13 Musical cryptography

THERE WAS MUCH talk when Pink Floyd's album *The Wall* concealed a secret message, a message which could only be heard when the record was played backwards. This was achieved through back masking, a technique where the reversed recorded sound rendered the unintelligible noise when played forward as clear speech. This was in 1979, but concealing secret messages in music is not a new idea. Various cryptographic techniques have been used in music, based on mathematical rather than technological premises, and going back about 500 years.247 Although in everyday language there is little distinction made between coding and cryptography, in mathematical terms coding theory refers to the reliable transmission of data and to the detection of and correction of errors in its transmission whereas cryptography is the branch of mathematics which is the practice of writing in code or cipher aiming to conceal information. The original message is called the plaintext and the enciphered message is called the cryptogram. The process of converting the plaintext to ciphertext is called encryption, with decryption denoting the reverse process. A code is a way of hiding meaning by changing whole words or phrases by giving them some different significance, often substituting one word for another, whereas a cipher uses an algorithm which usually replaces a letter or other single character with another to convert the plaintext, a message, for example, into another text known as the ciphertext.

This chapter examines various uses of cryptography in music from an early example by the Renaissance composer Josquin des Prez to Olivier Messiaen's

247 Track eight of *The Wall*, *'Empty Spaces'*, conceals a hidden message which cannot be understood when the record is played normally. However if the record is played backwards a secret message can be heard which includes the words 'Congratulations. You have just discovered the secret message.'

10.5920/mathsandmusic.13

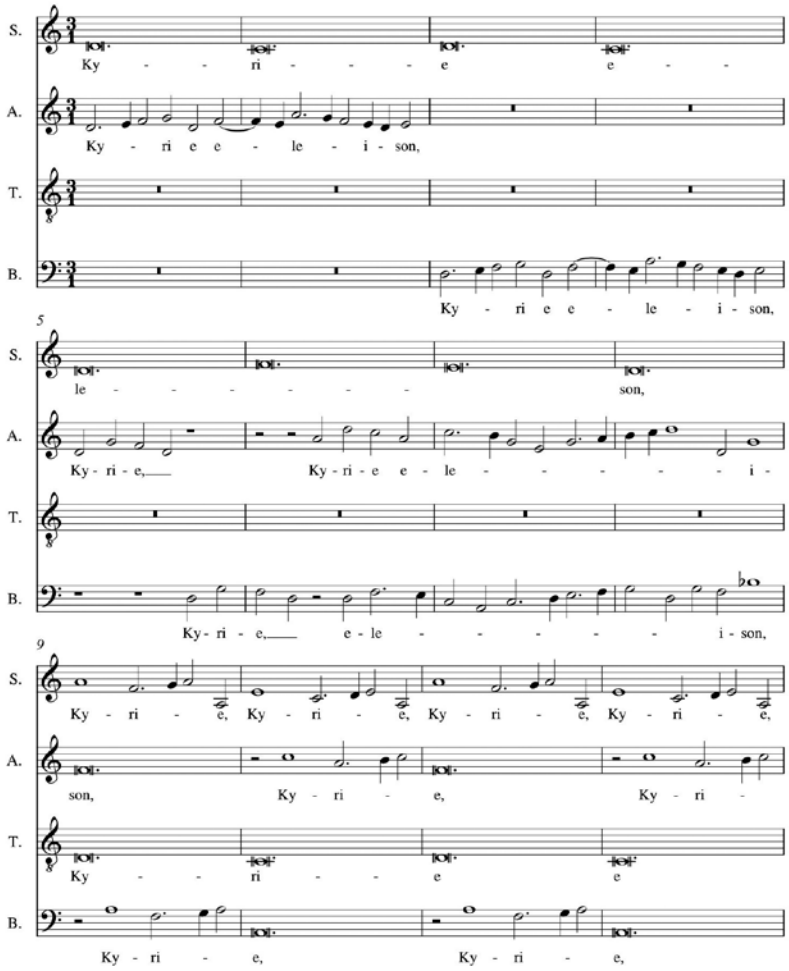
use of a coded musical language in the twentieth century. It explores the use of monograms as cryptograms by composers including Schumann and Shostakovitch. At the same time it looks at some of the limitations of cryptograms in music, questioning whether musical encryption can produce a convincing piece of music and work as a successful encryption, emphasising the relative simplicity of musical encryptions in comparison with those used in mathematics. The chapter concludes with an examination of one of the most famous pieces of music embodying a secret message – Edward Elgar's *Enigma Variations*.

One of the first instances of a musical cryptogram can be found in *Missa Hercules Dux Ferrariae* a setting of the mass dedicated to the Duke of Ferrara by the Renaissance composer Josquin des Prez (c. 1450 – 1521). Josquin takes the Latin name of the dedicatee 'Hercules Dux Ferrariae' and matches the vowel sounds to the vowel sounds of the solmization system. Solmization was devised by the eleventh-century monk Guido of Arezzo. He created a sight-singing system where a set of syllables is matched to the degrees of the scale - ut, re, mi, fa, sol, la (a system very similar to the one used today - do, re, mi, fa, sol, la, te, do). Josquin coupled the musical pitch of the solmization syllable with the vowel of text he wanted to represent. Thus 'Hercules Dux Ferrariae' translates as:

Her	cu	les	Dux	Fer	ra	ri	ae
re	ut	re	ut	re	fa	mi	re

The encryption becomes the pitches D-C-D-C-D-F-E-D in Josquin's *Missa Hercules Dux Ferrariae*. These pitches are used as the *cantus firmus*, the basis of Josquin's polyphonic mass. They can be heard in the opening bars of Kyrie I in the superius part, the top vocal line, and then moving to the tenor line in bar 9 (see below).

10.5920/mathsandmusic.13

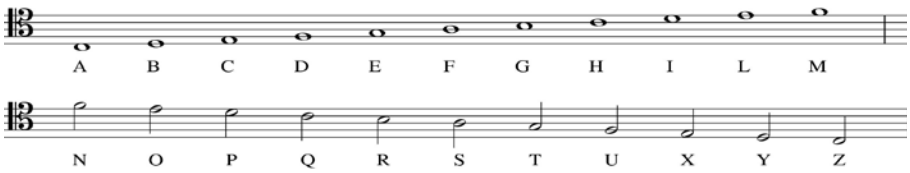


This cryptographic system which was later named 'Soggetto cavato' by the music theorist Gioseffo Zarlino in 1558. 'Soggetto cavato dalle vocali di queste parole' in full, translates as a subject 'carved out of the vowels from these words.' The *Missa Hercules dux Ferrariae* is the most famous example of a soggetto cavato and is also the first.[248]

Musical symbols, usually pitches, have been often used to create ciphers by matching up single notes with individual letters of the alphabet. Early examples can be found in the work of the sixteenth century scientist

248 Lewis Lockwood, '*Soggetto cavato*', in *Grove Music*.

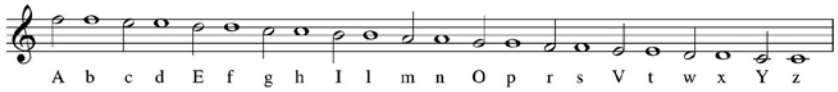
and polymath Giovanni Battista della Porta (1535–1615). During the Renaissance, at a time when political intrigue and war coincided with new scientific developments, there was a lot of interest in secret communication. Della Porta's seminal work on cryptography, *De Furtivis Literam Notis* (On the Secret Symbols of Letters, 1563) is primarily about codes and ciphers. One of his best-known ciphers uses a system where 11 different pitches are allotted letters of the alphabet.[249]



This system formed the basis of many subsequent systems across the years that followed. The musicologist Eric Sams, who has written extensively on cryptography in music, writes that it 'recurs in readily recognizable adaptations throughout the 16th and 17th centuries'. He goes on to list some of the different ways in which it evolved: the combination of crotchets and minims suggested by the British author Philip Thicknesse in 1772; the use of a cipher wheel where the notes and corresponding letters are written on two wheels, one fixed and one movable in the late eighteenth and early nineteenth centuries; the random allocation of musical notes to cipher letters; and the representation of one letter by a two-note group. As Sams writes, all of these methods were in the pursuit of a 'policy of analogy with real music'.[250]

John Wilkins (1614–1672) was the first to write a major book on secret communication in English -*Mercury, or the Secret and Swift Messenger. Shewing how a Man may with Privacy and Speed May Communicate his Thoughts to a Friend at any distance*. Chapter XVIII 'Concerning a Language that may consist only of Tunes and Musical Notes, without any articulate Sound' includes a cipher where musical notes are matched up with letters of the alphabet, no clef is given (see below).

249 Eric Sams. 'Musical cryptography' in *Grove Music*.
250 Sams, Cryptography, *Grove Music*.



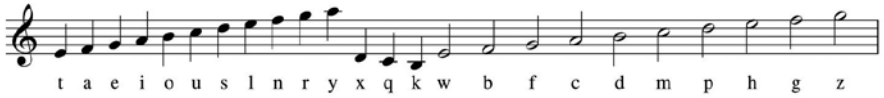
Wilkins writes 'Where the five Vowels are represented by the Minnums on each of the five lines, being most of them placed according to their right order and consequence, only the letters K and Q are left out because they may be otherwise expressed… By this you may easily discern how two Musicians may discourse with one another, by playing upon their Instruments of Musick, as well as by talking with their Instruments of Speech.'[251]

It is easy to see the limitations of this seventeenth-century cipher - there are only two note values and seven letter names- A B C D E F G. Philip Thicknesse (1719 – 1792) criticises the above example in his 1772 book *A Treatise on the Art of Deciphering, and of Writing in Cypher: With an Harmonic Alphabet*.[252] He argues that Wilkins system will 'instantly appear to anyone, the least conversant with music; that being without harmony or time, it must have no meaning or that some hidden meaning is *therefore disguised*'. He then puts forward his own method, an 'alphabet of musical notes' so that 'even a master of music shall not suspect it to convey any meaning'. 'I am persuaded an alphabet of musical notes may be so contrived, that the notes shall not only convey the harmony, but the very words of the song'. Thicknesse's proposed system is more sophisticated and uses a treble clef, minims and crotchets as well as a key signature to add authenticity (see below).[253]

251 John Wilkins . *Mercury, or the Secret and Swift Messenger. Shewing how a Man may with Privacy and Speed May Communicate his Thoughts to a Friend at any distance.* (London: printed for Richard Baldwin, 1694): 75-76.

252 Philip Thicknesse: *A Treatise of the Art of Decyphering, and of Writing in Cypher (London: W. Brown, 1772).*

253 H. Neville Davies. 'The History of a Cipher, 1602-1772.' *Music & Letters*. October, 1967, Vol. 48, No. 4, Oxford University Press: 325-329



The musicologist David Loberg Code questions whether musical encryption can be both a convincing piece of music and a successful encryption, coming to the conclusion that 'Musical encryption can rarely be both because the attributes needed for convincing musicality and strong encryption are not mutually conducive.' He finds that the music of those composers whose 'primary goal' was to 'create music that embedded extra-musical content by means of musico-alphabetic correspondences' used systems which 'were usually so superficial they should not really be considered encryption; whereas the systems used by the latter were so mechanical that most would not consider the results to be music.'[254] As Thicknesse observes, if music notation is to be used successfully to conceal information then it needs to look like a convincing piece of music.[255]

This lack of authenticity led to the downfall of a gambling group in 1940s New York. At the time, gambling was illegal and ingenious methods were devised to get around the law. One of the forms of gambling was a numbers game where bets were taken based on the U.S. Treasury Balance or baseball scores, for example. Those who recorded the numbers were known as policy collectors.

Back in 1940, a Brooklyn detective kept a policy collector under observation for the greater part of the day…he made the arrest but to his surprise, the pad on which the prisoner had been recording the bets did not contain the usual notations. It appeared to be the score of a musical composition…The detective was positive that the music represented some code…'For one thing, the whole piece was written on a range of ten notes. There seemed to be no variation in the value of the notes… So, I took it home and tried it out on a friend's piano. When I played it, I was sure that its atonalities were not music, either traditional or modern. So, I set to work to decipher it as a code…Not only were different musical notes used but their

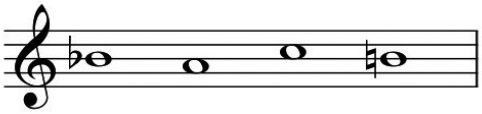
254 David Loberg Code. 'Can musical encryption be both? A survey of music-based ciphers', *Cryptologia*, May 2022: 318-364

255 Davies, 'The History of a Cipher', 327.

positions on the scale changed their values...Each measure, indicated by the straight line, constitutes a separate wager'.[256]

Monograms as cryptograms

Known examples of musical ciphers being used for espionage are rare. However there are many pieces of music where composers have used ciphers to create motifs or themes which are there to be interpreted rather than as codes to be decrypted. A common device has been to use a motif comprising notes whose letter-names spell words. These are often based on the composers own name or one of their friends. The problem in translating letter names into musical notes is the limiting nature of having only seven named pitches. The question arises as how to cipher the remainder of the alphabet. In German music however Bb is known as B and B natural is named H, hence the B-A-C-H motif which was used by J S Bach in several of his compositions, and then by many other later composers. Sams writes that 'Beethoven, Schumann, Liszt, Rimsky-Korsakov, Busoni and several others' used the BACH motif. This sequence of notes is not uncommon, so many of its appearances in Bach's work may be a coincidence.[257]



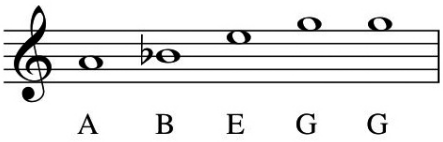
Further note names can be derived from their sound, for example E-flat, 'Es' in German, can be used to represent 'S' and other names can be arrived at by using the sol-fa system. A combination of the above offers the following possibilities of notes for the letters A, B (Ger. Bb), C, D, E, F, G, H (Ger. B), L (la), M (mi), R (re), S (Ger. Eb, 'Es') and T (te). Some composers took advantage of these extra letter names or used musical notes for more than one letter whilst others simply ignored any letters in their name which did not represent a musical note or made up their own systems.

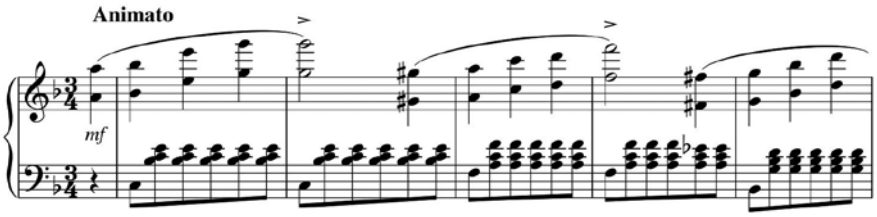
256 Anon. 'Codes are Fragile', *The Journal of Criminal Law. Criminology, and Police Science*. Spring 3100, 23 (New York, 1952), 10–13.

257 Sams, 'Cryptography', *Grove Music*.

A	B	C	D	E	F	G	H	L	M	R	S	T
A	B or Ger. Bb	C	D	E	F	G	Ger. B	la	mi	re	Ger. Eb	te

One well-known example of a thematic motif based on a person's name can be heard in Schumann's *Variations on the name "Abegg"* which are dedicated to the (possibly fictional) Pauline, Comtesse d'Abegg. In this instance the cryptogram is not used to conceal Abegg's name, rather it is used as a compositional technique.



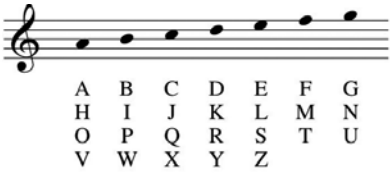


Schumann (1810-1856) uses the notes A – Bb – E - G - G as the basis of his opening theme, quoting the notes directly in the opening bars over a dominant seventh chord and then using them to build a sequence. As the piece goes on, less attention is focused on the ABEGG motif and more attention is given to the developmental possibilities of its first two notes A – Bb.

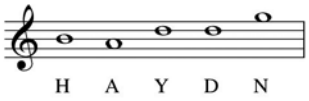
The German composer Johannes Brahms (1833 – 1897), however, included a cryptogram in his 1868 *String Sextet No. 2 in G major* which quite possibly conveyed a secret thought. In the summer of 1858, he had fallen in love with Agathe von Siebold. They planned to get married, but Brahms broke off the engagement in order to focus on his musical career. Brahms never married and although Von Siebold later married someone else, Brahms continued to long for her. The notes A-G-A-(T) H-E can be

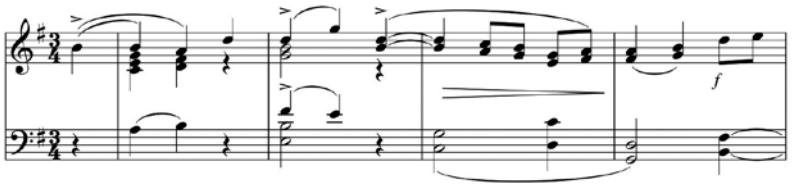
found as the music rises to a heart-wrenching climax in the first movement (bars 162 - 168). In a letter to his friend Josef Gänsbacher, Brahms wrote 'by this work, I have freed myself of my last love.'[258]

In 1909 six composers were commissioned to celebrate the life of the composer Joseph Haydn by the *Revue musicale mensuelle de la Société Internationale de Musique*. Haydn had died 100 years earlier and the composers – Maurice Ravel, Claude Debussy, Paul Dukas, Vincent d'Indy, Charles-Marie Widor and Reynaldo Hahn – were invited to compose a piece based on Haydn's name. Each of the composers used the same cipher system.



In Ravel's short piano piece of only 54 bars, *Menuet sur le nom d'Haydn*, H was given its German equivalent, B natural and was built on the following motif.



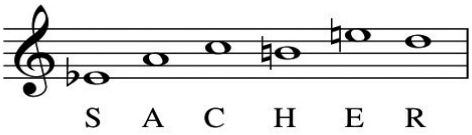


Similarly, in 1976, the cellist Mstislav Rostropovich commissioned 12 prominent composers to write a piece based on a musical cipher, this time for

258 Jacquelyn E C Sholes. *Allusion as Narrative Premise in Brahms's Instrumental Music*. (Indiana: Indiana University Press, 2018): 33.

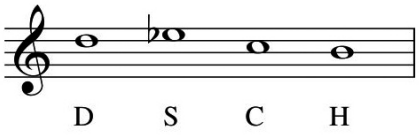
the 70th birthday of the Swiss conductor Paul Sacher. Rostropovich invited each of the composers Conrad Beck, Luciano Berio, Pierre Boulez, Benjamin Britten, Henri Dutilleux, Wolfgang Fortner, Alberto Ginastera, Cristobal Halffter, Hans Werner Henze, Heinz Holliger, Klaus Huber, and Witold Lutoslawski to write a variation. In *12 Hommages à Paul Sacher* each of the solo cello pieces is based on this cryptogram of Sacher's name.

E-flat (Es), A, C, B-natural (H), E and D (Re) which spell out eSACHERe



The variations are technically demanding and were composed in a variety of styles, some use traditional notation, others use extended cello techniques. Some of the pieces 'cleverly disguise' the hexachord whilst in others the pitches are used in a 'clearly recognisable manner'.[259]

The Russian composer Dmitri Shostakovitch (1906 – 1975) used his monogram D-S-C-H throughout most of his career. The notes transliterate to D Sch(ostakovitch) a musical encryption of his name. The monogram can found in several of his works including Symphonies No. 1 and 10, String Quartets No. 5 and 8, Violin Concerto No. 1 and Cello Concerto No. 1.

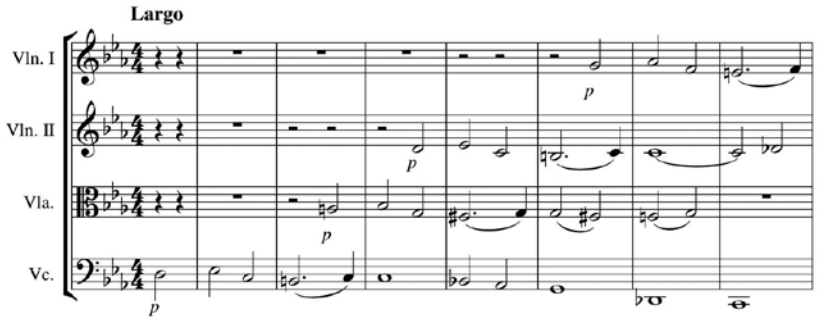


The signature motif permeates his *String Quartet No. 8* in C minor, Op. 110 (1960). Rather than disguising a secret message it contributed to what Shostakovitch described, in a letter to his friend Isaak Glikman, as the string quartet's 'superlative unity of form'.[260] It is an anguished work written after a

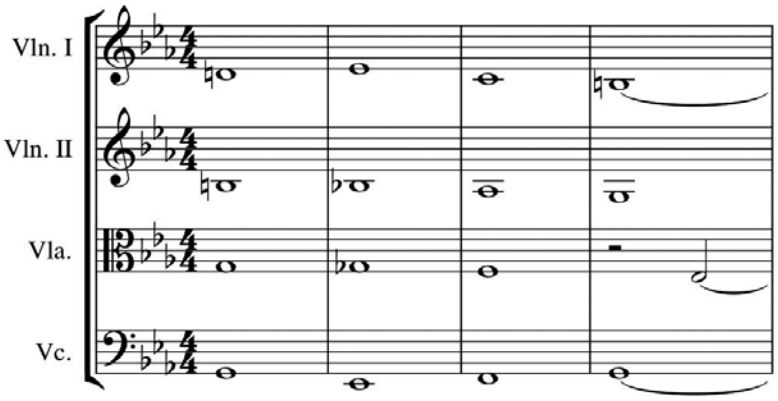
259 Ryane Dunnagan. An examination of compositional style and cello technique in *12 Hommages à Paul Sacher*. Unpublished PhD thesis. 2017.

260 Michael Mishra. *A Shostakovich Companion*. (London, Bloomsbury, 2008): 230.

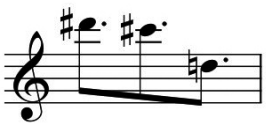
visit to Dresden where he witnessed the devastation which had been caused by World War II bombing. In some ways it could be described as an autobiographical work, as well as the signature motif being woven seamlessly into nearly every page, the work is full of quotations from earlier works. The piece is dedicated 'To the memory of the composer of this quartet'. His use of the four-note motif is ingenious and imaginative. The piece opens with the personal motto heard in the cello part initially and then moving up through the strings in imitative counterpoint (see below). The parts are all in a low tessitura contributing to the sombre mood.



Later on in the first movement (bar 79) the DSCH motif is heard in all the parts but this time the texture is homophonic (chordal) rather than contrapuntal. The resultant chords are G major, Eb minor and F major moving on to the harshly dissonant tone cluster of G, Ab, B. This time the theme is in augmentation using notes of twice the value (see below)

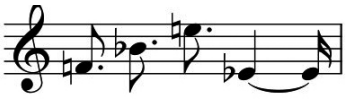


Rather than enciphering single words or names, the twentieth century French composer Olivier Messiaen (1908 - 1992) enciphers whole phrases and uses both codes and ciphers in his music. He devised what he referred to as a '*langage communicable*'. In the preface to the score of his 1969 organ work *Méditations sur le Mystère de la Sainte Trinité*, Messiaen outlines some of the compositional techniques he has used in the encryption of the work. Each letter of the alphabet is assigned a musical note and this cipher is used to encode quotations from the thirteenth-century *Summa theologica* of St Thomas Aquinas (a compendium of the theological teachings of the Catholic church). He also uses symbolic leitmotifs which act as codes, referring to these as *formules musicales*. Messiaen's works are imbued with religious significance. The following two melodic leitmotifs are used to represent the verbs 'to be' and 'to have'. Messiaen explains in the preface to the score that 'To be' uses a descending movement, because all that is comes from God (the Being par excellence, He who Is)'.



'To have' is an ascending movement because we can always gain more by raising ourselves towards God'.

10.5920/mathsandmusic.13



As Andrew Shenton points out, in sharing the cipher, Messiaen has removed any 'problem for the *performer* discerning the 'hidden' message', but this still leaves the more complex problem of 'comprehension for the listener'.[261] This brings us back to Code's earlier question as to whether musical encryption can function successfully as both music and code. Part of his criticism is that the 'musico-alphabetic correspondences' frequently used by composers are often superficial to the extent that they should not really be considered as encryption.[262] It is certainly true to say that in comparison even the simplest systems of mathematical coding are usually much more complex and sophisticated: they can involve, for example, probability theory, frequency analysis or set theory; some use random number generators; and others utilise concepts based on number theory.

The mystery of Elgar's *Enigma Variations*

This chapter would not be complete without some reference to Edward Elgar's (1857 - 1934) famous orchestral piece *Enigma Variations* (1899) which has attracted, as the BBC radio presenter Tom Service once put it 'more musicological and pseudo-mathematical sleuthery than any other work of orchestral music before or since'.[263] There are two enigmas. The piece is made up of 14 variations on an original theme, each being a musical sketch of a friend of Elgar's. In all but one cases the dedicatees are named, but the penultimate variation is simply marked with three asterisks. The first much-discussed enigma (which does not involve a cryptogram) is the identity of this anonymous dedicatee. The second enigma takes the form of a sophisticated cryptogram created by a skilled cryptologist. As Sams writes of Elgar,

261 Andrew Shenton. *Olivier Messiaen's System of Signs: Notes Towards Understanding his Music.* (London: Routledge, 2008).

262 Ibid.

263 https://www.bbc.co.uk/music/articles/cb7ac9cf-207e-4244-8302-2436f2c2ba5a

> He successfully solved a well-known challenge cipher, to which eminent experts later thought it worthwhile to publish their own solutions; he constructed a difficult if not impossible cryptogram; he made cipher entries in diaries and notebooks. One of his earliest works was an Allegretto for violin and piano on G–E–D–G–E, the name of a friend. It seems reasonable on the facts to conjecture that he used private ciphers in some of his compositions, and that suggestion has often been made in respect of the 'Enigma' Variations.[264]

Elgar suggested that the real theme of the Enigma Variations is not the theme that you can clearly hear, rather it is a familiar melody that can be played at the same time but never appears in full. In the programme note for the first performance Elgar is quoted as saying about the hidden theme that it is "so well-known that it is extraordinary that no one has spotted it".

> The Enigma I will not explain – its "dark saying" must be left unguessed, and I warn you that the connexion between the Variations and the Theme is often of the slightest texture; further, through and over the whole set another and larger theme "goes", but is not played . . . . So the principal Theme never appears… the chief character is never on the stage.[265]

In 1900 Elgar gave another clue in an interview he gave to the *Musical Times* where he said that the 'heading Enigma is justified by the fact that it is possible to add another phrase, which is quite familiar, above the original theme that he has written'.[266] So the key to the decryption would involve finding a well-known theme that would fit both harmonically and rhythmically in counterpoint with the original theme - no mean feat. Years of speculation followed with suggestions including God Save the Queen, Pergolesi's *Stabat Mater*, Rule Britannia and Auld Lang Syne as potential hidden melodies working in counterpoint with the stated theme, but none of these quite works. Furthermore, Elgar accepted none of the solutions proposed during

264 Sams, 'Cryptography', *Grove Music*.

265 Turner, Patrick (2007). *Elgar's 'Enigma' Variations – A Centenary Celebration*. (London: Thames Publishing, 2007): 49.

266 F G Edwards. 'Edward Elgar'. *The Musical Times*, May 1900, Vol. 41.

his lifetime. The question remains as to whether this matters when the piece can be enjoyed without any consideration of its inner puzzle. Indeed part of its attraction may lie in what the conductor Norman del Mar describes as 'the impenetrability of the riddle itself.[267]

267 Norman Delmar.*Conducting Elgar*. (London: Clarendon Press, 1998).

10.5920/mathsandmusic.13

10.5920/mathsandmusic.13