

# Cryptographic Music, an Introduction

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## Introduction

The purpose of this introduction is to motivate and develop a process for which to bridge language gaps between English alphabetical notation and specific pitch class notation. We proceed from the foundations of work conducted by Eric Sams, John Daverio as well as basics of modular arithmetic and music theory.

We begin our initial process by summarizing the cryptographic key developed in Sams' article "Did Schumann use Ciphers?" Schumann's key maps a single letter to a single pitch. Schumann mapped three letters: C, E, and F, representing his wife Clara and his two alter egos: Eusebius and Florestan to consecutive pitches D natural, E natural, and F natural respectively. Schumann chose every other letter to pitch mapping based around this joining of his own and Clara's names. It is important to note that in this case, Schumann chose every other letter to pitch mapping based around his musical compositional background and not in any mathematical processes or orderings.

We follow suit by developing an ordered system with which to map letters to pitches; one that is based in mathematical processes rather than Schumann's own compositional choices. The goal is to create a system with which anyone, regardless of musical or mathematical capability, may produce a melody based around a keyword and a message. It is important to note that this system, when unmodified by compositional choices, tends towards a-tonal, repetitive constructions.

## Process

We begin by reordering the alphabet with a keyword cipher that maps the ordered letters HELLOTHERE to the first five letters of the English alphabet. From this, we map the remaining letters in order to the alphabet, skipping the letters H,E,L,O,T,R.

```
#set up the keyword to be used
```

```
alphabet <- letters[1:26]
keyword <- "hellothere"
usedkeyword <- unlist(strsplit(keyword, split = ""))
C <- match(usedkeyword, alphabet)
```

Our for loop takes the object L, originally a vector of 26 0's, and maps the vector C, our keyword vector, onto the first 0's in L. It then maps the remaining numerical values mod 26 onto the vector L while also searching through duplicate values and removing them from use. The subsequent r-chunk then returns L mod 12 as the link to the set of pitch classes.

```
#rearrange the the alphabet mod 12 using the keyword
```

```
J = c(C, seq(26))

L = rep(0, 26)
pL = 1
```

```
for(j in 1:length(J)) {
  p = 1
  while(p < pL & L[p]!=J[j]) p = p+1
  if(p == pL){L[pL] = J[j]; pL = pL + 1}
}
```

```
L%%12
```

```
## [1] 8 5 0 3 8 6 1 2 3 4 6 7 9 10 11 1 2 4 5 7 9 10 11
## [24] 0 1 2
```

Notice that every number occurs twice, except for 0 and 1 which occur three times. We now map these numbers onto the original alphabet.

We may now assign each letter in the alphabet a pitch class based on these mappings. The message GENERALKENOBI reads in pitch class notation as follows.

```
#compose a musical phrase
```

```
phrase <- unlist(strsplit("generalkenobi", split = ""))
```

```
L[match(phrase, alphabet)]%%12
```

```
## [1] 1 8 10 8 4 8 7 6 8 10 11 5 3
```

## Conclusion

The natural follow up to this process would involve a system with which to decode a musical melody created by our method. While the polyalphabetic nature of this cipher system lends itself to added security without knowledge of the keyword, we believe that, with sufficiently long messages, it is still possible to decipher through careful frequency analysis as well as analysis of bigrams and trigrams.

In conclusion, we believe that this process of transforming letters to pitches lends itself more to the development of modern composition techniques, rather than for practical security usage. However, there exists an inherent strength in this technique in that one may hide cryptographically created passages within compositionally created passages; as well as combine passages with different keywords across instrumentation. The compositional possibilities inherent in this system allows for those who are self-conscious or inhibited in their own compositional capabilities to develop a sonic framework from which to expand or modify to suit their tastes.