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## The Generation of Sounds According to Robert Grosseteste

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**Abstract:** A translation and discussion of the *De Generatione Sonorum*, On the Generation of Sounds, a short scientific treatise written by Robert Grosseteste, is proposed. The subjects are sounds and phonetics. In this treatise we find the medieval philosopher discussing oscillations and elasticity of materials as the source of sound. For what concerns phonetics, he uses some motions and their combinations to describe movements of breath and articulators in producing the voice.

**Keywords:** History of Science, Medieval Science, Acoustics, Phonetics.

### 1. Introduction

Robert Grosseteste, an English scientist and philosopher of the Middle Age, who was Bishop of Lincoln from 1235 AD until his death, on 9 October 1253, wrote several short scientific treatises. Recently we have discussed some of them concerning optics [1-5]: here we are proposing the translation and discussion of another short paper, which Grosseteste wrote on sounds and phonetics, entitled *De Generatione Sonorum*, On the Generation of Sounds. Sound is shortly discussed at the beginning of the treatise, which quite soon departs from physics to arrive into the main topic of the treatise, the phonetics, that is, the creation of sounds by the mouth to have syllables and words. However, this treatise contains some physics of motion in the discussion of vowels and consonants. In fact, Grosseteste uses an analogy with motions and their combinations to describe how the breath and the organs of speech are creating the voice.

In this treatise then, we can find that Grosseteste considers several motions, which can be rectilinear, circular, vertical or transversal, and combines them to have seven “species” of motion. These are not the simple classical seven types, up/down, right/left, forward/back, and rotary, proposed by Philo of Alexandria in his treatise *On Creation* [6]: the Grosseteste’s motions are quite complex, suitable to be applied to mechanics in order to describe how the parts of some machines can move. In the following section a translation of the Latin text [7] is given. After the translation, we will discuss the text.

### 2. On the Generation of Sounds

When a medium able to sound is struck violently, some elements of this medium are moving out from their natural positions, to which they come back constrained by the nature of the medium; and, in such

a manner, because of the strength of the attraction, by which the moving parts are affected, they completely return at their natural positions, and even have a further progression towards not natural positions; and the natural inclination of the medium, again, drives back the material at the natural position and the a subtle tremor is created at the ends of the medium. And this tremor is evident by touch and sight.

Such vibrations of each small part of the medium are necessarily a result of their displacement from the natural position, consisting in an elongation of the longitudinal dimension and a contraction of the transversal dimension; and, conversely, when returning towards the natural position, we have a contraction of the longitudinal dimension and an elongation of the transversal one. And this motion of expansion and compression in each part of the medium, where the local motion of vibration is consequent, is the sound or the natural sounding promptness. And when the parts of the sonorous medium are moving, they move the air near them, which, having a similar motion, creates a motion which arrives into the ears and this effect on the body is not hidden to the soul and creates the sense of hearing.

Moreover, we have the first moving reasons of the parts of a sounding medium in the following ways: either the motive force is internal the very sounding medium or external. The very reason of the internal motion can be only in the breathing. However, its nature cannot be the first principle of it; and since it is not such a motion continuous in the animals, it is not produced by vegetative spirits, but it is coming from some perceptible motivations by a voluntary movement, anticipated necessarily by some previous imagination or perception, then, a sound formed by



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such a first cause, in which imagination exists, is the voice.

Then, a proper setting of the vocal articulators and of the breath in them gives to a certain voice its appearance and perfection. However, to this voice, the setting of the speech does not give perfection automatically. In fact, it is the literate voice, to which the abovementioned configuration provides appearance and perfection. And the voice, after completing a specific setting, pronounces a letter, as well as several settings of the voice are composing several letters.

However, the might of the voice, on the purpose of which we are writing, is nothing else but the very configuration of some instruments, vocals and breaths, by which, inside us, the letter is generated. Therefore, it is possible to represent it by means of a visible shape similar to the shape of the setting of its generation. When the technique imitates the Nature - and the Nature always works in the best possible way - and, on the other hand, this technique is not wandering, it is clear that a better representation is obtained by exterior shapes similar to the interior ones, like in a representation according to the art of grammar, where the writing was created by using some exterior shapes similar to interior shapes to represent interior settings. If an objection had to be found, it is that we can find many shapes of the same elements in several literal representations; then, let us tell that there is not a difference in their essential nature, but just in some non-essential details, for example, the shape of element A in Latin, Hebrew, and Greek and in Arabic too is a triangle. However, the same triangle is indicated differently by the scripts of the three languages mentioned above. Similarly, the shape of the element R in every language is perceptible in the figure of a ripple, as it is formed by the tongue, and so on. The sound of a vowel is similar to itself totally or partially. It is therefore necessary of being it generated by a motion similar to itself totally or partially.

But motions, after being assimilated, totally or partially, are seven: and they are straight motion, circular and of expansion and contraction. Of these, two do not differ except in the direction forwards and backwards of the straight motion; then we have the circular motion about a center which is moving straight, and the circular motion about a center in circular motion; and likely, the motion of expansion and contraction over a center on straight motion and over a center in circular motion.

Because of these seven movements, the ancient Greek set seven vowels. However, the two motions about a center in straight motion and about a center

moving on circular motion, are possible to imagine, but are difficult or actually impossible to create. Because of this fact, just five motions remain, which are possible or operationally feasible.

Therefore, it is evident, that by the breath moved in a straight motion and through the trachea the vocal J is molded. Sometimes, however, there is less continuity of this same straight movement, not because the continuity is becoming trembling, but, very frequently, because it is going and coming. The true circular motion creates the form (O). Every true circular motion, about a center in straight motion, subtends a chord and any point on the circumference describes an arc on the chord, and so a pyramidal shape is created. And the motion of contraction creates the letter V, i.e. two lines concurrent towards a center. In fact the motion of expansion and contraction over a center of motion moving on a straight line subtends the basis of a triangle. And each point, which is moving in such a double motion, when there is the expansion, describes one of the sides of the triangle from the base up to the apex, and when there is the constriction, describes the other remaining side from the apex to the base; and then it is given the letter A. And in both occasions, we can create the sound of a vowel and the sound of a consonant. And even we can have two discontinuous occurrences too, because, between opposite motions as we like, there is a pause, a stationary point, in the middle: then, we have consonants which are so called because they seem to sound with another, and it is not possible to ear by themselves, but by generation of a vowel in the following occurrence.

To this I reply: the motive force, which is giving the vocalization, from the beginning of the syllable to its end, inclines the breathing and the articulators to create the vocal sound like its sound, and therefore moves breathing and articulators consequently. When, however, the said inclination is concomitant to reproduce the sound of a consonant, a combined motion resulting from two inclinations exits from the breathing and movement of the articulators, as it happens when a heavy body tends to move downwards, and it is pushed transversally, and the heavy body moves on a motion following some inclines different from the natural movement. Since, however, the inclination of a natural motion is continuous, the movement is always returning to the natural one. It is clear, therefore, that in the movement, by which the sound of consonant is formed, there is the inclination to form the vowel sound considerably, and so in the sound of a consonant, there is the sound of a vowel substantially; at last, a natural sound is like the motion of the sound of a consonant, like the natural inclination of a heavy body pushed transversally, it is

the motive inclination, several times excited, however not vehemently, that gives features and forms to the actual motion, rather than the natural inclination.

Yet, it can be what Priscian said, that vowels are like the breath of life and consonants like bodies, when he referring to the fact that the sound of a consonant cannot be heard outside the mouth, except by the actual sound of a vowel. However, since the times of the formation of a consonant and of a vowel in the same syllable are different, it is necessary that the sound of the consonant can be formed in the mouth without the sound of a vowel. But, as Isidorus (of Seville [8]) says, unless followed by the sound of a vowel within the syllable, a grumbling of a letter shall sound and, outside the mouth, it does not arrive to the ear. From what has been said, it is clear that when the movement for the formation of a consonant results in a shorter inclination to form the active vowel, a semivowel will be produced; however, when this movement is prolonged, in fact, it turns out to be speechless. From all these points, then, it is clear how a syllable is, by means of a breathing and an accent, pronounced immediately, although it may have many letters, because this unit is a continuous trend created by the sound of vowels, on which the inflection falls, such as in a natural tendency to pronounce consonants, as well as in the accidental characterization of an inflection.

### 3. Discussion

In the first part of the treatise we find the description of the origin of the sound from the oscillations of a medium or from a body having oscillating parts. After its generation from a vibrating source, the sound propagates in the air, and when it arrives to the air inside the ears, it produces the sense of hearing. From what Grosseteste is telling in his treatise, we can argue that he could have observed some vibrating elastic media and how they are generating sounds. For instance, it is possible to observe laterally the oscillations of a thin blade: when the oscillations have a low frequency, we can easily perceive it by eyes, because our eye is able to see clearly the oscillations up to about 20 Hertz. This situation corresponds to a low sound. It would be nice to imagine Grosseteste had observed a tuning fork (diapason) but this instrument was invented in the 1711 by the British musician John Shore [9]. However, it is possible that instead of using a tuning fork, Grosseteste had a metallic wire, bent to form a round or elliptic ring, which he could use as a medium prompt to sound when stricken. Then, he could observe that during the vibrations of such an ellipse, when the major axis elongates the minor is reduced and vice versa. This could be in agreement with the Latin text, where Grosseteste uses the term “diametrus”.

In the translation from Latin, I preferred to consider “diametrus” as “dimension”, in order to remember the Poisson modulus of elastic materials. Let us suppose an elastic material and a bar made of it. When the bar is stretched we see usually that to an extension in the direction of the applied tension, a contraction in the perpendicular directions is corresponding. When a material is compressed in one direction, it usually tends to expand in the other two directions perpendicular to the direction of compression. This phenomenon is called the Poisson effect, and the Poisson's ratio measures this effect. This ratio is positive in the usual abovementioned behavior of materials. However, elastic materials having a negative Poisson's ratio exist: these are the auxetic materials [10].

Grosseteste's treatise is telling that the reasons for a medium to sound are two, “either the motive force is internal the very sounding medium or external.” In the case that it is internal, it means that it is coming from a voluntary action on breath and articulators of speech. This is the voice. And a proper setting of breath and articulators gives to the voice its appearance and perfection.

For what concerns the Latin words used by Grosseteste, we find the “spiritus”, which is the “breath”, or the “breathing”, and therefore, “the spirit of life” too. In Greek, on the vowels, we can have a “spirit” [11], to indicate presence or absence of a “h” sound before a letter. Let us remember that our alphabet was invented by the Semites of the Mediterranean coast, who used simple symbols to represent consonants instead of words. The Greeks used the Phoenicians alphabet, adding seven vowels, which considered as containing “pneuma”, spirits, or “breath of life”. The reason is because the sound of each vowel could be pronounced as long as the breath in the lungs. There are three types of vowels: long (eta and omega), dual (alpha, iota, and upsilon), and short (epsilon and omicron).

Some Latin words in the Grosseteste's treatise, such as “accentus”, “formanda” and “inclinacione vocis”, are words used by Marcus Fabius Quintilianus [12], who was a Roman rhetorician widely referred to in medieval schools of rhetoric. It is then quite possible that Grosseteste knew Quintilianus' treatises and used them. The “accentus” is the accent; “formanda” is coming from “formare” which means pronounce, create by means of the mouth. “Inclinacione vocis” is the inflection [13]. Let us also remark that “consonant” is a “sound other than a vowel”; and the term is coming from Latin “consonans”, and “consonare” meaning to sound together, sound aloud [14]. Consonants were thought of sounds that are

only produced together with vowels, as we find in this treatise written by Grosseteste. In the last part of it, I rendered “tempus” with “occasion”, from “occurrence”. In the Reference 15, it is told that Grosseteste is using several terms, among them “tempus, proportion, sonus vocalis, motus contrarios, sonus consonantis” that could be also understood as a musical conceptual language. We can argue that Grosseteste, in the discussion of the voice, had in mind also the voice singing the chants of the liturgies of Catholic Church.

In the part of the treatise concerning phonetics, Grosseteste tells that the shape of the letters in the grammar is coming from a representation of some internal settings assumed when pronouncing them. In such a way, the grammar is imitating the Nature. Moreover, letters of different languages can have symbols which are only accidentally different, not substantially [15,16]. However, if the written letters are in their shapes representing the motions of breath and articulators when pronouncing the sound of them, we need to assimilate the possible motions in some types, each type representing a vocal sound. Then Grosseteste gives a list of motions, subdividing them in seven types according to their partial or total similarity. The assimilated motions are seven, because Grosseteste wants to represent the seven vowels of Greek. Let us remark that the seven Grosseteste’s types of motion are not the classical seven motions (up/down, right/left, forward/back, rotary), proposed by Philo of Alexandria in his treatise *On Creation*. On the contrary, the Grosseteste’s motions are quite complex.

I rendered the Latin text supposing Grosseteste was proposing a combination of motions. The seven motions are as in the following. Three motions are the straight motion, in the two directions, forwards and backwards, and the circular motion about a centre at rest. The fourth is the circular motion about a centre which is moving on a straight line. This is the description of a cycloid, even prolate or curtate. Let us remember that a cycloid is the curve traced by a point on the rim of a circular wheel as the wheel rolls along a straight line. It is then a curve generated by a curve rolling on another curve. After, the fifth motion given by Grosseteste is a circular motion about a centre in circular motion. This seems the description of an epicycloid, which is a plane curve produced by tracing the path of a chosen point of a circle, called an epicycle, which rolls around a fixed circle. This is the motions of the planets in the heavens as described by Ptolemy, well known by scholars such as Grosseteste. The last two are periodic motions, of expansion and contraction, wavelike motions, on a straight line and on a circumference. These Grosseteste’s types of motion seem suitable to be

applied to approximately describe, besides the motion of celestial bodies, how parts of some machines can move. It is possible that during the renaissance of sciences stimulated by the translation of texts from other cultures [17], such as the ancient Greek and Arabic works, some scholars started the developments of a scientific language, able to describe what happens in mechanics and technology.

After this description of these motions, Grosseteste tells that the ancient Greek set seven vowels according them. However, some motions are difficult or actually impossible to render by the voice. And then he concludes that “just five motions remain, which are possible or operationally feasible”. He tells about the motions associated with letters J, O, V, A, and R, because, as remarked in [16], the art of grammar imitates the nature, and nature does everything in the best way possible, and then the letters of the alphabets have a shape representing the motions of articulators when we are speaking. Grosseteste continues with a discussion of the consonants, “quasi cum alio sonans; et quasi per se non possit audiri, cum eius generatio praecedat, vel subsequatur tempore generationem vocalis;” consonants, which are so called because they seem to sound with another, and it is not possible to hear by themselves, but by generation of a vowel in the following occurrence. And then we have the formation of syllables, where Grosseteste is using again the analogy with the motion. In particular he uses the motions of a heavy body, which is falling or which is falling after receiving a transversal push. In the first case, we are pronouncing a vowel, the natural motion. When we have a combination of two motions, horizontal and vertical, we have a syllable, where the natural motion is altered by the consonant. Let us note that Grosseteste is also observing that the body returns to the natural falling. Of course, this is rough description of the superposition of vertical and horizontal motions in the gravity field, and of the fact that vertical acceleration prevails. In any case, the initial conditions of motion are giving the “shape” to the motion.

Grosseteste ends his treatise with some further considerations on consonants and semivowels, referring to Priscian and Isidorus. Priscianus Caesariensis, who lived in the VI century, commonly known as Priscian, was a Latin grammarian. He wrote the *Institutiones grammaticae* on the subject. This work was the standard textbook for the study of Latin during the Middle Ages. Isidorus, or Isidore of Seville, (c. 560 – 4 April 636), was Archbishop of Seville for more than three decades, and wrote on etymology. In phonetics and phonology, a semivowel is a sound, for instance the English “w” or “j”, which is phonetically similar to a vowel sound but acting as

the syllable boundary rather than as the nucleus of a syllable [18]. In fact, the description given by Grosseteste is similar to what we can read in the Wikipedia item and the same of for the discussion on syllables and sonorants [19].

#### 4. Conclusion

In this paper we have translated and discussed the *De Generatione Sonorum* written by Robert Grosseteste. This treatise is studied by scholars for its importance in the history of phonetics and music. In fact, in his Latin text, Grosseteste is using several words that could have been used in some early musical languages for liturgical celebrations. The fact that the treatise contains some interesting discussions on motions needs to be properly considered and remarked. Reading his treatise, it is clear that the philosopher widely used the combination of motions, rectilinear and circular, and vertical and transversal. For this reason, this Grosseteste's work is important in the history of physics too, because it can help understanding the roots of the modern language of physics, created by some medieval scholars in their treatises on the physical world.

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