A Talking Rosetta Stone

By Greg Lauzon

The Death of Tongues

The Rosetta Stone was discovered in the Town of Rosetta in 1799 during the Napoleonic invasion of Egypt. It was inscribed with three scripts, Hieroglyphs, Demotic and Ancient Greek. These three scripts were parallel translations of a decree in the name of the Greek Pharaoh, Ptolemy the 5th. The Greek script enabled Thomas Young to decipher the royal name Ptolemy within the hieroglyphs. However, it was Jean-François Champollion who proved that the hieroglyphs were largely a phonetic script. Prior to this the hieroglyphs were believed to be mostly a symbolic script representing words much like Chinese characters. It was ultimately Coptic, a living liturgical language related to late Egyptian, which enabled Jean-François Champollion to match its sounds with the Demotic (late Egyptian) script which in turn unlocked the secrets of the Hieroglyphs.[1] This was based on the Rebus principle, using pictograms as representations of sounds as opposed to their meanings to create words.

Vowels were not written in the hieroglyphs or Demotic, only consonants, and therefore it is not clear what the actual vocalizations were. Coptic, however, was a form of late Egyptian that adopted the Greek alphabet, which had vowels. This provided a basic phonetic framework. If only the Rosetta Stone could talk.

It took a living liturgical language like Coptic and a dead language like Ancient Greek to resuscitate a dead script like Demotic in order to decipher another dead script, the Hieroglyphs. The conditions for that development occurred by chance. The right people found the Rosetta Stone at the right time and place which enabled people with the right knowledge and skills to decipher the Hieroglyphs. This is a testimony to the importance of preserving languages. What would happen if only a small percentage of languages ever survived?

There are just under 7000 known languages in the world currently spoken. Most of these languages are oral traditions without a writing system. Globalization has made it necessary to learn a more established language for work and travel. As a result younger generations have abandoned the traditional language of their culture in favor of a more prestigious language in hopes of a better life. Linguists predict that half of these traditional languages will be extinct by the year 2110. At the current rate one language dies every two weeks as the last of the speakers grows old and dies. The percentage of endangered languages greatly exceeds that of endangered plant and animal species. This will be an incalculable loss to cognitive science, culture and a vast knowledge base that folk cultures have about plant and animal species not yet known to the outside world.[2]

The Sound of Resurrection

Thomas Edison was credited as the inventor of the phonograph in 1877. However, there is a prehistory to the recording of sound that many are not aware of. Thomas Young, who was also a key figure in the deciphering of the Rosetta Stone, demonstrated in 1806 that a tuning fork could produce visual tracings of

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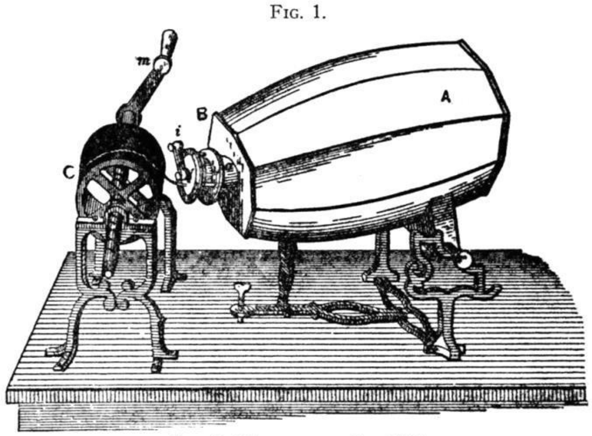
[1] Robert Solé, Dominique Valbelle, *The Rosetta Stone*, Translated by Steven Rendall, (London: Profile Books, 2001) 79-86

[2] K. David Harrison, *When Languages Die*, (New York: Oxford University Press, 2008) 3-22

waveforms.[3] The earliest known contraption for recording sound waves from the air was the phonautograph - a word not even recognized by spellcheck, today. (Fig. 1) The phonautograph was patented on March 25, 1857, in France by Édouard-Léon Scott de Martinville. The construction was fairly straightforward: a funnel, a membrane attached to the end of the funnel and a stylus attached to the membrane. Sound vibrations travelling through the air were amplified by the funnel to vibrate the stylus attached to the membrane. These vibrations were in turn etched onto smoke soot covered paper which was wrapped around a hand cranked cylinder.[4] These were the first air pressure waves to ever be recorded onto any medium. The phonautograph was only meant to be a scientific instrument for recording sound waves and could not play them back. At the time it was not known how engravings of waveforms could be used to recreate sound. Edison was the first to succeed at doing this.

These waveform etchings, or phonautograms, lay forgotten at the patent office in Paris and the French Academy of Sciences for 150 years. In 2008 scientists at Lawrence Berkeley National Laboratory in Berkeley, California acquired high resolution scans of phonautograms which they were able to educe into sound using optical imaging technology and a virtual stylus. This project was spear headed by an organization of audio historians called First Sounds.[5] The fact that it is possible to bring a 150-year old drawing of a waveform to life is significant for the long-term preservation of sound recordings.

Fig. 1.



Scott's Phonautograph.—1857.

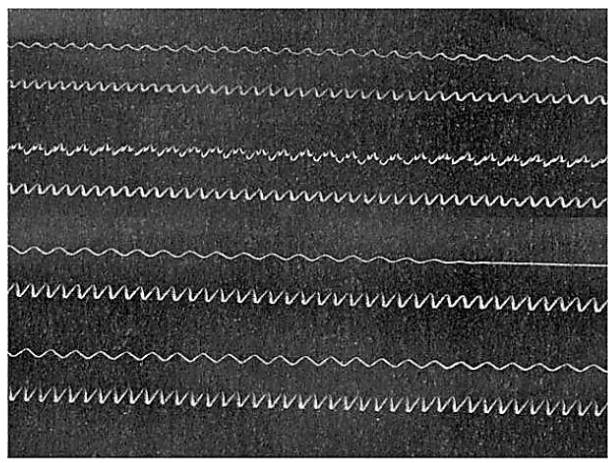


Fig. 1, Leon Scott's Phonautograph, left. Phonautogram tracing of "Au Clair de la Lune" April 9, 1860, right. Audio clip below.[6]

[3] Thomas Young, *Miscellaneous Works of the Late Thomas Young*, Edited by George Peacock, (London: J. Murray, 1855) 154-55
See also, David Morton, *Sound Recording: The Life Story of a Technology*, (Baltimore: John Hopkins University Press, 2006) 2
[4] Allen Koenigsberg, *Edison cylinder records, 1889-1912, with an illustrated history of the phonograph.*, (New York: APM Press, 1987) xi
See also, Allen Koenigsberg, *The patent history of the phonograph, 1877-1912: a source book.*, (New York: APM Press, 1991) 20, 25
[5] First Sounds, http://www.firstsounds.org/ (accessed August 4, 2017).
[6] The Phonautograms of Édouard-Léon Scott de Martinville http://www.firstsounds.org/sounds/scott.php (accessed August 4, 2017).

Preservation by Accident

There are numerous examples throughout history of ancient artifacts of one form or another, lost to antiquity, that have been discovered among ruins. In A.D. 79 Mount Vesuvius erupted, burying Pompeii and Herculaneum in ashes. Over 1000 papyrus scrolls lay buried under the debris for nearly 2000 years before being discovered in the mid 18th century. They are the only known library collection of texts from the classical period – history discovered by accident.[7] It cannot be presumed that current day holdings within libraries and archives will remain intact throughout history. War, natural catastrophe, looting and decay have laid a heavy cost upon history. Being buried under debris for thousands of years has in fact been the best protection in some cases.

It is theoretically possible that anyone in antiquity could have built a contraption like the phonautograph. The concept behind the construction is simple. An inventor living in ancient Rome could have used a hollow log or vase with a hole in the bottom, sealed the hole with an animal skin with an attached hog hair and then etched out sound vibrations onto scrolls of papyrus. These scrolls could have been buried under the volcanic debris of Herculaneum to be discovered 2000 years later. These waveform etchings could have in turn been used to recreate the voice of Philodemus. This scenario never happened because they did not know that waveforms existed and that they had meaning that could be educed.

Bits and Bytes

Digital is an invented language that uses binary sets of 1s and 0s as opposed to analog signals which are continuous waves of energy. Little power is needed to transmit digital signals and they are not susceptible to the kind of distortions that analog is. Digital information can also be more easily manipulated and stored than analog. It can be used to create any manner of media including sound, video, pictures, text, etc. These qualities might appear to give digital an advantage over analog as a storage medium of information.

However, the caveat of digital is the myriad of ever evolving formats surrounding it. Digital media formats such as floppy discs are no longer supported by computer. Physical longevity of digital media such as CD is uncertain. As an illustration, the Doomsday Book produced in the year 1086 on sheep skin was largely a geographical survey of England and Wales. That book still exists today. In 1986 a Doomsday Book II Project was established using digital formats at a cost of 2.5 million dollars. Within 16 years the information on the discs was unreadable due to obsolescence of technology and deterioration of media. This is an example of how the hardcopy method of preservation may still have advantages over digital preservation.

Long term digital preservation is custodian dependent. The custodian must know when it is time to transfer files to a more current hard drive or storage media, when to convert files to newer formats that will not become defunct in the foreseeable future. They must also choose someone to succeed them as a custodian, someone they can trust. These things may require resources and knowledge that may not be available to every individual or institution. An artifact that is at least to some degree neglect- proof has a greater chance of survival. It would appear that digital's advantages are more for short term uses that do

[7] David Sider, *The Books of the Villa of the Papyri*. *The Villa of the Papyri at Herculaneum*., Edited by Mantha Zarmakoupi. (Berlin/New York: Walter de Gruyter GmbH & Co. KG, 2010) 115-127

not require long term dependability.

Latest Discoveries
There are several initiatives being made to address the issue of long-term storage of digital information. In June 2013 a team of scientists from the University of Southampton and Eindhoven University produced a glass disc using nanotechnology that could hold 360 terabytes of information for up to a million years.[8] Scientists from Harvard Medical School encoded 700, 000 gigabytes of digital code onto the molecules of a long chain DNA strand. It is estimated that it can last up to a million years.[9]

However, there is still the issue of evolving formats and long-term survival of digital languages. It is unlikely that mass amounts of digital code will be decipherable in the distant future without some knowledge of the software coding schemes used to create and access it. This would be particularly difficult with digital files that have been compressed or encrypted and have errors in the code as a result of deterioration from age.[10]

Elemental Forms
I propose that preserving information in its most elemental form bypasses many of the problems associated with changing computer technology and digital formats. A visual image of a waveform can lend itself to any number of computer programs that can be designed to convert it into sound or other forms of technology that may be simpler. Contrast this with a digital audio file that must fit within strict code parameters of a program in order to even be playable. The analog waveform is elemental, natural and universal. The grooves in a record are a literal representation of an actual event in a way that the pits and valleys on a digital format like CD are not. The digital language used to convert the analog waveform into a digital format and play it is conceptual, artificial, and invented. These digital concepts change; human hearing does not nor does the behavior of the waveforms with respect to the laws of physics.

This is an example of Lonergan's category of heuristic method, upper and lower blade scissors metaphor.[11] The upper blade is that which is invariable and fundamental. A waveform etched onto a cave wall 50,000 years ago can be educed and create the same sound today. It is an elemental form.

The lower blade is that which is variable and subject to probabilities such as the technology for playing the waveform. A waveform that has been converted to a digital language of 1s and 0s may not be decipherable by a computer 50,000 years from now. The ability to interpret the language behind the 1s and 0s may be lost even if the information survives. This is similar to the circumstances around the Rosetta Stone - subject to chance events in history. Conceptual meanings in the form of codes and alphabets can change. The heuristic structure of upper and lower blades is like the engine within

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[8] Zhang, Jingyu, Mindaugas Gecevičius, Martynas Beresna, and Peter G. Kazansky. "Seemingly Unlimited Lifetime Data Storage in Nanostructured Glass." *Physical Review Letters*112.3 (2014): 033901 https://link.aps.org/doi/10.1103/PhysRevLett.112.033901. (accessed August 9, 2017).
[9] Gopalratnam, Arjun. "DNA Goes Digital." *Chemical Engineering Progress* 108, no. 11 (11, 2012): 64
[10] Howard Besser, Digital Longevity. Edited by Maxine Sitts, (Andover: Northeast Document Conservation Center, 2007) 155-166
[11] Bernard Lonergan, *Insight*, (Toronto: University of Toronto Press, 1992) 337

emergent probability. The upper blade is like the classical laws that are invariant such as the waveform. The lower blade is the chance occurrence that sets the conditions for the classical laws to happen.

It would stand to reason that a culture in the distant future with some knowledge of digital computation would have already discovered the science behind waveforms and would recognize them if they saw them. However, it would be difficult to surmise whether a culture that is developed enough to have some knowledge of waveforms would necessarily be advanced enough to recognize and decipher the binary code of an unknown digital language. In this epoch the discovery of waveforms came before the establishment of any advanced digital computing. The principle behind this is that the lower the technological requirements are to retrieve the information from the storage medium the greater the probability of it being recognized in the distant future. A technologically developing culture would likely discover things that were closer to nature first and then move into discoveries based on theory such as digital computer science.

Making the Dead Speak

There is an effort to apply this principle to the written word. It is called the Rosetta Disk created by the Long Now Foundation.[12] It is a disc of solid nickel that has been micro-engraved with 13, 000 pages of information on 1500 languages. Its estimated life expectancy is around 10, 000 years. Any culture that has a microscope with a minimum 100x magnification will be able to read the information on this disc. Like the Rosetta Stone, the disc uses parallel translations to maximize the probability of decipherment. The technology to produce this disc is modern and cutting edge but the technology needed to retrieve the information has been around for hundreds of years. This initiative was a response to the crisis of the many endangered languages facing extinction and to the need to make the information as accessible as possible to future cultures.

Perhaps a similar project could include micro-engraved pictograms of waveforms. Any culture with basic magnification ability and the equivalence of late19th century sound technology could theoretically recognize the waveforms and find a way to educe them into sound or transfer the images to a playable format. Combined with corresponding texts, the waveforms would provide examples to future linguists of how these languages sounded as well as how they were written.

One might logically question the relevance of preserving the sound of the language in pictorial waveforms. The conceptual meaning of the words educed from the waveforms may not even survive. This is where parallel translations have their greatest value. The more translations of a language that exist, the higher the probability that one of those translations can be correlated with a language of the future. This approach is much less custodian dependent in terms of which language preserves the meanings. The windows of opportunity to update and refresh translations and meanings are longer.

However, it is also worth investigating how concepts might be preserved or reconstituted from oblivion like the language of the Indus Valley Script using heuristic method through computers. Rajesh Rao is a computational neuroscientist. He is responsible for finding patterns within the Indus Valley Script that

[12] Long Now Foundation, http://longnow.org/ (accessed August 8, 2017).

resembled language by using comprehensive statistical analysis through a computer.[13] By contrast, the Rosetta Stone was deciphered because it was written in three scripts, Hieroglyphs, Demotic and Ancient Greek. Having three linguistic reference points enabled the hieroglyphs to be deciphered. Perhaps a computer could have found patterns within each of these languages. However, is it possible for a computer to decipher an unknown language by referencing it to known languages? It would seem that the ability to grasp conceptual meaning requires the act of insights currently not available with artificial intelligence.

However, researchers from the University of California created a computer program that could reconstruct early proto languages by replicating what linguists do manually with an 85% accuracy. Using a database of 140,000 words this program reconstructed 600 proto-Austronesian languages that existed before the earliest known systems of writing 6000 years ago. What would have taken linguists years to do manually this program did within hours using algorithms.[14]

Initiatives have been made to emulate as many software programs and operating systems as possible and to establish universal conventions. There remains the difficulty of copyright, cost and cooperation from software developers to provide source codes to programs. These initiatives are important. However, alternatives to this approach should also be explored because it is difficult to predict how history will unfold.

The Reading of Sounds

It is also worth exploring the use of spectrograms as visual representations of sounds. Spectrograms use fourier analysis, which breaks the sound of a waveform down into smaller segments that enable them to be more easily analyzed visually. (Fig. 2) They are displayed differently than waveforms. They are typically represented vertically by frequency and horizontally by time as opposed to waveforms which are represented vertically by amplitude and horizontally by time. In a spectrogram the amplitude or loudness is represented by the color of the regions.

While a spectrogram image may be generated from a sound it is also possible to generate a sound from an image of a spectrogram through a process called reverse fourier analysis. This method was popularised by Patrick Feaster with his work on Paleospectrophony, the playing of old inscriptions of sound.[15] For this process, the colors of the image are reversed like the negative of a picture. Many freeware programs exist that can do this by converting a graphic file into an audio file. The sound produced through this method is different than the sound produced from an educed image of a waveform. Spectrogram images do not have the phase information that waveform images do. This is why a spectrogram image that has been educed through reverse fourier analysis software, although intelligible, does have a somewhat synthetic sound.

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[13] Rajesh P. N Rao, "Probabilistic Analysis of an Ancient Undeciphered Script," *Computer* 43, no. 4 (2010) 76-80

[14] Alexandre Bouchard-Côté, David Hall, Thomas L. Griffiths, Dan Klein "Automated Reconstruction of Ancient Languages Using Probabilistic Models of Sound Change," *Proceedings of the National Academy of Sciences of the United States of America*, *2013 110 (11) 4224-4229,* http://dx.doi.org/10.1073/pnas.1204678110 (accessed August 16, 2014)

[15] Phonozoic http://www.phonozoic.net/paleospectrophony.html (accessed August 8, 2017).

While spectrograms may have shortcomings as a method of preserving the original integrity of the sound they do provide great potential as a sound image that can be read visually like a script. Leon-Scott demonstrated that it was possible to interpret waveforms visually by measuring the number and size of amplitudes along with their oscillations for a sound within a measurement of time.[16] This was quite an accomplishment considering that a waveform is often a multitude of sounds combined into one wavy line. This would have required comprehensive calculations to identify the various sounds within one waveform. It is for this reason that a spectrogram is more appropriate for identifying sounds visually.

The idea of visually reading sounds from a spectrogram is not new. Spectrograms have been used successfully in speech therapy for the hearing impaired as a form of visual feedback. Subjects were able to learn how to articulate words better by identifying whether they were producing the sounds correctly on spectrograms of their speech on a monitor – a form of self-mediation.[17]

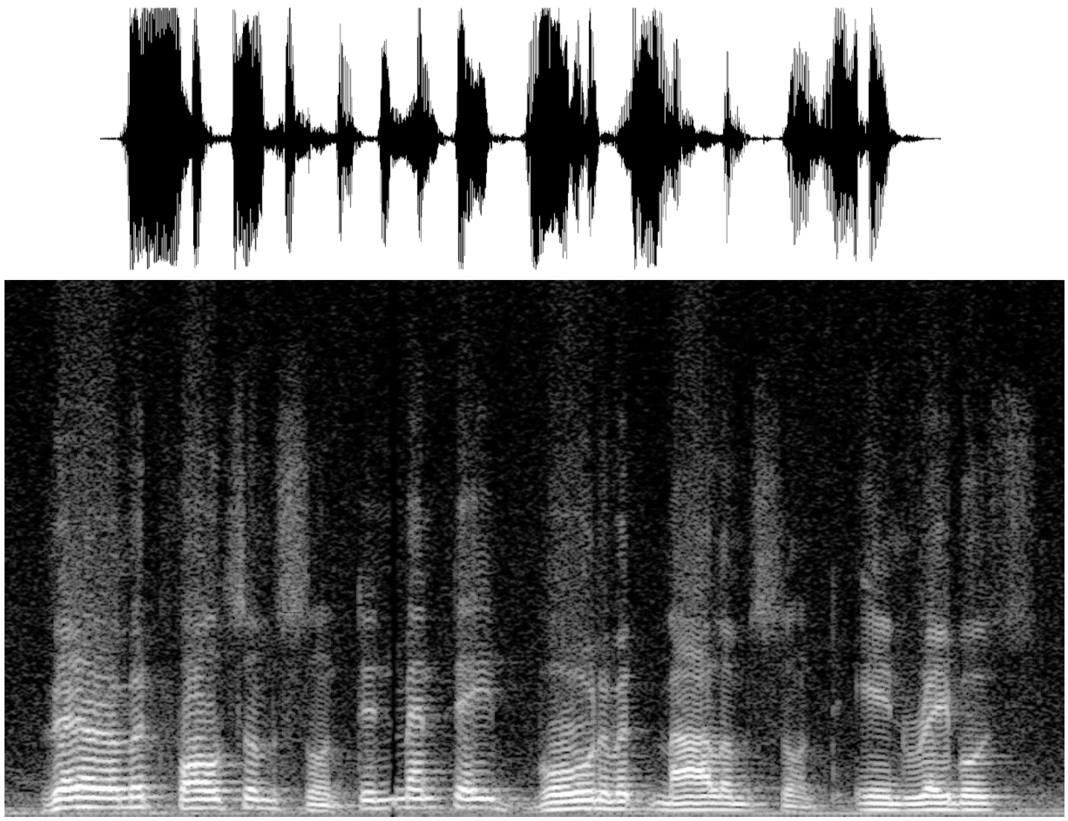

Fig. 2 A waveform (top) and an inverse image of a spectrogram (bottom) of Lonergan's voice from *Method in Theology 1962*, "Verum et falsum sunt in mente, bonum et malum sunt in rebus." Audio clips below.[18]

Original recording

As a spectrogram image converted into a sound file.

[16] *1861 Communication to the Académie des Sciences.* First Sounds. http://www.firstsounds.org/publications/facsimiles/FirstSounds_Facsimile_06.pdf (accessed August 8, 2017).

[17] Sharon F. Elssmann and Jean E. Maki. "Speech Spectrographic Display: Use of Visual Feedback by Hearing-Impaired Adults During Independent Articulation Practice." *American Annals of the Deaf* 132, no. 4 (1987): 276-279

[18] Bernard Lonergan, "M*ethod in Theology"* Recorded July 10 1962. Archive Number 30300A0E060. Web, http://www.bernardlonergan.com/archiveitem.php?id=77 (Accessed August 8, 2017).

Currently, spectrograms are created entirely within the digital domain. However, it is possible to create and play spectrograms using electromechanical means. A device called the *Pattern Playback*, was developed in the 1940s at Haskins Laboratories.[19] It could electromechanically playback an image of a spectrogram. This is in keeping with the principal that the lower the technological requirement is for information retrieval the higher the probability is for information surviving into the distant future.

Sonic Hieroglyphs

There are shapes within the spectrogram created by frequency amplitude peaks called formants visible as the whiter colors when viewed as an inverse image. (Fig. 3) An inverse image is used for reverse fourier analysis. These formants are surrounded by less essential frequencies which can be removed. When these formants are separated from the other sounds around them they take on a slight resemblance to cuneiform or some other ancient script. These elemental forms still contain the basic information necessary to recreate the sound but with the simplicity in appearance that enables them to be read as a script. This is how a spectrogram can become a sonic hieroglyph or spectroglyph for that matter.

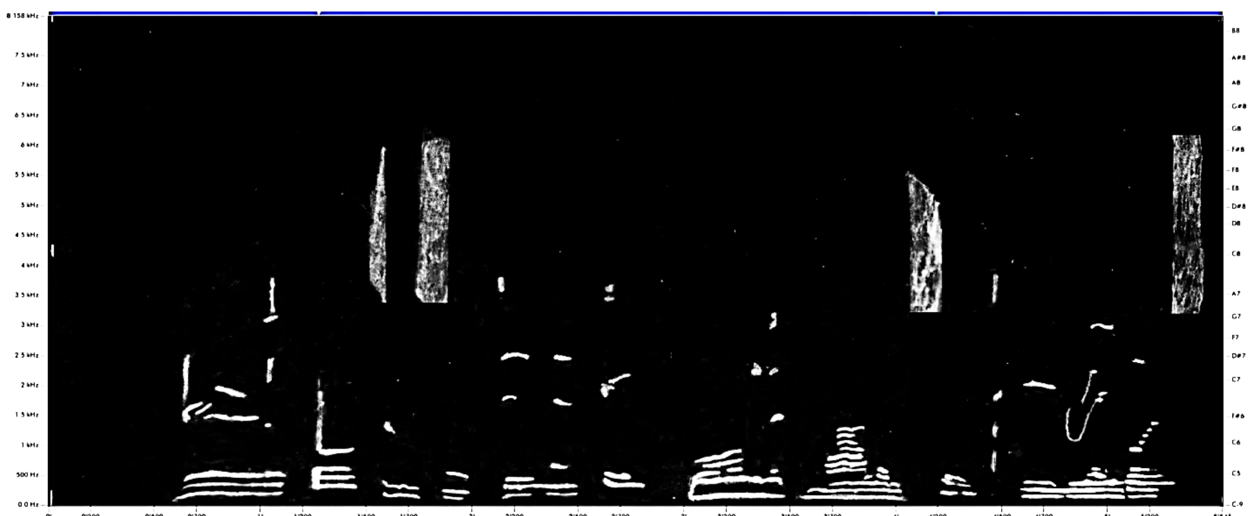

Fig. 3 An inverse image of a spectroglyph of Lonergan's voice from *Method in Theology 1962* after the essential formants in the spectrogram have been isolated. "Verum et falsum sunt in mente, bonum et malum sunt in rebus." Audio clip below.

The advantage of this type of script is that the shapes can be read like letters and words or played as a sound file. This ties the written and spoken word together in a way that will enable them to always accurately represent one another over time. The sounds of consonants and vowels occupy certain frequency ranges that will not change over time. An S sound will always occupy the 5 to 7 Khz range. The human voice and mouth will always be able to produce these sounds. This makes it possible to create a type of phonetic script like the hieroglyphs except these shapes are the actual sounds in spectrogram form, not pictograms whose meanings have been arbitrarily assigned to the sounds or vice versa. These shapes can in turn be used to recreate the sounds. The visual and sonic aspects of these shapes are one

[19] Franklin S. Cooper, Alvin M. Liberman and John M. Borst, "The Interconversion of Audible and Visible Patterns as a Basis for Research in the Perception of Speech." *Proceedings of the National Academy of Sciences of the United States of America* Vol. 37: pp. 318-325

and the same. These spectroglyphs can be used for any language. Unlike a typical spectrogram which is created from a sound, spectroglyphs can be created manually first as an image prior to being educed into sound.

This approach is comparable to a musical score. A formant would represent specific frequency ranges related to human speech in the same way that the notes of a musical scale represent a specific pitch. Combinations of formants create resonances that distinguish one vowel from another much like the different combinations of notes create different chords.

A Universal Alphabet

There are currently 44 distinct sounds or phonemes in the English Phonemic Chart. A spectroglyph could be created for each of these phonemes to create an alphabet. A spectrogram of speech is comparable to messy cursive handwriting that is difficult to read. The goal of the spectroglyph is to make the sound forms easily recognizable so that they can be read visually yet able to render a clear sound when played as a sound file from a spectrogram image.

It is difficult to predict where spectroglyphs would most likely be needed. They would likely be most useful as an archival script. They are too pictorial in nature to be used for practical day to day matters. Perhaps linguists could use it as a makeshift script for endangered languages that never developed an alphabet. As a universal phonetic alphabet it could be a linguistic hub from which translations and transliterations into other languages could be made.

However, there already exists the International Phonetic Alphabet (IPA). One might ask why another phonetic alphabet is needed since the IPA already has a robust collection of phonemes. There are likely many advantages to using the IPA and spectrogplyphs should not be viewed as an attempt to replace it. But it is important to consider some of the challenges for the IPA. Languages change as do their articulations. There are already competing standards of IPA that have emerged to address these changes. This has caused some controversy because of the potential confusion that may result when the same character represents two different sounds.[20] There can be no confusing spectroglyphs with other writing systems because of their uniqueness nor can one spectroglyph represent two sounds. A spectroglyph will always produce the same sound. IPA characters, like most other scripts, are arbitrarily assigned to a sound. Spectroglyphs are not arbitrary – they are the sound.

Conclusion

The chance occurrences around the discovery of the Rosetta Stone and the information it contains relates to emergent probability. The parallel translations inscribed on it set the stage for new developments once the conditions around its discovery were fulfilled. The waveforms of the phonautograms that were discovered after sitting in an archive for 150 years are the upper blade of Lonergan's scissors metaphor. The circumstances around the Rosetta Stone and the Phonautogram provide examples of how to create more secure heuristic models for the preservation of languages. Spectroglyphs challenge conventional ideas about media. The idea of a sound and a visual image being used for the same task gives new meaning to the phrase, "A picture is worth a thousand words".

[20] International Phonetic Association, *Handbook of the International Phonetic Association*, (New York: Cambridge University Press, 1999)