 correct Morse code characters (Taylor, 1943). However, these expert Morse code operators are able to correctly identify all 30 Morse code characters at the faster speeds (10 – 20 wpm) (Taylor, 1943). Koch performs an additional experiment with the expert Morse code operators where the distance between the Morse code characters in the slower speed (5 wpm) is increased, and this resulted in a higher accuracy rate then previously (Taylor, 1943). This led Koch to support the Gestalten approach (whole elements) of learning Morse code where, at approximately 10 wpm Morse code characters are perceived as whole elements (Morse code letters) as opposed to individual elements (Morse code characters - ‘dits and darts’).

Historically, the research of learning and teaching approaches to Morse code suggests that learning Morse code evolved as the teaching strategies and technologies developed

(Thurstone, 1918; Taylor, 1943; Allan, 1958). For instance, the initial stages of learning Morse code involved learning 'simple' letters first, learning Morse code characters with visual stimuli, learning Morse code sound patterns with auditory stimuli, and then grouping the Morse code letters together through a synthetic approach where individual letters were recognised as parts of words (Thurstone, 1918; Taylor, 1943; Allan, 1958). Learning Morse code during wartime presented ongoing challenges as researchers searched for the most successful method to learn Morse code. More recently, researchers examined the most effective strategy to not only learn Morse code, but to retain the Morse code over a period of time.

2.4.6 Retention and memory of Morse code letters

The search for the most effectual strategy to learn Morse code letters still intrigues researchers (Clawson, Healy, Ericsson, & Bourne, 2001). Clawson et al (2001) describe two distinct components of Morse code as represented in single elements (where Morse code is learned as a collection of single entities – similar to that of the analytical approach described by Allan (1958) and Taylor (1943) and pattern elements (where Morse Code is learned as a unit – similar to that of the synthetic approach described by Allan (1958) and Taylor (1943).

Clawson et al (2001) investigate methods on retention and memory for Morse code letters in novices and define two sets of Morse code letters, "easy" and "difficult" (Clawson et al, 2001, p. 131). The level of difficulty is based on two and three-element codes, and the reverse patterns of Morse code letters (Clawson et al, 2001). For instance, the easy Morse code letters are defined by two-element codes (dit-dart) and three-element codes (dit-dit-dit) and difficult Morse code letters are defined as reverse

pattern two-element and three-element codes, eg (dit-dart) and (dart-dit), and (dit-dit-dart) and (dart-dit-dit) (Clawson et al, 2001). An example of the easy and difficult Morse code letters described by Clawson et al (2001) is shown in Table 3.

Table 3: 'Easy' and 'difficult' Morse code letters (after Clawson et al, 2001)

Easy		Difficult	
Alphabet	**Morse code**	**Alphabet**	**Morse code**
I	**. .**	**A**	**. —**
M	**— —**	**N**	**— .**
S	**. . .**	**D**	**— . .**
O	**— — —**	**G**	**— — .**
R	**. — .**	**U**	**. . —**
K	**— . —**	**W**	**. — —**

In their research, Clawson et al (2001) investigate the effects of part-whole training of Morse code letters with novices, in other words whether it is more effective for novices to learn 'easy' Morse code first, or 'difficult' Morse code letters first, or both at the same time. Novices are initially trained on only one set of 'easy' or 'difficult' Morse code letters, and later are trained on the whole set of all twelve Morse code letters (shown in Table 3). Participants are tested over a three-day period for learning the Morse code letters and then retested 4 weeks later by the same initial stimuli. Results show that there is a distinct disadvantage for learning 'difficult' Morse code letters first and Clawson et al (2001) suggest that this could be due to the perception of segmenting

the Morse code elements as ‘dits’ and ‘darts’, where training with the ‘easy’ Morse code letters first novices could quickly form a pattern of the Morse code letter and perceived this as a whole unit.

2.4.7 Sending versus Receiving Morse code

Sending and receiving Morse code transmissions requires different skills (Bryan & Harter, 1897; Taylor, 1943). There is comparable evidence that sending and receiving Morse code is unique and requires a different approach in learning both skills and executing both abilities (Taylor, 1943). Taylor (1943) report that students learn to send Morse code much faster then to receive Morse code. “Expert operators can receive more rapidly than they can send” (Taylor, 1943, p. 474). It was impossible to send Morse code flawlessly; however, the deviation between sending ‘dits’ and ‘darts’ of Morse code between operators was not random (Taylor, 1943). Bryan & Harter (1897) proclaim that senders of Morse code have a distinct style of sending. This means that the senders of Morse code develop a style in sending Morse code that is recognisable to the receiver, with whom they would work with regularly (Bryan & Harter, 1897). This deviation in style of sending Morse code is easily recognised by other operators and is reported as also identifying that the sender of Morse code is actually one of the operators and not an imposter (Bryan & Harter, 1897). The deviation is unique to each sender and creates a distinctive style of sending (Bryan & Harter, 1897).

2.4.8 Reported Errors and Difficulties in learning Morse code

Bryan & Harter (1897) report that students preferred to practice sending Morse code rather than receive Morse code. Receiving Morse code is also referred to “copying behind” (Bryan & Harter, 1897, p. 32) and this signifies that receivers of Morse code

would guess ahead and anticipate, from only a few characters of Morse code ('dits' and 'darts') what the rest of the message would be (Bryan & Harter, 1899). In telegraphic language, Bryan & Harter (1899) propose that rhythm in reading is a probable aid to making and learning new phrases and sentences, providing that the particular rhythm of such words is maintained. Bryan & Harter (1899) believe that in the initial stages of learning Morse code, it is crucial to learn the individual letters of Morse code before moving on to words, sentences and phrases. According to Bryan & Harter (1899) it is important to learn all the units of Morse code in their proper setting, that is to learn letters first and then words.

The age by which one learned Morse code is reported as "before the age of eighteen" (Bryan & Harter, 1897, p. 35). According to Bryan & Harter (1897) it is very difficult, or impossible, to become an adequate operator of Morse code after the age of thirty, and it is noted that the maximum age of retaining these skills is sixty-five. Intense practice and systematic effort is required to maintain high standards, as inferior operators are not accepted (Bryan & Harter, 1897). Therefore, according to Bryan & Harter (1897), a systematic approach to the task of learning, and automatic habits, or automaticity, of Morse code is deemed essential to ultimate mastery.

2.4.9 Automaticity

Bryan & Harter (1899) maintain the importance of achieving automaticity in the Morse code alphabet and vocabulary as a fundamental mastery of the telegraphic code. Through memorisation and incidental practice, it is proposed that automaticity is achieved and that without automaticity, the mastery of Morse code is unlikely (Bryan & Harter, 1899). Automaticity refers to the point in which the receiving and/or sending of

Morse code become automatic and no longer a conscious act (Bryan & Harter, 1899). According to Taylor, (1943), automaticity is achieved at approximately 10 wpm. Below this speed (10 wpm), students break down the Morse code characters as individual entities and no longer perceive groups (Taylor, 1958).

2.4.10 Aptitude

Aptitude testing involves general schooling, age, and mental tests and is required for all telegraphists and the results show that aptitude for telegraphy is not dependent on general schooling, suggesting that learning telegraphy is a special ability (Thurstone, 1919). Age does not show any significant relevance to aptitude for telegraphy, although older students report as more likely to persevere with the monotonous testing (Thurstone, 1919). The age range studied in Thurstone (1919) is limited to 21 and 31 years. Students are tested in eight areas such as rhythm, opposites, arithmetic, sentences, spelling, Gordon Directions test (the speed in Morse code learning after 100 hours of training), Trabue Completion Test (a general intelligence test) and analogies (Thurstone, 1919).

The most significant correlation between achievement in Morse code and aptitude testing is the rhythm test (Taylor, 1943; Thurstone, 1919). Rhythm is tested using a buzzer and telegraphic key (Thurstone, 1919). In Thurstone's (1919) study, students are given a repeated audio rhythm pattern consisting of 'dits' and 'darts' and the rhythm patterns are categorised as simple and difficult, a simple rhythm pattern is one 'dit' and one 'dart' and a difficult rhythm pattern is several 'dits' and 'darts'. The rhythm patterns are played at approximately 10 wpm and the overall test takes about 15 minutes. The student is then required to reproduce all 35 rhythm patterns on a blank

piece of paper using a horizontal line for a ‘dart’ and a short vertical line for a ‘dit’, and the final score is determined by the amount of errors made (Thurstone, 1919).

2.4.11 Summary

There is no clear instruction as to the definitive teaching and learning method for Morse code. Learning Morse code presents unique challenges that bewildered teachers and students, experts and novices as they strive to make sense of the complexity of Morse code. The reduction of speed by transmitting in less words per minute (Taylor, 1943), changing the frequency so ‘dits’ and ‘darts’ are on two separate pitches (Taylor, 1943), starting with words, then sentences (Bryan & Harter, 1899), and looking for patterns in the Morse code elements (Allan, 1958), and the order and categorisation of learning ‘easy’ first or ‘difficult’ Morse code letters first (Clawson et al, 2001), all influence the skill acquisition of Morse code but does not provide a unified solution. It seems there is no conclusive method to teach and learn Morse code, and the attempts to formulate the ultimate strategy or methodology for learning and teaching Morse code is futile.

3 THE WRANS

With the impending arrival of the Second World War, Australia braced for emergency plans and action. Ordinary Australians assisted in ammunition, food supplies, nursing and medical treatment, driving duties and mechanics, but there were also many who learned wireless telegraphy skills (Fenton-Huie, 2000). Wireless telegraphy skills were learned from a key group of volunteers. These volunteers formed the Women's Emergency Signalling Corps (WESC). The WESC was developed in 1939 and continued through to the commencement of the Second World War. The WESC learned electrical engineering, wireless telegraphy, radio communications and Morse code. The women were so proficient; their skills were drawn on to teach Police officers, airmen and soldiers and other military personnel from many regions including India, the United States of America and Australia (Fenton-Huie, 2000).

War was imminent and there was a shortage of shore-based men for military duty. Despite political debate, these women replaced men in shore-based communication roles so that the men could then be spared for combat and sea duties. The WESC were employed as wireless telegraphists and Morse code operators for the Royal Australian Navy. These women formed, and served, in the Women's Royal Australian Naval Service (WRANS) as Morse code operators and kept duties like regular military personnel throughout the war (Fenton-Huie, 2000). The women were trained in electrical engineering, radio communications and Morse code and were solely responsible for transmitting secret messages, creating shorthand signal codes, and intercepting foreign code (Fenton-Huie, 2000). The younger WRANS (postwar) are

now in their 70s whilst the Second World War WRANS are now in their early 90s. It is important to me that I capture the history and stories of these remarkable women at a time when it is all still in their memory. I was concerned that revisiting wartime operations may evoke memories for the women that were fearful, but to the contrary, my research was greeted with an eagerness to share fond memories that were created from the unbreakable sisterhood that still exists today.

The women were guided by the teaching methods of their founder, Mrs Florence Violet McKenzie; affectionately known to them as "Mrs Mac". Mrs Mac became legendary and innumerable men and women from services such as the Australian Army, Royal Australian Air Force, Police Officer and military personnel from many countries around the world (such as India and the United States of America) all learned Morse code from Mrs Mac and her girls (Fenton-Huie, 2000).

3.1 Mrs Mac the Educator

Legendary Mrs Florence Violet McKenzie established the wartime teaching regime of Morse code and wireless telegraphy. From 1939, Mrs Mac, an electrical engineer herself, had a warehouse in Clarence Street Sydney where she started her school in Morse code (Fenton-Huie, 2000). To accelerate their learning, Mrs Mac drew on all resources available to her. She designed mnemonics, rhymes and games for the women. She would make these up herself, and have the women make up their own. Mrs Mac was not a musician, but also used music to teach specific Morse code letters. Her teaching methods were resourceful and creative. Morse code became a way of life for the women (and men) who learned from Mrs Mac; however, little is known about her extraordinary teaching style.

The Women's Royal Australian Naval Service (WRANS) trained and served as wireless telegraphists during wartime and peacetime and used Morse code as a very efficient communication method to send messages with speed and accuracy. Their teaching methods and learning strategies of Morse code were unique and formed an applicable training regime for many people learning Morse code. These women were regular Australians who devoted many years to serving in Australia's military. These training methods of Morse code are compelling and are still used to coach wireless telegraphists today.

Wartime women carried out duties of significant importance and this research focuses on the wireless telegraphy skills of a key group of women, the WRANS. The purpose of this research is to investigate the teaching methods of Mrs Mac from the women who learned Morse code from her and to test these methods on novices.

4 PROJECT 1: MORSE CODE IN WAR TIME

What strategies did Mrs Mac use to teach Morse code? How did the WRANS learn Morse code? Did the women need to show aptitude for learning Morse code? Can anyone learn Morse code? What inspired these women to learn Morse code in time of war? Little is known about what actually happened during the training and learning of Morse code during the second World War and Post-war. This study was designed to investigate the teaching strategies of Morse code from Mrs Mac and the WRANS. The purpose of Project 1 is to report the teaching strategies and learning methods from Mrs Mac the WRANS.

4.1 METHOD

Ethics

The institutional Human Research Ethics Committee approved the project. Ethics documentation is located at Appendix A, Information Statement at Appendix B and Consent Form at Appendix C.

4.1.1 Participants

Five wireless telegraphists and Morse code operators from the Ex Women's Royal Australian Naval Service Association of New South Wales took part in the Project. Their ages ranged from 69 years to 92 years. The women served during the second World War and Post-war. Follow on interviews involved two women Jean Nysen and Diana Avent. Table 4 below, introduces the WRANS, their wartime service and a short description of how they learned Morse code. Participant's voices are recorded in italics.

Table 4: Details of service and training methods of Morse code operators (WRANS) - Project 1

Name	Service	Duties	Learned Morse code	How?
Jean Nysen	WWII	Telegraphist	Mrs Mac (WESC)	There is only one way to learn Morse code. You learn the alphabet and keep up the practice with someone sending to you with increasing speed until it becomes a natural reaction.
Marion Stevens	WWII	Telegraphist	Mrs Mac (WESC)	Maintain practice
Elizabeth Watts	Post-war	Telegraphist	RAN Signal School, HMAS *Cerberus*	Listening to Morse through earphones and typing onto paper. Slowly at first and then faster as my skills increased. We also learnt to send Morse.
Rona Jarrett	Post-war		Self taught from aged 10 years, then the RAN Signal School, HMAS *Cerberus*	Basically rote learning that was reinforced with the Guides then Sea Rangers and then as a WRAN. With WRANS I only remember learning procedures, typing etc. and joining Morse to typing.
Diana Avent	Post-war	Morse Operator	RAN Signal School, HMAS *Cerberus*	Written in dot and dash form then by listening to a transcribing tape at progressively faster speeds.

4.2 Design

A qualitative design was chosen for this study. The design was to report the teaching and learning methods from Mrs Mac and the WRANS through focus groups discussions and follow on interviews.

4.2.1 Materials

An Interview Schedule was used to guide focus group discussions. Video and audio recording devices were used to capture any patterned behavioural observation. Each participant was required to fill out a questionnaire indicating their age, WRAN identification number, their primary role in telegraphy as coder, transmitter or receiver, and an indication of prior music training.

Stimuli

The recordings of Morse code were generated from an online Morse code translator designed by Stephen Christopher Phillips (2013) where a 'dart' is equivalent to three 'dits'. The audio recordings of the Morse code letters were pre-recorded at 700 hertz and at 22 words per minute (wpm). The Morse code excerpts ranged in complexity and combined all letters of the English alphabet. For instance, 'the five boxing wizards jump quickly'.

4.2.2 Procedure

Focus Group Discussion

The focus group discussion was held at the conclusion of a regular monthly meeting held by the Ex-WRANS Association In New South Wales. The meeting took place in the City of Sydney RSL Club. The women reflected on their service as wireless

telegraphists during wartime and peacetime with their love and passion for Morse code, and their unique sisterhood and lifelong friendships. An interview schedule was used as a guide to initiate conversation-type focus group discussions for the women to share experiences of their wireless telegraphy duties during wartime and post war. The interview schedule consisted of four main topics; Learning Morse code, Practising Morse code, Games for learning Morse code, and Rhythm Pattern exercises used to learn Morse code. Discussions lasted between 45 and 60 minutes.

Follow-on interviews

Two women volunteered for follow on interviews. These two women represented wartime WRANS and post war WRANS and provided a comprehensive account of the various themes prompted from the focus group discussion. The follow on interviews were based on the same interview schedule used to guide the focus group discussions; however, these follow on interviews allowed the two women to expand on the responses they provided earlier in the focus group discussions. During the follow on interviews, the women were asked to decipher some short Morse code excerpts. The follow on interviews lasted between 60 and 90 minutes.

4.3 RESULTS

The main themes emerging from focus group discussions and interviews are summarised by four main areas; learning Morse code, encoding Morse code, grouping Morse code, and errors in learning Morse Code. The commonly reported phrase from these women is that learning Morse code during their time of military service *was fascinating, fun ... and some of the best years of my life (Jean).*

4.3.1 First stage of learning Morse code

To open the focus group discussion, I asked the women if they could describe to me the initial stages of learning Morse code. I wanted them to describe the process of learning Morse code and to teach me Morse code using the same methods and in the same way they had learned. I wanted to follow their footsteps in the very first stages of learning Morse code and to emulate this process. The women served in different times of war and peace. The sense of urgency with the wartime WRANS implied that there was no time to understand how they were going to learn or teach Morse code, they just had to get on with it and get on with it quickly. The post-war WRANS had a little more time to structure the learning and teaching of Morse code where the necessity to acquire Morse code skills quickly was less of a primary focus. Regardless of whether the sense of urgency was a primary factor in learning and teaching Morse code, the two approaches by both wartime and post-war WRANS were very similar. For all the women, learning Morse code started slowly and with single phonetic letters. They would start with the letters of the English alphabet *A*, then *B* and so on. Once the alphabet letter was learned, more letters were added, then numbers and finally punctuation. The initial stages of learning Morse code were very basic but fun in nature. The importance was placed on learning individual letters of the English alphabet, including punctuation.

The women described to me how Mrs Mac set up the room so that you progressed in stages. The room was set up like a schoolroom with desks in rows. You would progress from one desk to another desk and each desk would have a Morse code operator transmitting various words at faster and faster speeds (words per minute). The person sending the Morse code on each table would transmit the Morse code at one particular

speed. The various stages at which you were able to receive and transmit Morse code were measured in words per minute (wpm). The natural progression of stages was increased by words per minute (wpm) to develop speed and accuracy.

> *Jean: You would start off as a beginner, then you go to two words per minute and then when you could do that comfortably you go to the six words per minute table and work up to the one that went ... brrrrt (really fast Morse code) ... that would be Marion Stevens from the top table sending something from today's paper ... sort of thing.*

During this initial stage of discussions, the women described their learning of Morse code with casual deliberation. To start with, *you have the letter and then the 'dit-dart' then 'A' then 'B'...'dart-dit-dit-dit'* and then *"after a while, like learning anything at all, you get to learn the words ... (Jean)*. Jean sang the Morse code letters as she explained the individual characters of 'dits' and 'darts'. Morse Code was transmitted on paper tape. You would *start off with the tapes really, really slowly like one letter at a time. And when you got that class, then on to another one... jumbling them up and then quite quickly, within six weeks, everybody would be up to about 18 wpm (Diana).*

The women were keen to explain how Morse code actually works, so during these initial stages of learning the letters, and to engage the women in more detailed explanations of learning Morse code, I wondered if the women had to know more about Morse Code in addition to the phonetic letters and codes.

It was important in the initial stages of learning Morse code to think of it in every way possible. Morse code has been linked to every day activities such as knitting. In the same way that knitting has knit one- pearl one, *we have with Morse, dits and darts. So it is amazing what you can do with two things (Jean).*

Whether it be knitting or mathematics, the women explained to me that it was important to constantly revisit Morse code in every opportunity. They would think of Morse code *in the shower (Diana)* where the pattern of the drops of water cold be translated into Morse code. They would assist each other with rote learning, relentlessly repeating Morse code at every opportunity. The women would intone through the English alphabet in Morse code as a way of reciting it to themselves. This way they would be *hearing (Diana)* the Morse code in everyday sounds. The initial stages of learning Morse code involved strategies such as rote learning, repetition and audiation. This chapter will discuss each of these learning strategies from the perspectives of the women.

4.3.2 Rote learning

The rote style of learning Morse code was utilised by the WRANS in the very early stages. The women would start by learning one letter at a time with Morse code tapes at a very slow speed (approximately two words per minute). During my interview with Diana, she described to me the teaching strategies she used in her Morse code classes.

> *Diana: Rote learning and then starting off with the tapes really, really slowly like one letter at a time.*

Eventually, the speed of the tapes would increase, as did the number of letters you would learn. The speed of the tapes increased as you became more familiar with the Morse code. During the practising of Morse code, *the tempo was increased gradually but quite consistently* to *cut out the thinking process until it became a reflex (Diana).*

The initial stages of learning Morse code required time to think. You would start *by writing the alphabet then putting the symbols which were dits and darts beside the letters (Diana).* There was no formula to the order in which the letters were learned. This was because there was not any reason to learn the letters alphabetically, or according to Morse code patterns. The women identified that because Morse code was rarely associated with plain language, it was not necessary to learn the Morse code letters in a particular order. Morse code as mostly associated with signalling codes and other 'short hand' codes that were learned, not plain language. Learning plain language did not help or hinder their progress in learning Morse code. The key was to identify the letters, and then *go over it in your head (Diana).* According to Diana and Jean, the most effective way to learn Morse code was by repetition.

4.3.3 Repetition

When asked if there were particular methods or special techniques used to practise Morse code, the women would respond with one most frequently used method, *there was only one way and that's practice, practice, practice. (Jean).* Mrs Mac used her skills as an electrical engineer and wired up her building in Clarence Street, Sydney, so that the women could practice sending Morse code to each other. The women would be on the first floor of the building and sending Morse to other women on the second floor. They were in different rooms and different floors. They would practice sending Morse

code and receiving Morse code. They would practice this at every opportunity. Sometimes the women would practise Morse code with each other, and test each other. *I would be sitting on a key and I would go 'dit dit dit dah' and you would write 'V' (Jean).*

> *Diana: It was just pure repetition until it became a reflex, rather than you know at first you are thinking about it, because you have time to think about it, but when you don't have time to think about it… it's just bang, bang, bang, (tapping Morse rhythm on the table) and that's how it went on .*

The women did not mention a 'cheat sheet' or some similar aid to assist with learning Morse code. When I cheekily enquired if there was a short cut or some way to by-pass some of the trickiness of Morse code, the women were confused. There was no method to expedite their learning and any suggestion that a design or model arm existed as a guide for Morse code teachings or instruction was robustly denied by the women. At the same time as our focus group discussions, the women were approaching the author to nullify these claims. It was a sensitive topic with the women and was not mentioned again. The women all attribute their wireless telegraphy skills to the teachings of Mrs Mac and her ingenious approach.

> *Jean: Some people have said that Mrs Mac designed a model arm which simplified the teaching of Morse. This is not true as I learned to operate Morse code in WESC (Women's Emergency Signalling*

> *Corps) in December 1941, and then taught it to others and then joined the Navy in June 1942. I asked Marion Stevens (WRAN Number 5) who was one of the very first to join WESC if she knew anything about a 'Model Arm' and she assured me there was no such thing.*

Practice was not limited to wartime service. Even after the war, some of the women maintained their skills in sending and receiving Morse code. They would practice on telegraphic keys *incase they were needed for war duty again (Jean).*

> *Jean: Sue and Marion both had keys. Sue (Rogers) and Marion (Stevens) were both in Molonglo with me. And they use to sort of keep up their practice… just for the fun of it… and they loved it.*

Marion Stevens was in command of the wireless telegraphy station *Molonglo*, in Canberra. Molonglo Naval Wireless Station held significance to the women as this was the only wireless telegraphy station manned solely by the WRANS during the second World War.

Some of the women learned Morse code directly from Mrs Mac and then passed on their teachings to the next generation of wireless telegraphists. A common approach used throughout the generations was the method of converting written text into Morse code.

Jean: When you are learning it you look everywhere ... everything you look at you're sort of reading it in Morse and getting use to it all the time ... practising the whole time.

The women would find unique ways to practice this learning method of Morse code. They would see a printed notice, a poster, the newspaper or other text and convert this (with audiation) to Morse code. This practice technique reinforced Morse code in all types of circumstances. Audiation was a very important stage of acquiring the skill of knowing Morse code. Audiation occurs as we hear things in our mind when no sound is present.

4.3.4 Audiation

Some women would practise Morse code by singing it to themselves. They would start with the letter *A* and sing their way through the alphabet. These vocalisations used the same text. For example, they would use the same Morse code language of 'dits' and 'darts', *A* 'dit-dart' *B* 'dart-dit-dit-dit' and so on. As the women intoned the Morse code to me, I realised something quite extraordinary. They intoned Morse code at the same pitch every time. It was as though they had a perfect sense of pitch, along with a perfect sense of Morse code rhythm.

Liz: You sort of sing it to yourself ... go through the alphabet and sing it to yourself as you go along.

Audiation, or hearing the Morse code in their minds, became part of the everyday lives of these women. They discussed how they would 'hear' Morse code in almost

everything they did. In their everyday activities, they were 'hearing' Morse code and the women explained to me how these regular every day activities would be *sending them Morse (Diana).* They would suddenly find Morse code messages in peculiar settings. They would 'hear' Morse code…

> *Diana: in the shower ... everywhere ... you would hear birds ... they were sending you Morse ... the note of your engine if you were driving ... you would hear Morse.*

It was clear to me that the learning and teaching strategies the women used for acquiring Morse code skills were strikingly impressive. It made me listen more closely to birds chirping and the sound of the car engine. My ear is not finely tuned to Morse code rhythms, but I had a sense of what the women were trying to explain to me. Their ability to use these strategies to learn Morse code and remember Morse code was marvellous.

4.4 Encoding Morse code

The next stage in learning and teaching Morse code was memorisation. The women used various methods to remember and retain the Morse code information that they had learned and would draw on these newly formed skills throughout their Morse code training. The women drew on training resources such as mnemonics, music, pattern recognition and visualisation. Mrs Mac used many methods to teach Morse code quickly and thoroughly and taught according to her students needs by constantly devising new ways to engage her students in learning Morse code and learning it quickly.

4.4.1 Mnemonics

Mnemonics were used frequently by Mrs Mac and the WRANS to learn and teach Morse code. This involved quirky methods where short spoken and sung phrases were linked to a specific phonetic letter. The women explained some of the additional mnemonic techniques they used to memorise Morse code, and the importance of identifying patterns within the transmissions. Mnemonics were used to assist with memorising specific letters of the alphabet, and more effectively in remembering and encoding complex or longer Morse code letters from the phonetic alphabet. In some cases, the Morse code did not relate to the mnemonic, however the women acknowledge that some fifty to sixty years after initially learning Morse code, they still accurately recall the Morse code transmissions.

> *Jean: We remembered some of those longer ones, dit-dart-dit-dit* ***[.***
> ***_ . .]*** *was 'get out of it ... get out of it...'.*

The Morse code letter Jean is referring to is the phonetic letter *L*. Some of the women also reported as remembering this letter as *L* for *to 'ell with it (Diana).* The long Morse code letters consisted of several Morse code characters. A long Morse code letter was the letter *B dart-dit-dit-dit* **[_ . . .]**. A short Morse code letter consisted of fewer Morse code characters, like *E dit* **[.]** for instance.

Mrs Mac designed mnemonics for the women to assist their learning. She would make these up herself, and have the women make up their own mnemonics. These mnemonics were skilfully devised from casual phrases but had an enormously profound affect on

the women. Mrs Mac would make up mnemonics to make the women laugh. For example, we take the phonetic letter *D. D* for *Delta*. The Morse code for *D* is *dart-dit-dit*. Mrs Mac used the mnemonic, *Dog did it*. The women would chant this mnemonic and sing through the English alphabet with this new strategy. They would sing their way through the alphabet with mnemonics now in addition to the Morse code 'dits' and 'darts'. If the women were prompted with the audio Morse code transmission of *D*, they would respond by rallying with '*Dog did it'.* The Morse code notation is **(_ . .)**. Another example is with the letter *A*. This is the first letter the women learned. *A* for *Alpha* was considered an entrance or opening, as if a magician was appearing after a disappearance act. *De dah*. The Morse code is *dit-dart* and the notation is **(. _)**. Approximately half way through the English alphabet is the reverse Morse code *dart-dit*, **(_ .)**. This is for the letter *N* and was remembered as a closing statement, like *no way (Jean)* for example. The concept is simple, and a very effective learning strategy for Morse code. The WRANS used anything and everything they could to learn Morse code quickly and it seems that Mrs Mac used every strategy available to her to help them. Mrs Mac's strategies for encoding Morse code included mnemonics, music, patterns and visualisation.

4.4.2 Music

Mnemonics combined with music provided another source for learning Morse code letters. Some of the mnemonics were associated with music; *particularly the long ones (Jean).* Music was frequently used to assist with learning long Morse code letters. For instance, 'The Bridal Chorus' from *Lohengrin* by Richard Wagner became a clever trigger to memorising the phonetic letter *Q (dart-dart-dit-dart).* The letter *Q* is notated in Morse code in Figure 7 below.

Figure 7: The letter Q (dart-dart-dit-dart) in Morse code notation

The letter *Q* was learned with the music to Wagner's *Lohengrin* and verbalised as *Here comes the Bride (Jean).* Jean sang it to me with all the elements of music; melody, rhythm, pitch, tempo and duration. The association between the alphabet letter *Q* and the music is less important than the association between the Morse code rhythm of the letter and the music. The rhythm of the music is not quite accurate to the mathematics of the 'dits' and 'darts' of Morse code, however this still helped the women learn the letter and encode it to a format they could use at a later stage to remember the letter. In Figure 8 below, is a short excerpt of Wagner's *Lohengrin* and this is the melody used by the women when they recall the letter *Q*.

Figure 8: The music notation for Wagner's *Lohengrin*

Music served as a useful resource when learning long Morse code letters. The women explained to me that a long Morse code letter is one that uses several characters of Morse code. In other words, a lot of 'dits' and 'darts'. *Q* is considered a long letter.

Jean: Q..., that's another long one which we didn't use very much, and that would be dart-dart-dit-dart ***[_ _ . _]****... 'here comes the bride'... So those things would help you a little bit.*

The women reported that it was the rhythm of the music that was the most helpful part in learning Morse code. It is the rhythm of the music they associate first with Morse code letters as opposed to tempo, pitch, duration or melody. Another very helpful example of how music assisted with learning and teaching Morse code is a very clever musical germ that was used to remember the letter *V*. *V* (dit-dit-dit-dart) is also considered a long letter as it consists of many Morse code characters; three 'dits' and a 'dart'. In Figure 9 below, the letter *V* is notated in Morse code.

Figure 9: The letter *V* in Morse code notation

Mrs Mac used music to teach this Morse code letter. For instance, the letter *V* (*dit-dit-dit-dart)* was learned with the opening few bars of Beethoven's *Fifth Symphony*. As described by the women, again the association of the alphabet letter with the music is not the important part, but rather the way in which the women encode the Morse code letter so they can retrieve this information when necessary, and retrieve it quickly and accurately.

Jean: V for victory… we never learned this as V, rather as the roman numeral for five. Dit dit dit dart ***[. . . _]*** *Beethoven's fifth….*

The significance is not that the women learned the letter *V* as the Roman numeral for the number 5, but rather that they then heard the Morse code pattern for *V* as Beethoven's *Fifth Symphony*. They heard the Morse code letter even though the audio version of the music was not present. The women encoded *V* in elements of music including rhythm, melody, meter and duration and then audiated the music. They heard it in their mind.

In Beethoven's *Fifth Symphony*, the 'dits' represents quavers and the 'dart' represents a minim (Figure 10). The mathematics of this Morse code letter is also not completely accurate to the mathematics of Morse code transmissions; however, the association of the music and the Morse code letter is the element that was significant to encoding the Morse code letter *V*.

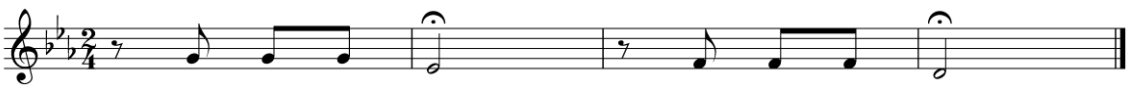


Figure 10: Opening bars to Beethoven's *Fifth Symphony*

The women considered Morse code to be quite musical, even when they did not feel they were learning music. The women have not received any formal music training so they presented their views on music from the perspective of the musically illiterate. However, I do not consider their limited understanding of the elements of music, or the inability to read musical notation should categorise them as musically illiterate. Their ability to combine all the elements of music in their learning and teaching of Morse code is remarkable. *It's mostly rhythmical, isn't it? The Morse… (Jean).*

There is inherent rhythm in Morse code transmissions. At the same time when Morse code was used to communicate messages with speed and accuracy, there was a parallel telegraphic system; the telegram. Jean explained to me that, due to my age, I would not have heard telegrams being sent or received at the Post Office. She was right. However, Jean wanted to make sure I was aware that there was a distinct difference in the way the telegram was transmitted. To Jean, there was a distinct difference between the transmissions of telegrams and Morse code. Telegrams were just not as *musical (Jean).*

> *Jean: You wouldn't have been in a Post Office when the telegrams were coming over, but they came over on… sort of a landline which wasn't musical like Morse was… clack cla clack cla cli cla clack… (Jean singing the sound of the telegram transmission).*

The letter *A (dit-dart*) was referred to as the first Morse code letter learned by a novice Morse code operator. It was also referred to as the opening, as if the start to a symphony. It was difficult for the women to recall what specific symphony they could hear with the letter *A*, but after further discussion and singing of Morse code, I believe the women were associating the letter *A* with the opening bars of Mozart's overture to *The Magic Flute.* In Figure 11 below is the Morse code notation for the letter *A.*

Figure 11: The Morse code notation for the letter *A*

In Mozart's Overture to *The Magic Flute* (Figure 12), the music notation consists of minims and semi-quavers. In Morse code, a 'dart' represents the minim and a 'dit' represents the semi-quaver.

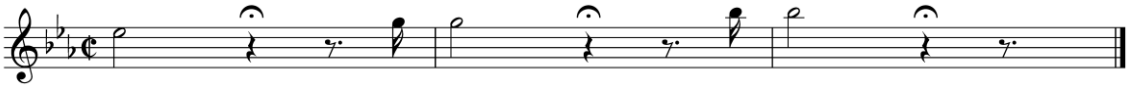


Figure 12: The opening bars of Mozart's *The Magic Flute*

Finally, the women offered one more aspect of connecting music with learning Morse code. The rhythm of Morse code and music is demonstrated in the previous paragraphs; however, the actual process of Morse code transmissions has not been mentioned. The science behind the way in which the Morse code transmissions are carried out also generates musical interest for the women.

> *Jean: When working with Morse I also felt, like music, it was an arrangement of sound and a very effective way of communicating. There is an even more musical quality to sound, which is organised or shaped by being bounced up against the heavy side layer and back to Earth again. By the time it has reached Earth it has gained an extra dimension and fluctuates according to weather.*

Without fully understanding the science behind Morse code transmissions and the heavy side layer, it is difficult to capture the sophisticated mechanics of how Morse code transmissions occur. The point though, is that the women report a deeper knowledge of

Morse code transmissions and they hear the transmissions, both sending and receiving, of Morse code with musical quality.

Not all the women found that music was suitable to learn Morse code. Some women found it more helpful to associate the meaning of the letter with something more relevant. For instance, some women found that spoken mnemonics when connected with the phonetic alphabet was more suitable to reach the same results of memorisation. There is a slight difference between associating Morse code with music or other meaning with the teachers of Morse code and non-teachers of Morse code. Diana gave Morse code instruction and reported an approach to teaching Morse code by symbol association. This means that the phonetic letter was matched with a mnemonic or an alternative association.

> *Diana: Q had a more regal presence... 'God Save the Queen'...*
> *you associate the symbol with the phonetic alphabet.*

For example, *Q* for *Queen* is related with the phonetic letter as opposed to the music association with Wagner's *Lohengrin* (dart-dart-dit-dart). There were quite a few women who had no prior training or learning of music and chose their preferred method of learning Morse Code by association, rather then what they consider musical tricks.

4.5 Musical tricks

The women also referred to musical tricks in the way Morse code was taught to them. Diana explained that there were similarities between the way she gave Morse code instruction and they way her children learned music.

Diana: It reminds me of the way my children learned music. My daughter learned by the Yamaha method using flashcards. I can certainly see similarities in the system there. It was sort of… get to know the symbols. It was a very similar system with recognising symbols and putting them together and then increasing the speed. They (Diana's children) just thought they were having fun….

The Yamaha Method to learning music has been explained previously but I found it very interesting that Diana saw similarities between the two methods: Morse code and music education. The Yamaha Method uses flashcards to associate patterns with sound symbols in the similar way that Morse code uses Morse code letters and notation to associate with sound pattern recognition.

4.5.1 Standard Buzzer exercises

The women talked of standard buzzer exercises they used throughout their Morse code training. Recalling the exact exercises proved difficult; however, the women did recall, *the 'standard buzzer exercise' [which] uses groups of numbers, letters, plain language and foreign language (Jean).* Jean recalled an exercise Mrs Mac used. It was made from the Morse code letters of *Beef Essences*. Jean sang the excerpt to me with irregular rhythm, but flawlessly accurate in Morse code timing. She thought it was a beautiful tune *it's a lovely little tune, isn't it? (Jean).* I didn't have the heart to tell Jean that I found her tune to be quite unusual. I have notated Jean's 'tune' in Figure 13 below.

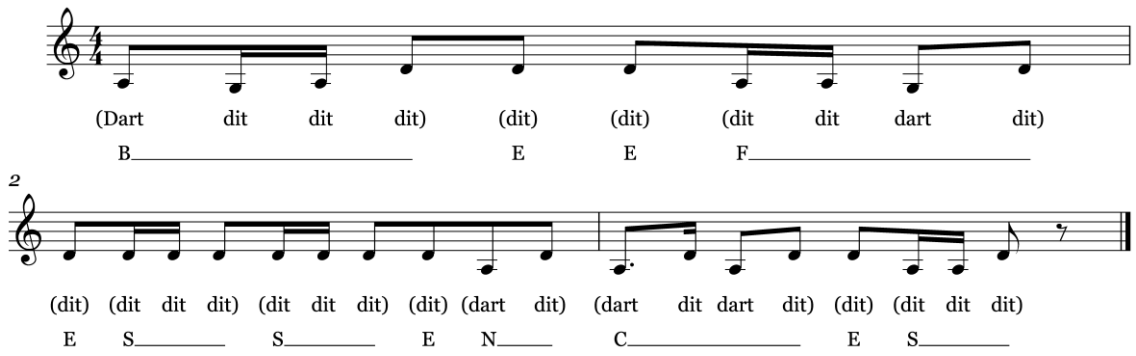


Figure 13: BEEF ESSENCES Rhythm Exercise

Diana gave another rhythm exercise of Morse code as an example to practise the rhythm. This was an exercise purely based on the rhythm. The rhythm exercise is *Best Bent Wire / (forward slant) G (Diana).* Diana explained that the women would make up their own rhythm exercises and were encouraged to do this as a practice regime mainly for senders of Morse code.

> *Diana: It evolved more for the senders of Morse, Best bent wire / G... to establish a rhythm. Some of the operators… it can be quite addictive… and they are very happy to coach you as well… and that's where I have picked up the Best Bent Wire slant (/) Golf (G) for sending rather than (receiving)... it is nice to receive as well, but it was to establish the rhythm… and they were quite musical to listen I suppose. They really took pride in how they worked.*

Best Bent Wire / G is notated in Figure 14 below. The exercise was not accurate in the mathematics of Morse code, but rather for the rhythm of music and Morse code manipulated into a 4/4 meter.

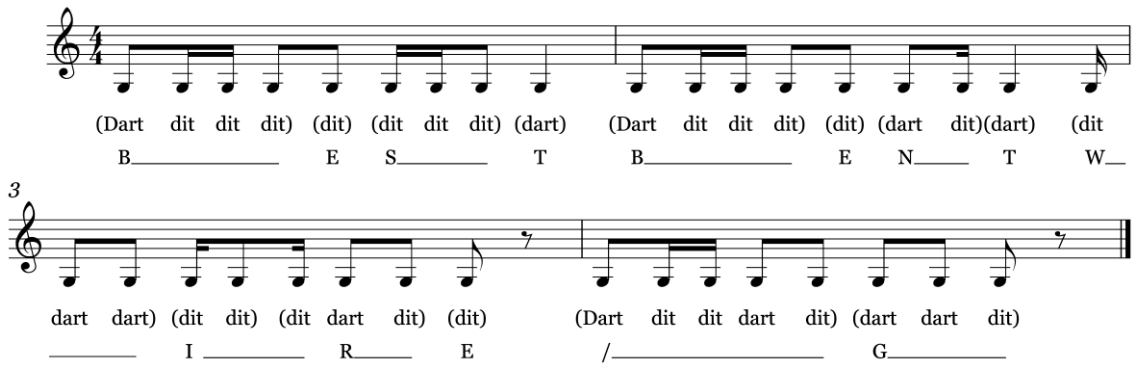


Figure 14: BEST BENT WIRE / G Rhythm Exercise

4.6 Pattern recognition

After the initial learning phase of Morse code, the telegraphists found it useful to *pick out patterns* and *divide them up into little blocks in your mind (Liz).* Liz explained how she would look for patterns in the Morse code transmissions to break up the length of the transmission so she could recognise individual letter patterns. The women would hear tapes of Morse code and pick out the letters they recognised. They would then continue to add new letters to this and effectively expanding their Morse code vocabulary. The women would use this technique in both visual and audio transmissions.

> *Diana: In the first Morse class, the students would write the alphabet with Morse code and then when you look you can see there are patterns and some are the reverse of others, which makes it easier to remember….*

The women would constantly be looking for patterns to learn Morse code quickly and thoroughly. The patterns would form letters and in the learning stages of Morse code this technique was used frequently. This learning process was considered simple by the women and was referred to as solving a puzzle. A bit like Find a Word puzzles. They would then search for patterns within the alphabet and link them. They would look for ways to associated letters in a different manner. For instance, the letter *B* (dart-dit-dit-dit) **(_ . . .)** and the letter *V* (dit-dit-dit-dart) **(. . . _)** were linked purely on their reversed pattern; not phonetically or linguistically.

> *Diana: We would put a tape on and listen to it ... follow it through and pick out certain patterns ... some letters were the reverse of others ... like B (dart-dit-dit-dit) and V (dit-dit-dit-dart). You do recognise that they sort of pair up… and some of them don't at all. So those ones would stay in your mind and that would break up the whole thing ... the number of symbols.*

The expansive quantity of Morse code and related punctuation the women were required to learn was overwhelming; however, they all managed to find their individual methods to learn and retain the Morse code information. Some women would come up with their own individual ways to identify a systematic approach to learning Morse code. This was unique to the individual and an interesting way to view the poetic characteristics of the English language. Jean talked about two letters that not only formed patterns for her, but also expression. The letters *A* (dit-dart) and *N* (dart-dit) generated an added layer of meaning for Jean.

Jean: If you take letters separately, by themselves, dit dart... that's 'A'. It's sort of an opening, whereas you reverse it and say dart dit... it's 'No'. It's dart dit... you don't have to put expression into it. It says it. So whoever made up the Morse was very conscious of the English language. N is halfway through… it has balance. And then there is dart dart… and that's 'M' like an agreement... MM… and dit dit… that's 'I'… It's a balance.

The Morse code characters had their own sound and voice. The Morse code spoke to the women in a unique way that gave them meaning and expression. It gave them a sense of shape and a story to associate a deeper layer of understanding. As the women spoke to me about the Morse code, they spoke as if the Morse code had a sense of poetic symmetry, that there was more to it then just 'dits' and 'darts'.

Jean: Dit is final... it has a sharp ending… you know, a flat wall….

The shape and sharpness of the Morse code became part of a bigger picture. It became a story of shape and sound that generated a deeper appreciation for the Morse code notation and visual aspects.

4.7 Visualising Morse code

Visual representation of Morse code was very important. It was important to see the written alphabet letter followed by the Morse code notation. In the early stages of learning Morse code, *we were still following what it looked like with what it sounded*

like... (Diana). The early stages of learning Morse code involved linking visual and audio representations.

> *Diana: it was important to see what it looked like as well as what it sounded like ... so at some stage, I would say under ten words per minute, it would come together.*

Visual representation of Morse code letters combined with the sound of Morse code were both required for this unique communication to make sense. It was important to see what the Morse code looked like, along with how it sounded, to reach automaticity.

4.8 Automaticity

So when did it all become automatic? At what stage during the learning process of Morse code did the women feel they had worked it all out? For the women, there were different thoughts about when automaticity was achieved. Automaticity was referred to as the stage in which Morse code became automatic and it was difficult to zone in on a specific time when the women felt automaticity was recognised. For Jean, automaticity was reached when *it goes in one ear and out the pencil ... it becomes automatic.* Jean described how there was no time to think about the Morse code. There was no time to think about what you had just written, as the Morse code transmission would not suddenly stop so you could catch up. There was little time to think about it. You would write down what you heard and then go on to the next transmission.

Jean: You just wouldn't think about it… and I didn't think about it… you just wrote it down. And you didn't know what you had written….

It was essential to achieve automaticity. The importance of automaticity is demonstrated in the essential skills of multitasking required by the women. The women were required to carry on with a conversation, answer questions and monitor two frequencies (via headphones) simultaneously.

Jean: You've got to be able to carry on a conversation or listen in to what's going on around you… you have to be able to answer a question… one ear phone on and one ear phone off… that's as long as you weren't on Bells[1]*… then you have a different frequency on each ear because you were monitoring those both… because you were supervising an automatic tape that was going through… it was fun.*

There were varying responses as to when automaticity was achieved. The varying responses were related to a specific time in the learning of Morse code and whether automaticity could be pinpointed as occurring at a particular moment. The main difficulty in understanding automaticity was related to my curiosity as to if there was a stage, or a part of the learning process when you were expected to know Morse code

[1] 'Bells' is a type of broadcast system used to send taped messages of Morse code in operation priority. It was developed in 1942 and replaced the 'I' Method. Bells were transmitted on up to four different frequencies (Jean).

and be a competent operator of it. Diana explained when she felt she reached automaticity.

> *Diana: I think it's when you stop thinking about it ... when you are writing it down and you are seeing it and hearing it ... that's sort of conscious and then it becomes unconscious....*

Diana identified that *at around ten to twelve words per minute* is the moment where automaticity was achieved in learning and practising Morse code. This is equivalent to approximately 60 beats per minute. Diana explained that there are further techniques used to reach automaticity. These techniques involve grouping.

4.9 Grouping Morse code

Morse code is inherently grouped into two binary notations of 'dits' and 'darts'; short and long sounds. Within these two elements, groups are formed. The 'groups' form letters and these letters then form part of larger groups. Grouping Morse code in the learning stages was a common strategy and Morse code was grouped, or framed, by speed/tempo, chunking and groupers.

4.9.1 Speed/Tempo

Tempo was very important in learning and teaching Morse code. As a beginner, the speed was always very slow, approximately 2 wpm. The women described the learning process as determined by the speed of the Morse code transmissions. Interestingly, the women reported that the faster the speed of Morse code the easier it was to understand. The required speed at which the Morse code must be learned to enter the Royal

Australian Navy was 22 wpm. The women felt that the faster the speed of Morse code transmissions, the closer they were to achieving 22 wpm, and automaticity. It was noted that once people had a grasp of Morse code, the speed was increased. Of particular note, is that very few people were not able to keep up as the speed of the Morse code was increased.

> *Diana: Tempo or speed, was increased gradually, but quite consistently and very few people couldn't keep up as the speed was increased. And sometimes you would think that over a few days there was quite a big jump, but once people became familiar with this basic thing and could work out the individual letters, the speed was increase quite quickly.*

The increase in speed of the Morse code assisted with automaticity. The faster the speed, the less time there was to think about the Morse code. It became a reflex as opposed to a conscious awareness of each individual Morse code letter. The increase in speed of Morse code transmissions left the women with no choice but to develop a reflex technique in Morse code. There was no time for the thinking process.

> *Diana: It did cut out the thinking process... because at first it was a thinking process and then it became a reflex.*

Interestingly, there was an association between putting Morse code together and putting music together.

Diana: tapes becoming increasingly fast ... and I don't know exactly when it happens but it does become a reflex that which you could probably put together in a way you would read music or hear music....

The entrance standard in Morse code for the women to join the Royal Australian Navy was very strict and there was little room for error. Throughout the one-on-one interviews, I used pre-recorded Morse code excerpts of random words and sentences; all in plain English. These were used as discussion points and exercises to trigger conversation topics with the women. The Morse code excerpts were all pre-recorded at 20 words per minute.

Jean: That's about 22 words per minute… See to get into the Navy we had to be perfect at that speed [22 wpm] for twenty minutes and they'd give you a mixture of plain English language, then foreign language, then groups of coding letters... and this would go on for twenty minutes and if you got more than five mistakes, you failed.

There was an expectation of the wartime WRANS and they were required to reach 22 words per minute (wpm). They were expected to be very good at wireless telegraphy and reported as learning Morse code very thoroughly and flawlessly. They were expected to be fluent in plain language, foreign language and signalling codes. The difference between the three types of Morse code involves the same letters but in different order. The foreign language was received in Morse code and considered

nothing special than just another type of Morse code. The women would chunk this in the same way as plain language.

> *Diana: It (Foreign Language) was just another thing we did actually… as most of our translation and Morse code reception was in foreign language. But we got to know the language, so you could fill in gaps like that as well, but you still leave it to the linguists to make the final decision. You just put suggestions in… which they didn't need….*

4.9.2 Chunking

Chunking was considered a very important technique for wartime WRANS. Chunking involved anticipating what was coming up next and was used when the Morse code was not clearly transmitted. This could be due to interference in the frequency. Some plain language was chunked for quickness of receiving Morse code. The chunking process was individual and not all women did this. By hearing the immediate start of letters some women were able to predict the remainder of what they were about to hear.

> *Jean: T H E ... that's always [_ …. .] and it's a pattern in a word so that you don't even think of it as something different... [dart di di di dit dit] (Jean singing the Morse).*

As Jean sang the Morse code for *T*, *H* and *E*, she gestured an upward motion with her right hand. I have notated Jean singing *T H E* in Figure 15 below.

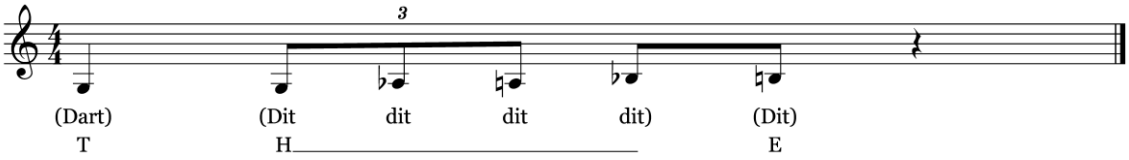


Figure 15: T H E notated as sung by Jean.

Here, the start of the word triggered an instantly recognisable pattern. In the same way predictive text suggests words in SMS messages, the individual letters of Morse code become a word before the remainder of the Morse code has been transmitted. *You are not thinking of dits and darts... it's like a word...(Jean)*.

Chunking was used to speed up the process of learning Morse code. During wartime, the women had very little time to learn Morse code so they would draw on various skills to expedite the process.

4.9.3 Groupers

There is another technique used in transcribing Morse code that is very similar to chunking and was referred to as *groupers (Diana)*. *This was used in deciphering Morse code to plain language and involved writing five totally unrelated letters (Diana)* down in sequence followed by a forward slant (/). For instance, the phrase *The Most Wonderful Time of the Year* would be coded as *THEMO / STWON / DERFU / LTIME / OFTHE / YEAR. /*

> *Diana: What we call 'groupers' which were just five letter or five number groups ... you just didn't know what was coming next ... it was just a reflex then.*

Groupers were used to avoid anticipating what Morse code message you were about to receive. Groupers and grouping was literally a way to chunk five elements into a unit that would then be given to the linguists to decipher. Groupers enabled the Morse code to become more of a reflex that didn't require you to think about what you were writing down.

> *Diana: It was so much more simpler, you could read the paper while you were doing that. It was quite possible to do that because you were just doing it on a completely different level, and you could still think while that was going ahead. A lot of people can do two things at the same time, but this was like walking and chewing gum… that sort of thing.*
>
> *Jean: It became automatic. It was like a puzzle....*
>
> *Diana: Groupers were encrypted and encoded messages. So when it was decoded again, it would be plain language. It was a plain language message gone through an encryption process, and part of that encryption process was grouping in five letters. It was like a word puzzle where after every five letters there was a space, whether you needed it or not.*

There was no reason for the five letters or numbers. It had no relation to the text. During the Post War period, *most [of the Morse Code] was in foreign language* and *foreign*

language uses identical Morse (Diana). This did not alter the way in which Morse code was transmitted. The deciphering of Morse code was left *to the linguists (Diana).*

4.10 Errors in Morse code Transmission and Reception

The women reported that there were some possible errors that occur in learning Morse code. The errors are associated with journalisation, signatures, anticipation and quite simply that Morse code was not for everyone. Journalisation occurs when receivers of Morse code start to read what they are taking down instead of what they are hearing. Signatures refer to the rhythm in transmitting Morse code. Some telegraphists develop a rhythm unique to their individual style of transmitting the Morse code. Anticipation is where receivers of Morse code anticipate what is coming next in the Morse code message and incorrectly notate this with what they are anticipating will be next.

4.10.1 Journalisation

Systematic errors such as 'journalisation' occurred whilst transcribing Morse code. Journalisation occurs when receivers of Morse code begin to read what they were receiving and predict what the next part will consist of. These errors were not directly related to the techniques used to translate the Morse code, rather that the message that was being translated or received was starting to be journalised into a different message. Journalisation came about when Diana deciphered an audio excerpt of Morse code, but missed the first few letters. She the explained that journalisation is where the receivers of Morse code start to read what they are receiving and can project what the message is going to be or what the next letter is.

Diana: Journalising is where you start to see a word take shape and think oh yeah, it's going to be this and it may not be that at all. It's writing a story instead of just letting it go straight on to the page.

Journalisation was more difficult, and virtually impossible, with foreign language. Foreign language was considered easier in this regard because the receivers of Morse code literally had to just write down what they heard because they were not familiar enough with the foreign language to journalise.

Diana: Foreign language was actually much easier because people were inclined to journalise when they start reading what they are taking.

4.10.2 Signatures

Wireless telegraphists of Morse code developed their own style of transmitting messages. This individual style was referred to as signatures. Signatures refer to the inherent rhythm of the Morse code as it is transmitted. The women all learned Morse code with the mathematical accuracy and science of how the code was generated; however it was virtually impossible for small variances not to occur. These minor variances provided a natural rhythm when sending Morse code.

Diana: We use to get to know all operators … and it was a big no no… All operators have a signature. This was more for senders of Morse ... to establish a rhythm.

Senders of Morse code developed a unique pattern or rhythm in their style of transmitting the code. This was unavoidable as it was virtually impossible to maintain mathematical accuracy whilst transmitting Morse code.

Diana: We could work out who was on our shift... we could add something personal to our transmission.

Signatures were unique to the sender and at times *they were quite musical to listen to ... they really took pride in what they were transmitting (Diana).*

4.10.3 Anticipation

Anticipation is another form of predictive text and is where the women were able to predict what was being transmitted. Different to chunking, anticipation refers to the anticipation of letters not words. It was frowned upon with the Post-war women and considered unhelpful for all Morse code operators.

Diana: It is anticipating what the next letter is going to be, or what the whole word is going to be. We just found it better not to get involved at all, and everyone found it much easier if we didn't.

On the other hand, anticipation was frequently used during the second World War due to the high level of interference experienced over the wireless frequencies. Noises and random splashes of sound would interfere with Morse code signalling and create distorted sounds during the transmission. It was important that receivers of Morse code could try and work out what the missing letter or number was. This skill was useful during these times of interferences, but could also create some time where the message was not clear. The consensus with all Morse code operators is that anticipation was mostly avoided where possible.

> *Jean: You can anticipate with things ... and if you get a noise or a splash ... it is easier ... you can often work it out ... what that letter was because of the space it took.*

Depending on the duration of time between the Morse code elements, the interference and the next Morse code element, telegraphists were able to work out what the missing part of the message was. *You could always finish off a sentence for somebody (Jean).* Morse Code operators always had one ear connected to the headphone and one ear clear to the noises and conversation around them. *You've got to be able to carry on a conversation or listen in to what is going on around you... (Jean).*

When I presented Jean with an audio recording of an excerpt of Morse code she explained the concept of anticipation. I arranged a few words and used a Morse code program to translate the English word to Morse code. The program then plays the Morse code translation. This small exercise started with the word, beautiful. The most recent

exposure Jean had to Morse code was over fifty years ago so this exercise took her some time to tune in.

> *Jean: Another thing, it took me a while to tune in and I, the first one I got was U T I F U L but then in true wireless operating parts you made up ... you knew what that word was. And it's like if you are coming up to a word then you think this is probably got an 'ING' on it's... di dit dah dit dah dah dit [.. _. _ _.] ... that gives you just enough time to put the time and the number of the message in your logbook and then go back to the message and things like that.*

Anticipation occurred when text was pre-empted and consequently, albeit rarely, mistakenly notated. When telegraphists anticipated what was coming up, there was a chance that these messages were incorrectly received. However, in some instances anticipation was not only necessary and vital, but may have been the only means available to decipher a message. Anticipation was mostly avoided.

4.10.4 Morse code is not for everyone

Not every person successfully completed the required training to become an operator of Morse code. When I asked if there were techniques that could be used if learners were struggling with particular Morse code letters or speed, the response from the women was quite simple.

> *Diana: It was acknowledged that some people would never pick it up... I think it would be unusual to just have a block on one particular letter, and that would be easier to deal with because then you would know what it was… there weren't mediocre operators.*

It was acknowledged that there were some people who had the necessary skills to learn Morse code, and to learn it quickly, and then there were others who did not have the required skills to learn Morse code. Although some were better at receiving Morse code than sending it, there was no place for incompetent operators. The women were brutally honest in their comments about people who did not have the necessary skills to become a Morse code operator.

> *Diana: The Navy's solution would be to bung you in with the interpreters section… you know because you had classes coming in every couple of months… and you know… you couldn't have log jams with anyone who couldn't do Morse….*

There was no room for *middle of the road (Diana)* Morse code operators, you had to be exceptionally accurate and report consistently high in all of the testing. It was not frowned upon if you were not highly skilled in Morse code as there were several roles to fill during wartime. For the women, it was extremely important to maintain a very high standard of Morse code operators as they progressed quickly through the learning stages and then into the operational duties.

The women, who were not able to progress to the required standard in the minimal time available, would take on other roles within the wireless telegraphy communications. These women would become coders or interpreters of Morse code. It was acknowledged by all the women that there was a clear standard that must be reached so that the importance of their wireless telegraphy work was never compromised. There was a clear understanding amongst the women that aptitude was important. Some women were good at sending Morse code whilst others were better at receiving Morse code. Decisions were made according to this aptitude and the women were assigned specialist roles when needed. These decisions were, mostly, made in a reactionary way and according to the direction the war was taking. Women were randomly assigned roles in foreign language. The women were gathered together and lined up in categories of senders and receivers. Every second telegraphist was assigned a role in learning foreign Morse code, and then categorised even further into senders and receivers of foreign Morse code. Jean remembers the moment when Morse code operators were assigned foreign language (Japanese Morse) as the day after the Fall of Singapore in 1942.

> *Jean: It was the day after Singapore fell, every second lot they were putting into Japanese Morse… and they would keep the best senders back… so they took the ones who were good at reading but not so good at sending…Some were good at reading, but not at sending. You need a supple wrist....*

Apart from the sense of urgency in learning Morse code quickly, there was also the urgency to convert that training into foreign language. There was no time for re-training

or inferior standards in Morse code operations, whether it be sending or receiving Morse code (and foreign Morse code). It was a harsh approach but necessary to sustain their very high standards.

> *Diana: You either passed or you didn't. It would be very, very obvious whether you got it or if you hadn't got it. They did it well, or they were bunged off….*

There was clearly a very high standard required for sending Morse code. Diana explained to me that after teaching Morse code she completed an Instructional Techniques course and realised that there was some disconnect between the instructional techniques concepts and how she taught Morse code. However, there was no time to question the instructional techniques used in teaching Morse code. You had to just get on with it.

> *Diana: I did Instructional Technique long after I started teaching this (Morse code) and realised a lot of things didn't gel with what was the accepted wisdom and how we actually did things, but it was very much get on with it or move over.*

4.10.5 Tuning Morse code machinery

The women had to know more about Morse code than just sending and receiving. They were required to understand the mechanics and science behind how the transmissions of Morse code worked and how to fix it if something went wrong. The women worked on

duty watches. Duty Watches were shifts that occur throughout the day and night. Before their Duty Watch shifts, the women were required to tune the Morse code machinery into the correct frequency. The whole act of getting the Morse code was musical. Jean described to me how she tuned the Morse code machinery as *like conducting a symphony orchestra and making sure every thing was in tune*. Tapes were used to record the electrical currents of Morse code 'dits' and 'darts'. The 'dits' and 'darts' were marked on the tape with indentation markings. A Morse code operator then translated the indentations on the tapes.

> *Jean: Needles would come up underneath it… I mean they would go over needles and that's how we got the Morse over to England at high speed. So there was that sort of tape and we had other tapes which would give you undulator…. long (dart)… short (dit)... so it would come like that. This one you could put into a direct printer… and it would play Morse back at you.*

The printed Morse code available today is slightly different to the printed Morse code the women used. The current Morse code is printed on two distinct levels where a 'dit' looks like this **(.)** and a 'dart' looks like this **(_).** The 'dart' is visually lower then the 'dit'. The printed Morse code the women were familiar with was printed on the same level; which is impossible to reproduce with the current computer typing software. When I gave Jean a copy of some printed Morse code that I found on the Internet, she became a little embarrassed because the Morse code was unrecognisable to her.

Jean: I'll see what this is… it was very embarrassing when I couldn't read it at the meeting….

Jean: That one is a bit messy… and if there was any sort of interference that would upset that sort of thing… that didn't effect the ordinary Morse that we were mostly using… it was Molonglo that did the other….

The way in which Morse code actually worked is very complex. Jean served during the second World War and explained to me how the sending of Morse code worked back then.

Jean: Our type of sending was… you would send… a signal would go up and hit the heavy side layer… and come down again. You go up… down… and depending on the height of the frequency… it would depend on how far those points of coming down were again. Well you could hear….when it hit the Earth, you could hear in that area… then as it got towards the middle before you go to the next place it came down, it would fade out gradually… depending on the time of day. So that's the way it use to work in those days. And that is only a few miles up bouncing up against the heavy side layer and the ionosphere… but then when they started with satellites, we were getting most of our stuff off now from a satellites about 23,000 miles away from the Earth… going up….

Mrs Mac's legacy

Until now, little is known about the Morse code training undertaken by the women telegraphists during the second World War and Post Wars.

> *Jean: There was very little written… not much recorded properly during the war; we were all too busy.*

The women thought of their Morse code training as clever and ingenious. They all regarded Mrs Mac as enterprising and resourceful, and thought themselves fortunate to have received Morse code training from her.

> *Jean: We were just so lucky to have had the training and the foresight of Mrs Mac because out of the first hundred girls... all but five were from Mrs Mac.*

4.11 DISCUSSION

Despite the prevalence of Morse code, little is known about the way in which the practice was taught and learned in times of war. The WRANS from the New South Wales Branch of the Ex-WRANS Association were able to shed some light on how they became skilled in Morse code during this unique time in history. These WRANS agreed that learning Morse code during wartime presented a seemingly impossible challenge without a manual or model to equip or assist. To overcome this, they recounted that the legendary Mrs Mac devised and adapted unique and creative teaching methods to learn Morse code at speed. For these women, learning Morse code during wartime did not

come with a manual or quick guide and Mrs Mac's strategies were devised on the spot to learn Morse code and to learn it quickly. The rhythmic phenomenon of Morse code and its training provides us with a fascinating opportunity to understand the human capacity for engaging with rhythm and assimilating rhythmic properties in extraordinary circumstances. While the WRANS reported wonderful stories of achievements under insurmountable pressure, they also unwittingly tapped into the inherent structures in learning Morse code, to understand rhythm.

The ability to understand rhythmic information in Morse code began with imitation. Mrs Mac and the WRANS achieved this by tapping out Morse code letters for their students to imitate and practise in pairs. The WRANS were forming patterns in Morse code with no real thought given to the structure of how they were learning and understanding Morse code. For these WRANS the importance was placed on learning the Morse code letters by any means available and the structure of learning Morse code came later. In the first instance, the WRANS were learning random order patterns/letters and this simple technique equipped them to understand Morse code letters. The women applied these skills of imitation in mastering complex rhythmic patterns, in the same way as music educators apply 'call and response' activities with rhythm and singing exercises (Garner, 2009). Music educators have long adapted such practices to introduce rudimentary concepts of rhythm in music (Dalcroze, 1930; Kendall, 1986; Orff & Walter, 1963; Sándor, 1969; Seitz, 2005). The Suzuki Method is renowned for imitation where students would play back what they hear (eg, matching the same sound and rhythm) without any association to the meaning or notation of what they were hearing (Kendall, 1986). Similarly, Orff and Kodaly focused more on the imitation of rhythm

patterns and singing in the elementary stages of music education as the first vital step of accumulating rhythm information (Orff & Walter, 1963; Sándor, 1969).

In the next stage, the WRANS were taught to associate individual letters with their 'call and responses' in dits and darts. When intoning the Morse code, WRANS placed accents or stresses on 'darts' (the longer character of Morse code) and started to generate a sense of rhythmic awareness in Morse code. The WRANS were unknowingly framing Morse code letters with rhythmic patterns of intoned responses to Morse code according to long and short sounds of Morse code. The WRANS were forming rhythmic patterns framed by long and short sounds and this has recently been termed as stress grids (Jackendoff & Lerdahl, 2006) and metric interpretation (Iversen et al, 2009). The way the WRANS were learning Morse code letters resembles the concept of stress grids and metric interpretation where the inherent rhythmic sounds of Morse code letters were being framed by groups of long and short sounds separated by silence.

Silence generated between the transmitted Morse code letters provided natural rhythmic patterns that the WRANS resourcefully manipulated to develop framework for learning Morse code letters. More recently this has been linked to the innate human ability where our brain naturally wants to frame things (perceive borders) to form patterns from the silent omitted beats (Iversen et al, 2009; Povel, 1984) and/or long pauses (Fraisse, 1982). Similarly, the WRANS may have been bringing to light the elemental coding patterns (strong-weak, weak-strong) music educators used to teach meter and beat (Dalcroze, 1930; Orff & Walter, 1963; Sándor, 1969). The WRANS were instinctively

following the natural framework and perfect rhythms of Morse code to learn Morse code letters.

This concept of following the natural framework of coding rhythmic information is well established in music education where rhythmic syllables and mnemonics are used to support learning of rhythm and understanding musical rhythm (Shehan, 1986). Zoltan Kodaly used rhythmic syllables such as ‘ta’ and ‘ti’ (Sándor, 1969) to represent crotchets and quavers and build pattern recognition of musical phases. Just like dits and darts, ‘Ta’ could represent a crotchet and ‘Ti’ could represent a quaver. The Orff Approach uses different rhythmic syllables and rhymes drawn from the children in each classroom (Orff & Walter, 1963). Orff uses rhythmic syllables that are already known to children and then uses these known rhythmic syllables to mimic musical rhythmic patterns. Orff then modifies and changes the rhythmic syllables to suit the needs and abilities of the children.

The WRANS would learn to group the characters of Morse code (dits and darts) into a pattern for a letter, to then link it to a particular letter and label it with that letter. The WRANS used the most effective and uncomplicated process to ‘lock in’ the Morse code letter for future use. The WRANS reported that Mrs Mac’s tool-kit involved mnemonics and Mrs Mac used these mnemonics to mimic the sound of the Morse code letter to try and make sense of the patterns the WRANS were hearing. The WRANS outlined how Mrs Mac would harness the similarities of the letter being transmitted (eg. ‘Dog Did It’ for the Morse code letter *D*) or link subtly letters to phrases (‘To L with it’ for the Morse code letter *L*). The ability to recall this information was either solely based on the

poetic characteristics of the text, or the inherent rhythmical qualities of the Morse code. This mimics the process of how we perceive rhythm where chunking and encoding helps create rhythmic patterns by linking groups of sound information to a particular letter to then labelling it into a concept we understand (Brochard et al, 2003; Fraisse, 1982; McDermott & Hauser, 2005; Povel, 1984). The WRANS reported the importance of chunking letters of Morse code that formed words, such as *T*, *H* and *E* during wartime due to unavoidable and unexpected interference in receiving Morse code transmissions. The WRANS reported that chunking was vital during war.

The WRANS noted that the speed of sending and receiving Morse code letters was a significant part of the learning process. The significance is related to the rate of words per minute and the impact this has on the progressive stages of learning Morse code at speed. The WRANS reported that they learn Morse code slowly at first and then increase the speed as they feel more capable of understanding the Morse code. The WRANS advanced through stages of learning Morse code in a similar practice to advancing through stages of learning rhythm in music. In the methodologies of music education, rhythm is dependent on tempo to establish meter and beat (Dalby, 2005; Garner, 2009; Gordon, 1984; Orff & Walter, 1969). For instance, tempo in music influences how we group duple and tripe meter. In rhythm literature, speed influences how we perceive and group rhythm (more tones are grouped at a faster tempo) (Krumhansl, 2000).

The WRANS reported how they searched for ways to recognise the Morse code letters by listening for the learned (or known) Morse code letter in long transmitted sequences

of Morse code. The WRANS talked of not knowing all the letters at this stage but were encouraged to listen-out for the Morse code letters they did know and could recognise. This practice strategy resembles the way a beginner musician, who has learned to play *C, D* and *E,* on their instruments for example, join in with ensemble musicians who are more advanced. The learner musicians would play their known notes and pick out the recognised known letters as a practice strategy to progress to additional notes. Orff refers to this as the 'improvisation stage' of learning music and the purpose of the improvisation stage is to reinstate what students have already learned and gradually add more knowledge as the student builds confidence (Shamrock, 1986). The WRANS were building a Morse code vocabulary that resembles the improvisation stage of Orff where both methods are used to increase Morse code vocabulary and music literacy.

WRANS talked about hearing Morse code 'in their heads' and their daily environment. The WRANS used this as a practice method to learn the Morse code letters by reading a poster and converting the text into Morse code and to then hear that in their minds. The WRANS used this technique to bring all of the Morse code learning together so that the Morse code becomes an unconscious automatic process. The idea of converting text to hearing sound in our mind is a familiar term in music education as the ultimate triumph in music literacy, 'audiation' (Gordon, 1984). Audiation is where music educators consistently strive to have their students synthesise all of the music constructs like rhythm, timbre, tempo and pitch in their minds (Gordon, 1984; Kendall, 1986; Orff & Walter, 1963; Sándor, 1969). In these interviews, the WRANS termed this coherent skill as automaticity, when the Morse code becomes automatic and the single constructs

are no longer identified as single elements but now as the arrangement of the whole concept of Morse code.

The WRANS reported the concept of ‘signatures’ where the unique interpretative rhythmic attributes of the sender of Morse code could be identified. The WRANS strived to transmit a mechanically perfect rhythm of Morse code by the sheer rhythmic nature generated by the inherent constructs of Morse code characters. The WRANS reported unavoidable minor discrepancies in their transmissions they later classified as ‘signatures’. These ‘signatures’ became personal and the WRANS were able to identify the sender of the Morse code by the rhythm of the Morse code transmission, or as the WRANS termed their ‘signature’. These minor deviations from the perfect rhythm of Morse code are prevalent in music performance as musicians interpret music scores with individual expressive timing (Repp, 2001) and reflect nuance and artistic flair in the art of performance. The shared deviations are termed as an error in the perfect transmissions of Morse code, and as expressive ‘musical’ performing in music education.

Morse code is unique and the methods used by the WRANS to learn Morse code has uncovered a parallel understanding of how we perceive rhythm in music. The WRANS used specific terminology to describe their Morse code training like tempo, singing, tune, sound quality, shape, pitch, rhythm exercises, and music. The WRANS used these musical terms to describe their Morse code learning in the same way music educators use the terms to design lesson plans and learning aids for teaching music. It would appear the WRANS were not aware that they were applying the musical nature of

teaching and learning Morse code with learning and teaching strategies in music but were rather harnessing the natural attributes of Morse code and music.

Mrs Mac's final juncture was the combination of rhythm and musical line to link musical remembrances to the dits and darts of Morse code letters. Musicians and music educators take for granted that we have rhythm, we receive rhythm and we learn about rhythm in a structured way and Mrs Mac and the WRANS facilitated the natural and universal learning implications of rhythm to the unique constructs of Morse code. The WRANS were unknowingly using rhythmic constructs to fast-track intensive Morse code learning and this gives us a fascinating insight into the perception and learning of rhythm. By instinct, Mrs Mac and the WRANS uncovered the parallels of sequential learning of Morse code and the sequential learning of music. The next challenge is to investigate the efficacy of these methods on novices.

5 PROJECT 2: MUSIC AND MORSE

Since the 1900s, Morse code has baffled researchers as to the most effective learning and teaching strategies to combat its inherent problematic nature. These learning strategies vary from learning simple letters first (Bryan & Harter, 1897), the 'word method' (whole word before any letter) or 'sentence method' (short sentences before any word or letter), to using nonsensical material (Bryan & Harter, 1899), phonetic method (using sound patterns) and synthetic method (using whole words) (Thurstone, 1918), using different frequencies for 'dits' and 'darts' (Koch Method) and adding more or less space between the letters (Farnsworth Method), and to visual aids (Taylor, 1943), and pattern recognition (Allan, 1958), to part-whole training focusing on 'easy' or 'difficult' Morse code letters first, or both at the same time (Clawson et al, 2001).

Despite the exhaustive measures these researchers have taken to make sense of learning and teaching Morse code, the approach of using music to learn the unique rhythmical nature of Morse code has not been explored. Themes emerging from Project 1 suggest that incorporating musical elements into the learning and teaching strategies of Morse code may serve to solve these inherent complexities that have researchers perplexed. Is it more effective to learn Morse code with music? Do the teaching and learning methods of Morse code described by the WRANS in Project 1 hold relevance today and can inexperienced people (to music and Morse code) learn Morse code with these techniques? What impact does this teaching and learning method have on novices? Further investigation is needed to test the teaching and learning methods of Morse code with music. Project 2 will investigate whether there is a musical framework for learning

Morse code, if Morse code is more memorable with music, and if there are correlations between learning Morse code with music. Can music aid learning and recall of Morse code? What do novices bring to learning Morse code? Do the teaching methods of Mrs Mac hold relevance today?

5.1 METHOD

Ethics

The institutional Human Research Ethics Committee approved the project. Ethics documentation is located at Appendix D, Information Statement at Appendix E and Consent Form at Appendix F.

5.1.1 Participants

Sixteen participants took part in the Project, seven males and nine females. Participants were volunteers from the Royal Australian Navy Band and personal contacts. Their ages range between 30 - 58 years. Twelve participants reported as having had prior music training, and four participants have reported as having no prior music training. All participants were novices to Morse code and were randomly assigned to the experimental groups, Control Group and Music Group.

5.1.2 Design

The design was to test the effects of learning three Morse code letters, *Q*, *V* and *A* with music and without music between two randomly assigned groups (Music Group and Control Group).

5.1.3 Materials

Each participant was given an answer sheet to write down the Morse code letters as they heard them, and the Morse code letters they recognised. Each participant was required to fill out a questionnaire indicating their age, gender, and an indication of prior music training.

Stimuli

The project was generated on Microsoft PowerPoint software and a sound file generated from Garage Band software on an Apple Macintosh MacBook Pro. The recordings of Morse code were generated from an online Morse code translator designed by Phillips (2013) where a 'dart' is equivalent to three 'dits'. The audio recordings of the Morse code letters were pre-recorded at 700 hertz and at 10 words per minute (wpm). There were three audio music excerpts (stimuli) used in the project; Beethoven's *Fifth Symphony* for the Morse code letter *V*, Wagner's *Lohengrin* for the Morse code letter *Q* and Mozart's overture to *The Magic Flute* for the Morse code letter *A*. The project was pre-timed on PowerPoint so that each section of the project was not reliant on the participant controlling each slide. Blank slides were used in the two sections of the project that tested the listening of Morse code. Otherwise, each slide revealed visual representation of the Morse code letter as the pre-recorded Morse code excerpt was heard. The project design was 'stand alone' meaning that there was no need for the participant, or experimenter, to guide the progress of the study.

5.1.4 Procedure

Trial Phase

There were three exercises in the Trial Phase. Exercise 1 consisted of two Morse code letters; *S* (dit-dit-dit) **[. . .]** and *O* (dart-dart-dart) **[__ __ __]**. These Morse code letters are shown in Table 5 below.

Table 5: Morse code letters *S* and *O* used in Exercise 1 of the Trial Phase

Alphabet	Morse code	Alphabet	Morse code
S	**. . .**	**O**	**__ __ __**

Participants were asked to memorise the letters, *S* and *O*, as well as recognise them from an audio recording of pre-recorded Morse code transmission. Participants were not required to record their answers on an answer sheet. Answers were displayed on the computer screen for reference. In Exercise 2 of the Trial Phase, participants were given three trials of Morse code letters, *S* and *O*, presented in pairs. Again, participants were not required to record their answers. Answers were displayed on the computer screen. These pairs of Morse code letters are shown in Table 6 below.

Table 6: Pairs of Morse code letters for Trial Phase

Trial	Morse code letters	
1	**S**	**S**
2	**O**	**S**
3	**S**	**S**

Exercise 3 of the Trial Phase consisted of known Morse code letters, *S* and *O*, and three unknown Morse code letters, *D* (dart-dit-dit) **[__ . .]**, *G* (dart-dart-dit) **[__ __ .]** and *H* (dit-dit-dit-dit) **[. . . .]**. Participants were presented six trials of three letters. Known and unknown Morse code letters were used. For Exercise 3, participants were required to write down their answers on the answer sheet provided. All Morse code letters used in Exercise 3 are shown in Table 7 below.

Table 7: Known and unknown Morse code letters used in Exercise 3 of the Trial Phase

Alphabet	Morse code	Alphabet	Morse code
S	**. . .**	**O**	**__ __ __**
D	**__ . .**	**G**	**__ __ .**
H	**. . . .**		

Table 8 shows the order of known and unknown Morse code letters presented in Exercise 3.

Table 8: Format of Exercise 3 of the Trial Phase

Trial	Morse code letters		
1	**S**	**O**	**O**
2	**O**	**O**	**S**
3	**O**	**D**	**S**
4	**G**	**O**	**H**
5	**S**	**O**	**S**
6	**S**	**S**	**O**

At the completion of this Practice Phase, participants were offered the opportunity to repeat any of the three exercises as many times as they felt necessary.

Experiment 1

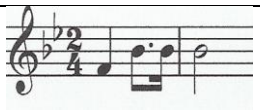
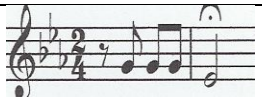
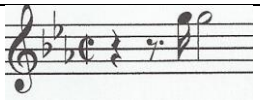
The Control Group participants were required to memorise three Morse code letters *Q* (dart-dart-dit-dart), *V* (dit-dit-dit-dart), and *A* (dit-dart). Participants were presented each Morse code letter three times. The format is shown in Table 9 below.

Table 9: Format for the Training Phase – Control Group

Example (x3)	Alphabet letter	Morse code letter (audio)	Morse code letter (verbal)
1	**Q**	**__ __ . __**	dart-dart-dit-dart
2	**V**	**. . . __**	dit-dit-dit-dart
3	**A**	**. __**	dit-dart

The Music Group participants were also required to memorise three Morse code letters *Q* (dart-dart-dit-dart), *V* (dit-dit-dit-dart), and *A* (dit-dart). They were presented each Morse code letter three times. Music Group participants were not given a verbal cue for the Morse code letters. Participants in the Music Group were given an audio music cue for the excerpts notated in Table 10 below. The format for Training Phase – Music Group is shown in Table 10 below.

Table 10: Format for the Training Phase – Music Group

Example (x3)	**Alphabet letter**	**Morse code letter (audio)**	**Music (audio recording)**
1	**Q**	— — · —	
2	**V**	· · · —	
3	**A**	· —	

Next, the participants were presented four trials of six letters. Morse code letters were presented with pre-recorded Morse code transmissions. The trials were played one time only. Participants were provided with an answer sheet and were required to write down the order in which they heard the Morse code letters. Table 11 shows the order of Experiment 1.

Table 11: Sequences of Morse code letters used in Experiment 1

Trial	Morse code letters					
1	Q	V	A	V	Q	A
2	V	Q	A	Q	A	V
3	V	Q	A	A	Q	V
4	Q	Q	V	A	Q	Q

Experiment 2

Participants were required to write down the Morse code letters they recognised on their answer sheet. Experiment 2 included known and unknown Morse code letters. These are all shown in Table 12.

Table 12: Morse code letters with their corresponding alphabet letter – Experiment 2

Alphabet	Morse code	Alphabet	Morse code
B	__ . . .	V	. . . __
N	__ .	A	. __
F	. . __ .	Q	__ __ . __
D	__ . .	G	__ __ .
M	__ __	O	__ __ __
H	. . . .	S	. . .
T	__	E	.

Experiment 2 consisted of ten trials with twelve letters in each. The trials were played one time only. These Morse code letters are shown in Table 13.

Table 13: Experiment 2 – Ten trials of twelve Morse code letters

Trial	Morse code letters											
1	B	D	N	A	O	A	B	V	Q	F	Q	V
2	D	N	A	B	Q	V	G	O	A	Q	V	A
3	N	A	B	V	Q	F	G	O	V	N	Q	O
4	V	A	V	B	O	M	A	Q	L	A	S	N
5	M	O	S	E	V	A	T	H	S	V	Q	V
6	A	V	A	Q	F	G	A	V	B	Q	L	M
7	B	V	B	A	N	N	A	B	V	T	M	Q
8	Q	L	B	A	V	B	A	G	H	S	O	A
9	Q	Q	V	V	A	N	M	G	Q	L	L	Q
10	B	D	N	A	O	A	B	V	Q	F	Q	V

5.2 RESULTS

Experiment 1

The study design was a 3 (Morse code letters *Q*, *V* and *A*) x 2 (Control Group and Music Group) ANOVA with Morse code letters as the within-subject variable, and the Control Group or Music Group as the between-subjects factor. Mean identification rates were higher in the Music Group than the Control Group across all three Morse code letters. Morse code letter *Q*, Music Group M = 9.62 (SD = .74), Control Group M = 5.75 (SD =

2.76). Morse code letter *V*, Music Group M = 6.50 (SD = .75), Control Group M = 3.87 (SD = 2.23). Morse code letter *A*, Music Group M = 7.00 (SD = .00), Control Group M = 5.25 (SD = 2.43). Table 14 shows the average mean responses for the different Morse code letters (*Q*, *V*, and *A*) in each group (Control Group or Music Group).

Table 14: Means and Standard Deviations for Music Group and Control Group in Experiment 1

Letter	Music Group		Control Group	
	Mean	(SD)	Mean	(SD)
Q	9.62	(0.74)	5.75	(2.76)
V	6.50	(0.75)	3.87	(2.23)
A	7.00	(0.00)	5.25	(2.43)

There was a significant main effect for the Music Group and Morse code $F(2,28) = 28.35$, MSE = 25.52, $p < .001$, that is accuracy increased when music was introduced in each Morse code letter. Posthoc Bonferroni tests showed that Morse code letter recognition accuracy was significantly higher in the Music Group than the Control Group ($p < .05$). There was also a significant main effect between the Control Group and Music Group with a statistically significant interaction effect between Music Group and Morse code letter recognition $F(1,14) = 11.28$, MSE = 90.75, $p < .01$, that is Morse code letter recognition was more accurate in the Music Group, than the Control Group. Mean accuracy of the Music Group and Control Group for each Morse code letter indicates that there are significant differences between the Music Group and Control Group. Morse code letter *Q*, Music Group M = 9.62 (SD = .74) compared to Control

Group M = 5.75 (SD = 2.76), *t*(8.01) = 3.83, p = .005. Morse code letter *V*, Music Group M = 6.50, (SD = .75) compared to Control Group M = 3.87 (SD = 2.23), *t*(14) = 3.15, p = .007. The main effects for Morse code letters *Q* and *V* were significant. Morse code letter *A*, Music Group M = 7.00 (SD = .00) compared to Control Group M = 5.25 (SD = 2.43), *t*(7) = 2.03, p = .082. The main effect for Morse code letter *A* was not significant. Figure 15 shows the main effects for each Morse code letter (*Q*, *V* and *A*) in each condition (Music Group – with music, and Control Group – with no music).

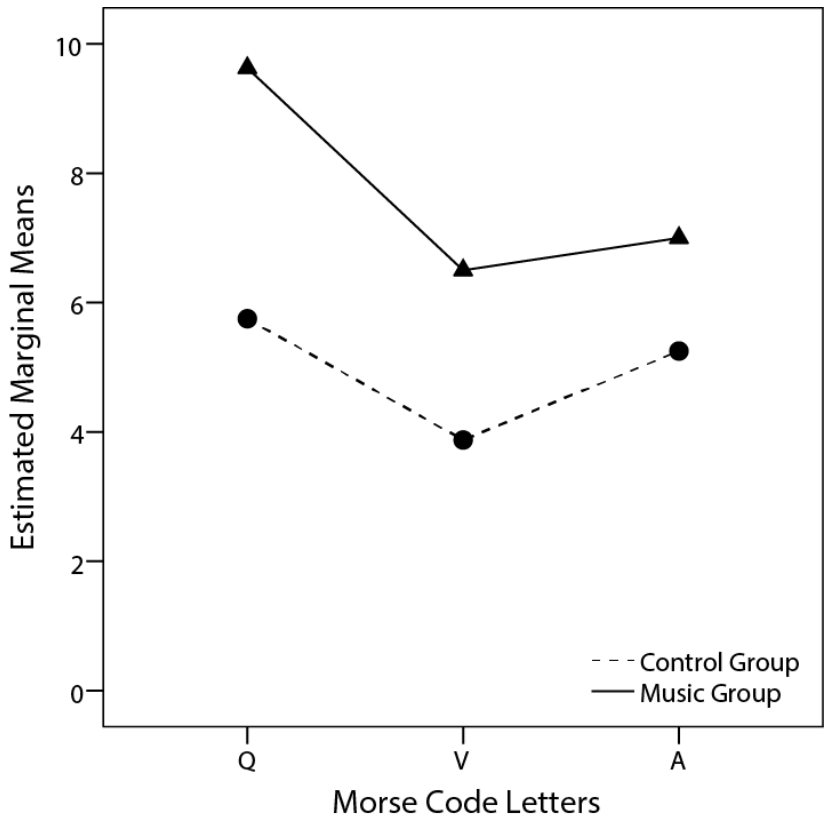


Figure 16: Main effect of Morse code letters *Q*, *V* and *A* in each condition (music and no music) (Experiment 1)

Experiment 2

The study design for the second experiment was again a 3 (Morse code letters Q, V and A) x 2 (Control Group and Music Group) ANOVA with Morse code letters as the within-subject variable, and the Control Group or Music Group as the between-subjects factor. Mean identification rates were higher in the Music Group than the Control Group across all three Morse code letters. Morse code letter *Q*, Music Group M = 16.37 (SD = 1.30), Control Group M = 5.75 (SD = 4.59). Morse code letter *V*, Music Group M = 15.50 (SD = 3.50), Control Group M = 8.50 (SD = 6.82). Morse code letter *A*, Music Group M = 16.12 (SD = 3.27), Control Group M = 8.75 (SD = 6.27). Table 15 shows the average mean responses for the different Morse code letters (*Q*, *V*, and *A*) in each condition group (Control Group or Music Group).

Table 15: Means and Standard Deviations for Music Group and Control Group in Experiment 2

Letter	Music Group		Control Group	
	Mean	(SD)	Mean	(SD)
Q	16.37	(1.30)	5.75	(4.59)
V	15.50	(3.50)	8.50	(6.82)
A	16.12	(3.27)	8.75	(6.27)

There was a significant main effect between the Control Group and Music Group with a statistically significant interaction effect between Music Group and Morse code letter recognition $F(1,14) = 19.91$, MSE = 833.33, $p < .01$, that is Morse code letter recognition was more accurate in the Music Group, than the Control Group. There were

no significant effects within each Morse code letter for both groups, which means all letters were the same. Posthoc Bonferroni tests showed that Morse code letter recognition accuracy was significantly higher in the Music Group than the Control Group ($p < .01$). Mean accuracy of Music Group and Control Group for each Morse code letter indicates that there are significant differences between the Music Group and Control Group for all Morse code letters. Morse code letter *Q*, Music Group M = 16.37 (SD = 1.30) compared to Control Group M = 5.75 (SD = 4.59), $t(8.12) = 6.30$, $p = .001$. Morse code letter *V*, Music Group M = 15.50 (SD = 3.50) compared to Control Group M = 8.50 (SD = 6.82), $t(10.45) = 2.58$, $p = .027$. Morse code letter *A*, Music Group M = 16.12 (SD = 3.27) compared to Control Group M = 8.75 (SD = 6.27), $t(10.54) = 2.95$, $p = .014$. Figure 17 shows the main effects for each Morse code letter (*Q*, *V* and *A*) in each condition (Music Group – with music, and Control Group – with no music).

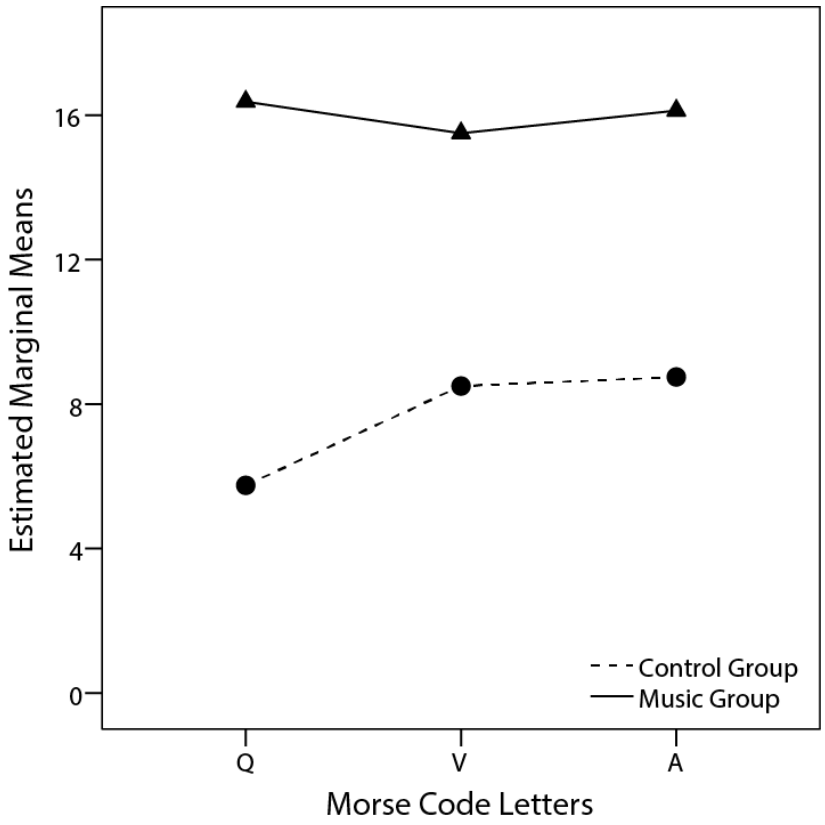


Figure 17: Main effect of Morse code letters *Q*, *V* and *A* in each condition (music and no music) (Experiment 2)

5.3 Participants' perceptions of Project 2

This next section outlines themes emerging from perceptions of Project 2 reported by participants in the Control Group (CON) and Music Group (MUS).

5.3.1 Music

Participants from the Music Group reported that the music training assisted with learning the Morse code letters. The Music Group felt that the music training stimuli effectively prepared them for identifying and remembering the Morse code letter *V*.

MUS 5: The music helped… the music was in my head… 'V' really stood out.

MUS 6: 'V'… I know Beethoven's Fifth… I know the symphony… I found myself trying to associated the V with 'V' in Beetho'V'en.

MUS 10: Every time there was a 'V' I got it. 'V' was very easy, I'll never forget it. The Morse code letter 'V' was easy to remember due to its natural structure. It stood out from the other Morse code letters.

MUS 16: V stood out… the structure of it.

Participants from the Control Group also recognised the Morse code letter *V* as Beethoven's Fifth Symphony. Notably, CON 3 identified the Morse code letter *V* after intoning the rhythmic nature of the Morse code letter with 'da-da-da-dah'.

CON 3: I just heard 'V' instantly as Beethoven. It was easy… da da da dah (CON 3 singing Beethoven's Fifth Symphony).

CON 7 reported hearing music for the Morse code letter *V*. CON 7 claimed that they *heard the letter 'V' as Beethoven.* CON 9 also stated that *with the letter 'V', I associated Beethoven's Fifth every time… it was the rhythm.*

With the Morse code letter *Q*, participants from both Music Group and Control Group instantly recognised Wagner's Lohengrin. MUS 1 reported that *Q… 'here comes the bride'… that really helped.* Similarly, CON 7 and CON 9 agreed. *'Here comes the bride' for the longer one… Q (CON 9). 'Q' as 'here comes the bride' (CON 7).*

Interestingly, even with the music training, participants from the Music Group reached for additional methods to assist them in remembering the Morse code letter *Q*. MUS 6 created a complex story to assist with learning the Morse code letter *Q*. The Morse code *Q* starts with two long 'darts' and MUS 6 associated the music, *'Here Comes the Bride'* with a couple getting married. MUS 6 linked the pair of 'darts' to the marriage of 'couples'.

> *MUS 6: Q is odd… 'here comes the bride' helped, so I tried to come up with my own story. It [the letter Q] starts with a couple of long ones, so I thought… couple… marriage… 'here comes the bride'…. that sort of thing. It was like the sound [of the Morse code] was secondary to the story. I felt like I had to recode it [the Morse code] to something I could understand.*

The Morse code letter *Q* (dart-dart-dit-dart) was also remembered for the marching rhythm. MUS 8 is a military drummer and as part of their employment as a military musician, they are required to memorise drum patterns for military parades and marches. MUS 8 reported finding the Morse code letter *Q* as sounding like a military

march and then recoded the Morse code letter *Q* to reflect their understanding of military marches and associated *Q* with queuing up for a march.

> *MUS 8: I've spent a lot of time remembering marches as part of my job. The letter 'Q' sounds like the start of one of the marches I know, Eagle Squadron. I then associated it with 'Q' as in queuing up for a march. We [military musicians] spend a lot of time queuing.*

MUS 8 reported that when learning various pieces of music they memorise the music first, and then work out drum patterns. MUS 8 reported that the music of the specific piece they were learning is the primary source to guiding rhythmic drum patterns. MUS 8 found the rhythm of Morse code much easier to remember when they heard pitch.

> *MUS 8: The rhythm is easier to remember when pitch is involved. It is like I needed the whole thing.*

MUS 10 reported that singing helps them to memorise music and to learn new information. MUS 10 explained, *there are things I know because they are songs* and during their schooling, singing random pieces of information assisted with learning.

CON 9 reported a random memory when they were developing a learning strategy for remembering the Morse code letter *Q*.

CON 9: For some reason it made me think of Mrs P when I was learning how to spell. Mrs P would make up a song to learn how to spell 'Parramatta' and doing Morse code made me think of it [spelling songs]. That's really interesting. I've never learned Morse code before.

The Morse code letter *A* was reported as a difficult letter in the Control Group. *'A' was difficult… I couldn't think of anything because it was too short. I found myself just saying 'da-dah', 'da-dah' (CON 9).* CON 9 intoned the Morse code letter *A* with short-long inflections. Similarly, CON 2 also identified the pattern of the Morse code letter *A* by the short-long durations. CON 2 was able to identify the Morse code letter *A* if they heard the 'dit' first.

CON 2: Sometimes the 'dit' felt more like a 'dart'… when it was the final sound… if it started with it [the 'dit'], it was ok.

CON 7 reported that the Morse code letter *A* was difficult to identify because if the simple structure of the letter. CON 7 applied tunes to the previous Morse code letters *Q* – Wagner and *V* - Beethoven) but reported as having trouble applying a tune to the Morse code letter *A.*

CON 7: 'A' was harder to pick… there was not much to it. It was just one of each [dit and dart]… I didn't apply a tune to it.

The Music Group reported the Morse code letter *A* was easy. *The letter 'A' felt like the beginning of something… a symphony… the alphabet… it was easy (MUS 6).*

Similar to reports from the Control Group, the Music Group also reported that the duration of the 'dits' and 'darts' in the Morse code letter *A* were too similar. MUS 10 was not familiar with Mozart's overture to *The Magic Flute* and instead recoded the music excerpt for the Morse code letter *A* as the sound made when a computer is shutting down.

> *MUS 10: 'A' was like 'ta-dah'. It sounded like a computer shutting down or something. It was like I had to distinguish between the two sounds [dit and dart], they sounded quite similar.*

5.3.2 Tempo

Participants from both Music Group and Control Group reported that the speed of the Morse code transmissions were too fast. MUS 1 reported feeling overwhelmed by the speed of the Morse code transmissions and not confident that any of their responses were correct. MUS 1 reported that they felt the speed of the Morse code trials were getting faster and faster, and thought this was the purpose of the study. MUS 1 reported as hearing the speed of Morse code transmissions through the trial phase as much slower than the remainder of the project. *It felt like the trials were getting faster and faster… the more I did. (MUS 1)*

CON 2 and CON 3 also reported that the speed of the Morse code transmission increased throughout Project 2. Additionally, participants from the Control Group also perceived the Morse code letters in Experiment 1 and 2 as much faster than the trial phase. *It felt too fast for me… the test… (CON 2). It was too fast… faster then the trial (CON 3).* Participants felt that they missed letters, and the flow on from that made them feel that they were not confident that the following letters were correct. *It felt like I missed one and then got out of sync… (CON 2).*

Participants from the Control Group reported that the speed of the Morse code transmissions made them feel anxious and panicked and that this hindered their ability to keep up. CON 7 reported as feeling 'freaked out' by the speed of the Morse code transmissions.

> *CON 7: The speed 'freaked me out', but as I got used to it [the speed] I got more letters.*

A few participants felt overwhelmed by the speed of the project and became agitated by their inability to complete the experiment with ease. CON 3 showed disappointment with the answers they recorded from Experiment 2 and requested another attempt.

> *CON 3: I missed one and then couldn't catch up. If I can't get it the first time, then I give up.*

MUS 10 did not report that the speed of the Morse code transmissions was too fast, however, did report that there was no time to think about whether the Morse code letters were correct. MUS 10 felt that the speed of the trials in Project 2 did not allow for a second thought.

> *MUS 10: By the time I thought about it, I had to keep going – I had missed some because I stopped to think about it. I should've kept going.*

There were some difficulties reported by participants in this study in relation to the duration of the 'dits' and 'darts'. Participants reported that they could not determine if they were hearing 'dits' or 'darts' because *there was a lack of gap between the next letter (CON 3).*

Participants generated confusion with the duration differences between the 'dits' and 'darts'. The length of the 'dits' and 'darts' did not change through the trial phase and Project 2. Participants reported confusion in the format of the Morse code characters where the silence between each Morse code letter was perceived are getting shorter and shorter. The gaps between letters did not change for the entirety of the project.

5.3.3 Repetition

Participants from the Control Group reported as needing the Morse code excerpts to be repeated during Project 2. *Repetition is the main thing for remembering things… I needed it to be repeated (CON 3). I needed it to be repeated (CON 13) The whole thing needed to be repeated (CON 15).*

There was no repetition during the project; however, all participants were offered the option to repeat the Practice Phase as many times as they felt necessary. No participants did this.

5.3.4 Timbre

The actual sound of the Morse code made some participants from the Music Group feel uneasy. There was a sense of urgency associated with the timbre of Morse code, and some participants reported as feeling panicked by this. This feeling of panic interfered with the participant's ability to focus on recognising the Morse code letters. Interestingly, although the timbre of the Morse code evoked a feeling of uneasiness and panic, it was reported that music calmed this panic and provided assistance for the participant to continue with recognising the Morse code letters. Participants reported that the effects of the music not only soothed their panic from the sound of the Morse code, and also helped them remember the Morse code letters.

> *MUS 1: the sound of the Morse code made me panic… so the music was really good.*

5.3.5 Visualisation

CON 9 reported that they felt it was important to see the Morse code notation as opposed to just hearing it, especially in the first stages of the project. There was no visual representation of the Morse code letters in notation at any stage. To learn the Morse code, *I felt like I had to look at something… but it was easier not to look. It was*

easier of you memorised it… more fluent if you know it… and then you don't have to look at it.

5.3.6 Reverse pattern Morse code letters

In Experiment 2, when the Morse code letters were mixed with unknown Morse code letters, participants from both Music Group and Control Group reported reverse pattern recognition for all three Morse code letters (*Q V A*), including the trial phase Morse code letters *S* and *O*. Participants mistook the Morse code letter *A* (dit-dart) for *N* (dart-dit), *V* (dit-dit-dit-dart) for *B* (dart-dit-dit-dit), *Q* (dart-dart-dit-dart) for *F* (dit-dit-dart-dit) and *S* (dit-dit-dit) for *O* (dart-dart-dart). These are outlined in Table 16 below.

Table 16: Reverse pattern recognition of Morse code letters used in Project 2

Alphabet	Morse code	Alphabet	Morse code
A	**. —**	**N**	**— .**
V	**. . . —**	**B**	**— . . .**
Q	**— — . —**	**F**	**. . — .**
S	**. . .**	**O**	**— — —**

For the Morse code letters *A* and *N*, the Control Group reported seven out of the eight participants who mistakenly identified the reverse letters. Similarly, in the Music Group, six out of eight participants mistakenly recorded *A* and *N*. For the Morse code letters *V* and *B*, half of the participants in the Control Group reported reverse patterns as opposed to one participant in the Music Group. Both Music Group and Control Group reported the same result for Morse code letters *Q* and *F* (see Table 17).

Table 17: Reverse pattern Morse code letter recognition (A-N, V-B, Q-F) breakdown of correctly and incorrectly identified in the Music Group and Control Group

Letters	Music Group		Control Group	
	Correct	Incorrect	Correct	Incorrect
A-N	2	6	1	7
V-B	7	1	4	4
Q-F	7	1	7	1

5.3.7 Perceived difficulties of encoding

One participant from the Music Group reported as hearing *V* and *B* incorrectly. MUS 6 revealed an encoding mistake where the letter *V* (dit-dit-dit-dart) was mistakenly encoded as *B* for Beethoven.

> *MUS 6: I think I may have written 'B' instead of 'V'. I kept hearing it as Beethoven's Fifth but found myself writing 'B' for Beethoven, not 'V' for five.*

Participant 4 was part of the Control Group and did not have any music. Interestingly, CON 4 starting hearing music when the Morse code letters were played. CON 4 reported as hearing music throughout the test and found it difficult to not hear music when particular Morse code letters were played.

> *CON 4: I started forgetting the letters but heard the music.*

MUS 10 found that the rhythm of the Morse code letter *Q* was too dissimilar to the music of Wagner's Lohengrin. For MUS 10, associating the Morse code letter *Q* with the music was confusing.

> *MUS 10: 'Q' didn't work for me. It was just 'dar-dar-da dar'[MUS 10 singing Morse code for the letter 'Q']. It just didn't sit for me. It just didn't match up to 'here comes the bride'. It didn't work for me.*

MUS 14 reported a similar difficulty. MUS 14 felt that the rhythm of the Morse code letter *Q*, and the music of Wagner's Lohengrin, was too dissimilar. MUS 14 felt it was [dart-dit-dit-dart] instead of [dart-dart-dit-dart].

> *MUS 14: There was a mistake with Q. The rhythm didn't match up. It didn't sound the same as Q. Once I worked it out for myself though, I was able to go on with it.*

The Morse code letters *S* and *O* were used during the Trial Phase of Project 2. Participants from both Music Group and Control Group recorded these Morse code letters on their answer sheets as 'known' Morse code letters. It is unknown whether participants recognised these Morse code letters, *S* and *O*, and chose not to report them on their answer sheets, therefore these results are not reported as significant results. Interestingly, CON 7 reported that the structure of the Morse code letters *O* (dart-dart-dart) and *S* (dit-dit-dit) from the Trial Phase *were bland*.

5.4 DISCUSSION

To explore the influence of music in learning Morse code, a group of novices (who were unfamiliar to all properties of Morse code) were asked to learn Morse code letters. Some novices had music training and some novices did not have music training. For these novices, music training unravelled the rhythmic properties of Morse code into a conceivable musical structure of pitch, rhythm, duration, contour and meter. Music conveyed an implicit learning strategy that was automatically applied as novices embraced all available resources in gaining new knowledge quickly. Music training sharpened the perception of sound in Morse code, and extended beyond musical engagement by providing novices with familiar mechanisms as they implemented music methodologies to learn Morse code.

In this study, the Music Group consistently achieved a statistically significant higher accuracy rate than the Control Group in identifying all three Morse code letters. The Music Group reported that the music training not only helped them identify and recall the Morse code letters, but also provided an added dimension to the rhythm of the Morse code where after a while they forgot about the Morse code letters and were hearing music. Control Group participants reported the need for additional prompts to help them identify Morse code letters and intuitively turned to music ideas to solve the urgency of learning the Morse code letters quickly. Participants from both Control Group and Music Group were more successful in remembering the Morse code letter when they associated it with music and the constructs of music, than if they had no music information/training at all.

When learning the Morse code letter *V* (dit-dit-dit-dart) all participants in the Music Group reported that the Morse code letter *V* was instantly recognisable because of the music stimuli (Beethoven's *Fifth Symphony* – three quavers followed by a minim). This means that to make sense of the rhythmic structure of the Morse code letter, participants were instinctively matching quavers with 'dits' and a minim with the 'dart' to represent the rhythmic germ of Beethoven's *Fifth Symphony*. Novices were instinctively manipulating the metric properties of the Morse code to fit in with the music properties of Beethoven so they could encode this at the letter *V*. It is possible that in this instance, novices who received the music training were drawing from the learning strategies of music education to identify the Morse code letter *V*, in the same way that children learn musical constructs by converting new musical information into known structures (Gordon, 1984; Orff & Walter, 1963; Sándor, 1969; Shehan, 1986).

The interesting part here is that in order to synchronise the two parts (Beethoven and Morse code), participants were instinctively manipulating the rhythm of the Morse code letter to fit in with the syncopated nature of the rhythmic germ. Beethoven's *Fifth Symphony* starts with an anacrusis, meaning that the first beat is silent. Novices were imaging a beat in the silence of the anacrusis, which means that the participants who immediately identified the Morse code letter *V* as Beethoven's *Fifth Symphony*, also perceived this anacrusis. This is subjective accenting in action (Iversen et al, 2009; Povel, 1984). Participants from both Music Group and Control Group were unconsciously engaging with subjective accenting as they perceived the 'omitted' beat in Beethoven's *Fifth Symphony*. In the transmissions of the Morse code letters, participants were placing subjective accents before each 'hearing' of the Morse code

letter *V* as the first step to identifying its natural rhythmic structure. Despite participants from both Music Group and Control Group reporting the 'ease' of Morse code letter *V*, the Music group most recognised the Morse code letter *Q* while participants in the Control Group recognised the Morse code letter *Q* the least.

The Morse code letter *Q* uncovered remarkable learning strategies from two participants in the Music Group where participants created stories to assist their learning. These stories triggered a memory for the Morse code letter *Q* and enabled the participants to recall the Morse code *Q*, on cue. Despite the music training, one participant re-coded the Morse code letter *Q* with a story about couples and marriage, and the other participant re-coded the Morse code letter *Q* with queuing up for a military march. This type of encoding has been referred to as the neurological link that helps our brain create a rhythm memory when no melody exists (Sacks, 2007) and we can speculate that participants were intuitively devising anecdotes to associate the rhythm of the Morse code letters with an instantly recognisable meaning embedded in their memory (Jackendoff & Lerdahl, 2006). The stories were quite complex, and given the speed of the Morse code transmissions there was little time to recode the Morse code letter with something completely different, yet participants turned to familiar and accessible known associations for easy retrieval to learn and identify the rhythms of the Morse code letters.

The concept of intoning the Morse code letters to assist in distinguishing between the lengths of the 'dits' and 'darts' and in particular with the Morse code letter *A* (dit-dart), featured prominently throughout the responses from the Control Group. Control Group

participants instinctively began reciting and singing spoken text of Morse code letters with rise and fall inflections, and pitch variations to make sense of the Morse code letter they were trying to identify. Music pedagogues would intone a musical phrase in the imitation stages of music learning to impart subtle nuances of music expression and timing (Orff & Walter, 1963), and intone rhythmic syllables with movement to learn rhythm (Dalcroze eurhythmics) in the same manner as Orff uses games and Kodaly intones normal melodic content (Orff & Walter, 1963; Sándor, 1969; Seitz, 2005). Participants in the Control Group spontaneously 'sang' the Morse code letters as the first step to making sense of the 'dits' and 'darts' and contextualised these learning strategies of music (singing) with the embedded structures of the rhythmic elements in Morse code.

One participant from the Control Group reported that the order of the 'dits' and 'darts' in the Morse code letter *A* was indistinguishable, suggesting that the 'dit' and 'dart' sounded the same. This participant did not intone the letter, instead listened for the 'dit' to come first. This simple method unravels the complex theory known as syllabic association (Iversen et al, 2008) where the tendency for bias in short-long duration is commonly preferred. When the Control Group participant thought they were hearing the 'dit' first, the participant felt they were able to proceed with identifying the Morse code letter *A*. Syllabic association is more commonly associated with short-long syllable words, such as Be-fore and To-day (Iversen et al, 2008) however, it is possible that this participant was unknowingly tapping in to syllabic association with the dit-dart of the Morse code letter *A*.

A pattern emerges between the duration of rhythmic syllables in Morse code and speech. Iversen et al, (2008) investigated the bias we show towards disyllabic words where the first syllable is stressed or accented more frequently than the second syllable. Be-FORE and be-CAUSE are also examples. A similar result is found in Project 2 where participants revealed the higher accuracy rate for the Morse code letter *A* (dit-dart) (short-long). Participants in the Music Group scored 96% and 75% in the Control Group for accuracy in identifying the Morse code letter *A* and it could be that a syllabic bias exists in how Morse code letters were identified.

All participants categorised the three Morse code letters by the duration of their inherent rhythmic patterns, in other words, the distinguishable feature of their entire length (as 'long' and 'short'). For example, the Morse code letter *Q* (dart-dart-dit-dart) and *V* (dit-dit-dit-dart) were thought of as 'long', and the Morse code letter *A* (dit-dart) as 'short'. The Control Group reported that the simple structure of the Morse code letter *A* (one dit and one dart) presented a challenge for recall because the Morse code letter *A* is too 'short'. Clawson et al (2001) considered the Morse code letter *A* (dit-dart) a difficult letter because it is more commonly confused with the reciprocal form Morse code letter *N* (dart-dit). Similarly in this study, all participants found the two-element Morse code letter *A* difficult to identify, however the da-dah in the Mozart music stimuli helped the Music Group learn *A.*

It was not uncommon for participants to categorise the Morse code letters with words such as 'easy' and 'difficult' and participants from both Music Group and Control Group have used these two terms (easy/difficult) to describe the complex nature of the

Morse code. Similarly, Clawson et al (2001) categorised these Morse code letters *O* and *S* as 'easy' because they are considered less often confused with each other. The Morse code letters *S* (dit-dit-dit) and *O* (dart-dart-dart) were reported by one participant from the Control Group as bland because the construction of the Morse code 'dits' and 'darts' were simple. The concept of coding rhythm patterns with words has been characterised as associative learning (McDermott & Hauser, 2005) where classifying terms are used to describe music in major (happy) and minor (sad) modes. The associative learning theory was also nurtured amongst music educators encouraging children to apply informal and familiar words to describe shape, sound and other music terminology (Gordon, 1984; Orff & Walter, 1963; Sándor, 1969). The skill of classification reveals a deeper cognitive strategy that participants in this project were using to encode and learn Morse code letters quickly.

Towards the end of the project participants from both Music Group and Control Group were starting to hear music when the Morse code letters were being transmitted. From a music education perspective, this is the ultimate achievement. One reason that participants were hearing music when the Morse code transmissions were being played could be that the rhythmic structure of the Morse code transmissions evoked an instantly recognisable link to music elements. Rhythm is the first music element children are exposed to in music education (Gordon, 1984; Orff & Walter, 1963; Sándor, 1969) and sets the foundations for the next elements of music to be added, like melody, pitch and meter (Orff & Walter, 1963; Sándor, 1969; Shehan, 1986). It is possible that participants were no longer recognising the rhythm and timbre of the Morse code because the music in their mind was taking prominence.

When learning and memorising the Morse code letters, participants from the Control Group found that the rhythm of Morse code letters alone did not provide sufficient information to learn and memorise the Morse code letter effectively, and that when pitch was heard in their mind's ear and added to the rhythm of the Morse code letter, learning the letter became achievable. Adding layers of music elements reflects the idea of whole-part awareness training (Gestalten principles), and occurs when all elements (music in this case - eg, pitch, meter, melody, rhythm) are added together, the learning and skill acquisition of new concepts is strengthened (Jackendoff & Lerdahl, 2006). The whole-part idea is the pathway to music literacy prominent music educators such as Gordon, Orff, Kodaly and Suzuki aspired to in their respective methodologies (Gordon, 1984; Orff & Walter, 1963; Seitz, 2005, Sándor, 1969). Participants from the Music Group reported that when additional music constructs were added to the rhythm of Morse code (ie, when music training was used), remembering the rhythm of the Morse code letter became a subliminal entity rather than the forefront of the Morse code letter. When other music constructs are present, the rhythm became less important.

Music calmed the state of mind for novices in the Music Group as they learned the complex material of Morse code. Participants reported that the sheer nature of the sound and speed of the Morse code transmissions made them feel anxious and panicky, but when the Morse code was learned with music, the panic and anxiety were lessened and this opened channels to easier recall of the Morse code letters. This could relate to the pitch of Morse code (700hz) where the pitch does not change throughout the Morse code transmission. When elements of music are added, (melody or changes in pitch), the tension generated by the inherent monotone pitch of Morse code is lessened

(Jackendoff & Lerdahl, 2006). It could be possible that participants from the Music Group and Control Group were instinctively drawing on elements of music in the rhythm of the Morse code letters as a coping mechanism with the speed and urgency associated with the study.

6 CONCLUSIONS AND FUTURE DIRECTIONS

The techniques used to learn Morse code by wartime Morse code operators inadvertently uncovered the inherent musical rhythmic form of Morse code, and the inspiration for this thesis. Music played a vital role in learning Morse code during time of war, and the new strategies employed by the WRANS have implications for the study of music. This thesis is the first study of this kind to investigate Morse code learning and, linked with music learning, this unique form of rhythm has expanded on current research in rhythm perception by connecting wartime Morse code teaching strategies with music.

Project 1 discovered extraordinary insights into the methods used to learn Morse code by telegraphists from the Women's Royal Australian Naval Service (WRANS), and the WRANS reported that music provided an intuitive mechanism used in teaching and learning particular Morse code letters (*Q V* and *A*). Music provided the WRANS with an efficacious approach to learning Morse code instantly and flawlessly. Project 2 explored their underlying model of music connection and Morse code by assessing the ability of novices to learn Morse code letters, with and without music training. Novices showed a higher accuracy of learning Morse code letters with music than without music, supporting the WRANS's model that when Morse code is associated with music and the constructs of music there is a higher success rate of remembering and identifying the Morse code letter.

Morse code provided an unusual opportunity to isolate rhythm from other properties of music (such as duration, tempo, pitch and contour) (Sacks, 2007). Morse code is a rhythm concept and the methods used by the WRANS to teach and learn Morse code shared a striking resemblance to the methods used in teaching music by prominent music educators such as Jaques-Dalcroze, Orff, Kodaly and Suzuki who conceptualised the learning strategies of repetition, audiation, memorisation and vocalisation. The WRANS who served during the second World War learned Morse code before Orff and Kodaly methodologies were formed, yet Mrs Mac and the WRANS were unwittingly employing these same music education strategies in teaching and learning Morse code. It may be that the WRANS harnessed the natural rhythmic qualities of Morse code and instinctively applied known music properties to the existing rhythmic framework, to accelerate the identification of Morse code letters.

To the WRANS, Morse code was 'perfect rhythm', and their ability to recall this perfect rhythm some 70 years after their initial Morse code training opens the opportunity for future research in music and the mind. The WRANS have given an insight into the remarkable possibilities for humans to access rhythm in a highly esoteric setting that is Morse code. For them, there is still an ongoing connection between Morse code, music and language. The brain converts material to speech sounds for retention (Patel, 2008), and it is unclear as to whether the non-speech sounds of Morse code are perceived in a similar approach, as language or non-language. To the WRANS, Morse code is both language and music. The findings of the current studies will provide the starting point for further exploration into the field of human perception in understanding rhythm.

Future research will investigate these connections and how our brain pieces together new information.

Morse Code is an audio medium and its inherent rhythm provided the framework for the musical context of this thesis. Learning from the original WW2 experts, it provided novices with an innovative tool to learn, identify and recognise complex rhythmic patterns. This thesis has documented the historical significance of the untold wartime service of a conspicuous group of women, the WRANS, and confirmed that their musical methods assist with the human ability to perceive the rhythm of Morse code.

This work has contributed to the growing interest in rhythm perception and the connection between rhythm and memory. It discovered that the WRANS used a variety of strategies to harness this enigmatic material of Morse code, and found that their strategies were applicable to novices of Morse code. These findings have implications for how we perceive rhythm, understand rhythm, and learn rhythm in music. The link between music, language and rhythm has profound implications for music pedagogy and Morse code has provided a fascinating medium by which to investigate educational strategies for learning complex rhythmic material.

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APPENDIX A: ETHICS APPROVAL – PROJECT 1

THE UNIVERSITY OF SYDNEY

RESEARCH INTEGRITY
Human Research Ethics Committee
Web: http://sydney.edu.au/ethics/
Email: ro.humanethics@sydney.edu.au

Address for all correspondence:
Level 6, Jane Foss Russell Building - G02
The University of Sydney
NSW 2006 AUSTRALIA

Ref: MF/JM

15th May 2012

Dr Helen Mitchell
Conservatorium of Music
The University of Sydney
Helen.mitchell@sydney.edu.au

Dear Helen,

Thank you for your correspondence date May 7th, 2012 addressing comments made to you by the Human Research Ethics Committee (HREC).

I am pleased to inform you that with the matters now addressed your protocol entitled "Music and Linguistics: the auditory memory in Morse and music" has been approved.

Details of the approval are as follows:

Protocol No.: 14778

Approval Date: 15 May 2012

First Annual Report Due: 31 May 2013

Authorised Personnel: Dr Helen Mitchell
Ms Cassandra Mohapp

Documents Approved:

Document	Version Number	Date
Focus group participant information statement	2	08.05.12
Focus group consent form	1	08.04.12
Letter of Invitation	1	10.04.12
Interview – Participant information statement	1	08.04.12
Interview – Participant consent	1	08.04.12
Questionnaire		Submitted 12.04.12

HREC approval is valid for four (4) years from the approval date stated in this letter and is granted pending the following conditions being met:

Conditions of Approval

- Continuing compliance with the National Statement on Ethical Conduct in Research Involving Humans.

Manager Human Ethics
Dr Margaret Faedo
T: +61 2 8627 8176
E: margaret.faedo @sydney.edu.au

Human Ethics Secretariat:
Ms Karen Greer T: +61 2 8627 8171 E: karen.greer@sydney.edu.au
Ms Patricia Engelmann T: +61 2 8627 8172 E: patricia.engelmann@sydney.edu.au
Ms Kala Retnam T: +61 2 8627 8173 E: kala.retnam@sydney.edu.au

ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

- Provision of an annual report on this research to the Human Research Ethics Committee from the approval date and at the completion of the study. Failure to submit reports will result in withdrawal of ethics approval for the project.
- All serious and unexpected adverse events should be reported to the HREC within 72 hours.
- All unforeseen events that might affect continued ethical acceptability of the project should be reported to the HREC as soon as possible.
- Any changes to the protocol including changes to research personnel must be approved by the HREC by submitting a Modification Form before the research project can proceed.

Chief Investigator / Supervisor's responsibilities:

1. You must retain copies of all signed Consent Forms (if applicable) and provide these to the HREC on request.
2. It is your responsibility to provide a copy of this letter to any internal/external granting agencies if requested.

Please do not hesitate to contact Research Integrity (Human Ethics) should you require further information or clarification.

Yours sincerely

Dr Margaret Faedo
Manager, Human Ethics
On behalf of the HREC

cc: *Cassandra Mohapp*

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007) and the CPMP/ICH Note for Guidance on Good Clinical Practice.

APPENDIX B: INFORMATION SHEET – PROJECT 1

THE UNIVERSITY OF SYDNEY

Sydney Conservatorium of Music

ABN 15 211 513 464
DR HELEN MITCHELL
LECTURER

Room 2123
Conservatorium of Music C41
The University of Sydney
NSW 2006 AUSTRALIA
Telephone: +61 2 9351 1250
Facsimile: +61 2 9351 1287
Email: helen.mitchell@sydney.edu.au
Web: http://www.sydney.edu.au/

Morse and music

FOCUS GROUP - PARTICIPANT INFORMATION STATEMENT

(1) What is the study about?

You are invited to participate in a study of the different methods used to learn and memorise Morse code and the associated effects on auditory memory.

(2) Who is carrying out the study?

The study is being conducted by Cassandra Mohapp, Post Graduate student at the Sydney Conservatorium of Music, and will form the basis for the degree of Master of Music in Applied Research Methods in Music Performance at The University of Sydney under the supervision of Dr Helen Mitchell, Lecturer at The University of Sydney.

(3) What does the study involve?

You will be asked to attend two focus group discussions at the City of Sydney RSL Club.

At the focus group discussions, you will be asked questions relating to how you learned Morse code, if you used the same methods in teaching Morse code and you will be asked to decipher a short excerpt of Morse code. The sessions will be recorded; both audio and video.

You will be asked to fill out a questionnaire identifying your age, years of enlistment in the WRANS, and the role you played in service.

This study is to investigate the way in which you were taught Morse code and the methods you used to learn Morse code and is not intended as a memory test.

(4) How much time will the study take?

Each focus group discussion will take no longer than one hour.

(5) Can I withdraw from the study?

Being in this study is completely voluntary - you are not under any obligation to consent and - if you do consent - you can withdraw at any time without affecting your relationship with The University of Sydney.

If you take part in a focus group and wish to withdraw, as this is a group discussion it will not be possible to exclude individual data once the session has commenced.

THE UNIVERSITY OF SYDNEY

(6) Will anyone else know the results?

Yes. Your participation in this study is unique to you as a member of the WRANS Association as are the stories and experiences you share. All aspects of the study, including results, may be recorded for archival purposes and published for historical reference.

A report of the study may be submitted for publication, and individual participants will be identifiable in such a report.

(7) Will the study benefit me?

This study will benefit musicians, music teachers, historians, linguists and members of the Australian Defence Force by collating the stories, experiences and histories generously offered by you. These do not currently exist in our National Archives and National history. You will be offered detailed information on the results of the study when the project has been completed.

(8) Can I tell other people about the study?

Yes

(9) What if I require further information about the study or my involvement in it?

When you have read this information, Cassandra Mohapp will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact Cassandra Mohapp on 02 9359 3553 or cmoh7371@uni.sydney.edu.au

(10) What if I have a complaint or any concerns?

Any person with concerns or complaints about the conduct of a research study can contact The Manager, Human Ethics Administration, University of Sydney on +61 2 8627 8176 (Telephone); +61 2 8627 8177 (Facsimile) or ro.humanethics@sydney.edu.au (Email).

This information sheet is for you to keep

APPENDIX C: CONSENT FORM – PROJECT 1

THE UNIVERSITY OF SYDNEY

Sydney Conservatorium of Music

ABN 15 211 513 464
DR HELEN MITCHELL
LECTURER

Room 2123
Conservatorium of Music C41
The University of Sydney
NSW 2006 AUSTRALIA
Telephone: +61 2 9351 1250
Facsimile: +61 2 9351 1287
Email: helen.mitchell@sydney.edu.au
Web: http://www.sydney.edu.au/

Morse and music

FOCUS GROUP - PARTICIPANT CONSENT FORM

I, ...[PRINT NAME], give consent to my participation in the research project

TITLE: Music and morse

In giving my consent I acknowledge that:

1. The procedures required for the project and the time involved have been explained to me, and any questions I have about the project have been answered to my satisfaction.

2. I have read the Participant Information Statement and have been given the opportunity to discuss the information and my involvement in the project with the researcher/s.

3. I understand that being in this study is completely voluntary – I am not under any obligation to consent.

4. I understand that my involvement is **not** confidential. I understand that any research data gathered from the results of the study may be published and that information about me may be used in a way that is identifiable.

5. I understand that I can withdraw from the study at any time, without affecting my relationship with the researcher(s) or the University of Sydney now or in the future.

6. I understand that I can stop my participation in the focus group at any time if I do not wish to continue; however as it is a group discussion it will not be possible to exclude individual data to that point.

THE UNIVERSITY OF SYDNEY

6. I consent to:

• Audio/video-recording	YES ☐	NO ☐
• Being Named	YES ☐	NO ☐
• Receiving Feedback	YES ☐	NO ☐
• Data to be stored in perpetuity	YES ☐	NO ☐

If you answered YES to the "Receiving Feedback" question, please provide your details i.e. mailing address, email address.

Feedback Option

Address: _____

_____

Email: _____

.....
Signature

.....
Please PRINT name

.....
Date

Morse and music
Version 1 080412

APPENDIX D: ETHICS APPROVAL – PROJECT 2

THE UNIVERSITY OF SYDNEY

Research Integrity
Human Research Ethics Committee

Wednesday, 20 March 2013

Music and Morse
Dr Helen Mitchell
Conservatorium Admin; Sydney Conservatorium of Music
Email: helen.mitchell@sydney.edu.au

Dear Helen

I am pleased to inform you that the University of Sydney Human Research Ethics Committee (HREC) has approved your project entitled **"Music and Morse"**.

Details of the approval are as follows:

Project No.: **2013/076**

Approval Date: **18 March 2013**

First Annual Report Due: **18 March 2014**

Authorised Personnel: **Mitchell Helen; Mohap Cassandra;**

Documents Approved:

Date Uploaded	Type	Document Name
29/01/2013	Recruitment Letter/Email	Letter of Invitation
25/01/2013	Questionnaires/Surveys	Music and Morse: Questionnaire
29/01/2013	Participant Consent Form	Participant Consent Form
29/01/2013	Participant Info Statement	Participant Information Statement
02/03/2013	Recruitment Email	Recruitment Email

HREC approval is valid for four (4) years from the approval date stated in this letter and is granted pending the following conditions being met:

Condition/s of Approval

- Continuing compliance with the National Statement on Ethical Conduct in Research Involving Humans.
- Provision of an annual report on this research to the Human Research Ethics Committee from the approval date and at the completion of the study. Failure to submit reports will result in withdrawal of ethics approval for the project.
- All serious and unexpected adverse events should be reported to the HREC within 72 hours.
- All unforeseen events that might affect continued ethical acceptability of the project should be reported to the HREC as soon as possible.
- Any changes to the project including changes to research personnel must be approved by the HREC before the research project can proceed.

Research Integrity
Research Portfolio
Level 6, Jane Foss Russell
The University of Sydney
NSW 2006 Australia

T +61 2 8627 8111
F +61 2 8627 8177
E ro.humanethics@sydney.edu.au
sydney.edu.au

ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

Chief Investigator / Supervisor's responsibilities:

1. You must retain copies of all signed Consent Forms (if applicable) and provide these to the HREC on request.

2. It is your responsibility to provide a copy of this letter to any internal/external granting agencies if requested.

Please do not hesitate to contact Research Integrity (Human Ethics) should you require further information or clarification.

Yours sincerely

Glen Davis
E

Professor Glen Davis
Chair
Human Research Ethics Committee

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007) and the CPMP/ICH Note for Guidance on Good Clinical Practice.

APPENDIX E: INFORMATION SHEET – PROJECT 2

THE UNIVERSITY OF SYDNEY

Sydney Conservatorium of Music

ABN 15 211 513 464

DR HELEN MITCHELL
LECTURER

Room 2123
Conservatorium of Music C41
The University of Sydney
NSW 2006 AUSTRALIA
Telephone: +61 2 9351 1250
Facsimile: +61 2 9351 1287
Email: helen.mitchell@sydney.edu.au
Web: http://www.sydney.edu.au/

Music and Morse

PARTICIPANT INFORMATION STATEMENT

(1) What is the study about?

You are invited to participate in a study of the different methods used to learn and memorise rhythm.

(2) Who is carrying out the study?

The study is being conducted by Cassandra Mohapp, Post Graduate student at the Sydney Conservatorium of Music, and will form the basis for the degree of Master of Music in Applied Research in Music Performance at The University of Sydney under the supervision of Dr Helen Mitchell, Lecturer at The University of Sydney.

(3) What does the study involve?

You will be asked to attend one session at the Sydney Conservatorium of Music or a convenient location.

At the session, you will be asked to memorise and reproduce rhythmic excerpts. You will be asked questions relating to how you memorised the excerpts. The sessions will be recorded; both audio and video.

You will be asked to fill out a demographic questionnaire.

(4) How much time will the study take?

The session will take no longer than forty five minutes.

(5) Can I withdraw from the study?

Being in this study is completely voluntary - you are not under any obligation to consent and - if you do consent - you can withdraw at any time without affecting your relationship with The University of Sydney.

(6) Will anyone else know the results?

All aspects of the study, including results, will be strictly confidential and only the researchers will have access to information on participants.

A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

THE UNIVERSITY OF SYDNEY

(7) Will the study benefit me?

This study will benefit musicians, teachers and researchers by exploring how we perceive rhythm. You will be offered detailed information on the results of the study when the project has been completed.

(8) Can I tell other people about the study?

Yes

(9) What if I require further information about the study or my involvement in it?

When you have read this information, Cassandra Mohapp will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact Cassandra Mohapp on 02 9359 3553 or cmoh7371@uni.sydney.edu.au.

(10) What if I have a complaint or any concerns?

Any person with concerns or complaints about the conduct of a research study can contact The Manager, Human Ethics Administration, University of Sydney on +61 2 8627 8176 (Telephone); +61 2 8627 8177 (Facsimile) or ro.humanethics@sydney.edu.au (Email).

This information sheet is for you to keep

THE UNIVERSITY OF SYDNEY

Sydney Conservatorium of Music

ABN 15 211 513 464

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LECTURER

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PARTICIPANT CONSENT FORM

I, ...[PRINT NAME], give consent to my participation in the research project

TITLE: Music and Morse

In giving my consent I acknowledge that:

1. The procedures required for the project and the time involved have been explained to me, and any questions I have about the project have been answered to my satisfaction.

2. I have read the Participant Information Statement and have been given the opportunity to discuss the information and my involvement in the project with the researcher/s.

3. I understand that being in this study is completely voluntary – I am not under any obligation to consent.

4. I understand that my involvement is strictly confidential. I understand that any research data gathered from the results of the study may be published however no information about me will be used in any way that is identifiable.

5. I understand that I can withdraw from the study at any time, without affecting my relationship with the researcher(s) or the University of Sydney now or in the future.

6. I understand that I can stop the interview at any time if I do not wish to continue, the audio and video recording will be erased and the information provided will not be included in the study.

7. I consent to:

- Audio-recording YES ☐ NO ☐
- Video-recording YES ☐ NO ☐
- Receiving Feedback YES ☐ NO ☐

If you answered YES to the "Receiving Feedback" question, please provide your details i.e. mailing address, email address.

Feedback Option

Address: _____

_____

Email: _____

.....
Signature

.....
Please PRINT name

.....
Date