



## EDITING KEMPELEN'S "MECHANISMUS DER MENSCHLICHEN SPRACHE": EXPERIENCES AND FINDINGS

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**Abstract:** Wolfgang von Kempelen's book "The Mechanism of Human Speech" from 1791 is a famous milestone in the history of speech communication research. It has an enormous relevance for the phonetic sciences and it marks an important turning point for the development of the (mechanical) speech synthesis. So far no English version of this work was available, which excludes many interested researchers. Access to the original versions in German and French is restricted for various reasons. For example the blackletter script of the German version is troublesome for most of today's readers. We report here on a new edition of Kempelen's book which unites a better readable German version and its English translation. It will now also be in a searchable electronic format and has been enriched with many commentaries, which aid in the understanding of details of the late 18th century that are little known or unknown to many researchers today.

### 1 Introduction

Scientific discussion about speech goes far into history. Already from antiquity we know of scholars like the Greek physician Galen who dealt with the production of speech and its physiological basis. During the Middle Ages less empirical but extensively philosophical and theosophical-based approaches dominated. Still in the 18<sup>th</sup> century theories were discussed that postulated that speech is a gift of God, often based on crude physiological "findings". At the same time the age of enlightenment settled down more and more so that empirical approaches to science became more common. In this period of scientific tension Kempelen's book was published.

In the history of science there are probably few persons whose work has been so varyingly judged over the centuries like that of Wolfgang von Kempelen. Although he himself was often referred to as a fraud, his book, released in 1791, was soon called a "classic" work [1: 84; 2: 316].

An intensive study of this seemingly "antiquated" work shows for instance that many theories of speech production (which could be verified by using modern technology) were already drafted long ago on the basis of "primitive" but nevertheless precise observation. Especially in contrast to contemporary publications, Kempelen's "Mechanismus" is a prime example of early empirical science that achieved very amazing results from today's perspective.

Having been a phonetic standard reference for many decades, the fame of the book has survived until today. In 1970 a very precise facsimile printing was edited by Herbert E. Brekle and Wolfgang Wildgen [3]. Due to the progressive digitalization of the last few years electronic versions of the text became easily available via the internet. But all these means of access did not eliminate the fundamental obstacles in reading and understanding this exceptional milestone of basic phonetic sciences.

Kempelen's book was published in German and French in parallel. Today, both versions are partially hard to understand because of their old-fashioned diction and lack of knowledge about the contemporary context. In addition, readers of the German edition have to be familiar with blackletter (or Gothic) script. An English translation of the book that makes it accessible for a really broad readership has been completely missing until now. The authors were often told by international colleagues that they had heard much about Kempelen's famous book but that they were not able to read it themselves. For this reason the authors decided to issue a new edition of this book which is central for the understanding of language research in the 18<sup>th</sup> century [4]. The edition contains a transliterated and commented version of the German original as well as a close translation into English. This paper presents some experiences and findings on the content of the "Mechanismus" that we made during the editing process.

## 2 Wolfgang von Kempelen

Kempelen's biography is quite prototypical for outstanding scholars of the age of enlightenment. He was a professional manager and a gifted mechanic, a brilliant magician and a sober naturalist, and not least one whose reputation has in posterity been romantically mystified, confused and accused of charlatanism. Due to a lack of work with primary sources and deficits in research, some of the "facts" on his life and work, which have now been proven as legends, find their way even to today's publications (see Reininger [5, 6] for a detailed and precise biography of Kempelen). Here we concentrate on a few central points.

Kempelen was born on January 23, 1734 in the then Austrian city of Pressburg (today Bratislava, Slovakia). He received an education in philosophy and law. From 1755 to 1798 he had a career as a civil servant at the Hungarian court chamber. Besides his official administrative duties he dealt with several technical improvements and innovations such as various water lifting mechanisms, a mobile bed, and a mechanical typing device for blind people. Best known of his inventions are his steam engines and the spectacular and today infamous "mechanical chess player" which served as the namesake for Amazon's *Mechanical Turk* (a web service that allows for crowd sourcing of tasks that humans excel at, but which are still difficult for machines). We focus here on his speaking machine described in his book "Mechanismus der menschlichen Sprache nebst der Beschreibung seiner sprechenden Maschine" from 1791 [3].

## 3 The "Mechanismus der menschlichen Sprache"

The motivation of Kempelen's book, its title and concept are not widely known. This is not surprising because Kempelen himself did not say anything about his motivation. Reading the full title of Kempelen's book<sup>1</sup> leaves the impression of a textbook on speech production with a short and less important appendix on the "speaking machine". In fact, it is exactly the other way around: The whole book was conceptualized to make the final description of the speaking machine understandable and to underpin its design.

When Kempelen first presented his "speaking machine" in 1783 he was massively criticized and accused of presenting yet another fraud following on his "mechanical chess player"<sup>2,3</sup>. For this reason he decided to disclose the construction of his speech synthesis device. But to make his readers understand his truly serious construction he firstly had to present his underlying physiological findings. It has sometimes been objected that Kempelen mostly compiled already published statements about speech production and presented few of

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<sup>1</sup> "Wolfgang von Kempelen Imperial-royal Court Councillor's Mechanism of Human Speech along with the Description of his Speaking Machine. With 27 Copper Plates."

<sup>2</sup> This actual was just as little a fraud than the "speaking machine" but just misunderstood like that.

<sup>3</sup> Cf. the prototypical polemic of the anonymous author "Rm", that shows very well the outrage as well as the fundamental misunderstanding of the "speaking machine" [7].

his own findings. But this method was imperative because he had to rely on already accepted authors to give more power to his own argumentation.

The book is divided into five chapters of very different scope:

- I. On speech in general. (27 pp.)
- II. Thoughts on the questions: Whether language was discovered by humans, or whether it was created for them? Whether all language originated from a single language? (29 pp.)
- III. On the organs of speech and their function. (121 pp.)
- IV. On the sounds or letters of the European languages. (210 pp.)
- V. On the speaking machine. (69 pp.)

In addition, the book is equipped with remarkable illustrations on 27 copper plates that were made by Kempelen himself.

Kempelen had already announced his publication in 1784 and we do not know why he needed seven years to finish the book. But there are some hints. Firstly, Kempelen was very busy with his administrative duties in that time. Secondly, the scope of the book was enlarged by and by. Presumably to achieve a broader reception, the book finally was published in German and French in parallel (Fig. 1). Though there is no evidence, it seems likely that the translation into French was made by Kempelen himself. Also nothing is known about the exact circulation of the book, but a number of about 250 copies can be indirectly assumed.

Wolfgang's von Kempelen  
k. k. wirklichen Hofraths

**Mechanismus**  
der  
**menschlichen Sprache**  
nebst der Beschreibung  
seiner Sprechenden  
**Maschine.**

Mit XXVII Kupfertafeln.

*Haec igitur penitus voces cum corpore nostro  
Exprimus, rectoque foras emitimus ore,  
Mobilis articulatur verborum dædala lingua,  
Formaturaque laborum pro parte figurat.*

Lucret. lib. IV. v. 553.

W i e n,  
bei J. B. Degen, 1791.

**LE MÉCANISME**  
**DE LA PAROLE,**  
suivi  
**DE LA DESCRIPTION**  
**D'UNE**  
**MACHINE PARLANTE**  
et enrichie de XXVII planches.  
Par M<sup>r</sup>. DE KEMPELEN, Conseiller aulique actuel  
de Sa Majesté l'Empereur Roi.

*Haec igitur penitus voces cum corpore nostro  
Exprimus, rectoque foras emitimus ore,  
Mobilis articulatur verborum dædala lingua,  
Formaturaque laborum pro parte figurat.*

Lucret. lib. IV. v. 533.

À V I E N N E,  
Imprimé chez B. B A U E R,  
& se trouve  
chez J. V. DEGEN 1791.

Figure 1. Title pages of the German and French original edition of Kempelen's book.

While in chapters 1–4 Kempelen partially compiled contemporary sources and discussed them, the last chapter of his book is completely his own work. Here, Kempelen describes the

construction of his speaking machine as well as its genesis. His frank report on his problematic first prototypes that were less anatomically based is remarkable. The level of detail in the description of his final machine is as surprising as the fact that some rather important measures, e.g. for the bellows or the reed pipe, were missing. Nonetheless Kempelen's ground-breaking approach to mechanical speech synthesis is clearly visible, and this was enhanced by his presentation of nine to-scale figures of the mechanism.

## 4 The New Edition

The goal of our work was to facilitate the approach and the understanding of Kempelen's book for today's readers as much as possible but without eliminating its essential characteristics. As much meta-information related to the original printing as possible had to be preserved. For that we decided to make a bilingual edition that offers an only typographically "modernized" version of the German original and an English translation. Every double page of the new edition corresponds to one single page of Kempelen's book in these two variants.

For the German version we decided to replace the black letter by a modern Antiqua type (such as Times New Roman). But Antiqua was already used in the original edition for non-German terms and for explicit examples. Those terms now were typeset in *italics*. Texts printed in black letter show some variation in font size for emphasizing. This was replaced by **bold** font style.

The original pagination was prefixed to the text block on the left. The modern editorial pagination was put at the end of the page. The German and the French versions of the "Mechanism" are fundamentally identical in their content but differ in details from one another. For instance, representations of some words or syllables in given examples have not always the same spelling. In these cases we added the French versions.

Kempelen expected his readers to generally be familiar with quotations from Latin and Greek classics. That is why he often quoted these in a rather careful way or – especially with longer citations – only gave the gist of them; also the references often are provided only cursorily. To facilitate today's readers' understanding of the argumentation linked to these quotations, these were completed to their full text and translated into German where necessary.

We intensively discussed how to incorporate our editorial comments into the text without disturbing the flow too much. Because of their very heterogeneous nature we decided on a two-part strategy: Short explanations of a phrase were placed as marginal notes on the outer page margin.<sup>4</sup> More detailed explanations such as biographical dates and notes on quotes were placed as footnotes at the very end of every page.

The excellent digitization by the Saxon State and University Library in Dresden served as a source for the illustrations.

## 5 English Translation

For a modern native speaker of German Kempelen's text is not easy to understand, and it is even harder of course for a second language speaker. But even in cases where his meaning is clear, finding the right way to express it in English that at least tries to convey the same nuances can be a challenge. One of the additional challenges with an old text like this is picking the right register. Ideally, one might have tried to translate into 18<sup>th</sup> Century English, but as this would likely be a challenge even for a professional translator, we arrived at the

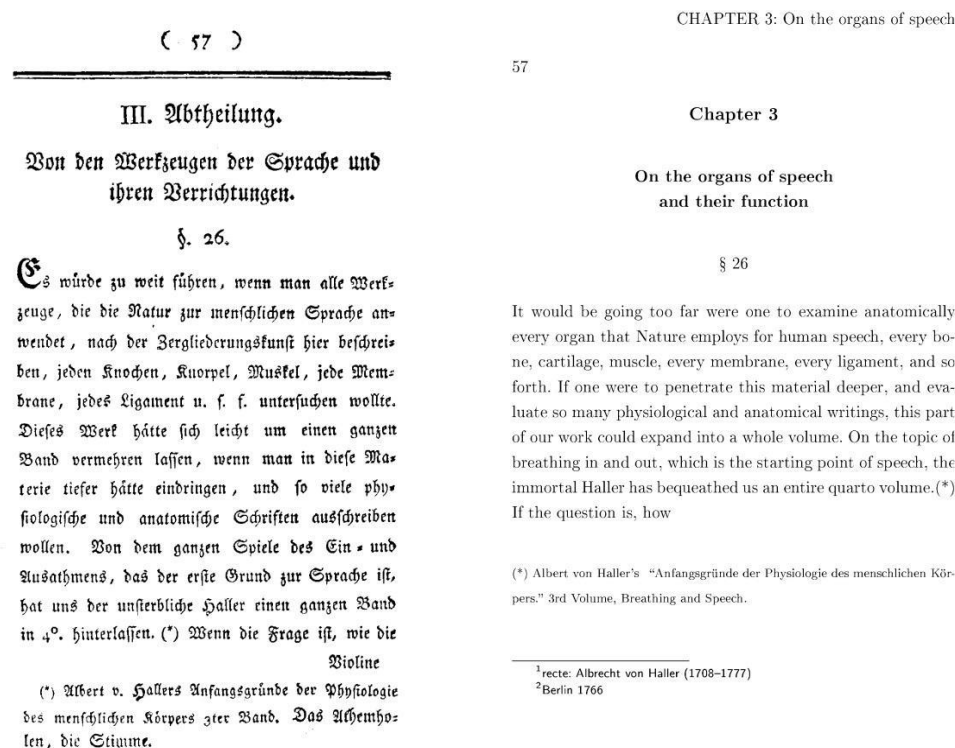
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<sup>4</sup> Sometimes Kempelen's wording is so different from its usage today that a comparison with the (original) French version was also helpful for a native speaker of German to understand the German version.

following compromise: namely to translate into modern English, but to try to avoid modern phonetic terminology where possible. Thus, for example, for his *Zungenkanal*, which clearly corresponds to our modern notion of *vocal tract*, the modern term was replaced by the translation *tongue channel*. We cannot exclude errors of consistency despite a thorough rereading of the translation after its completion, but if any such inconsistencies remain, they can be attributed to the long period over which the translation was done.

One fortunate feature of the modern age is of course the rapid access to a whole range of information. Never once was a print dictionary used, always online sources, including of course Wikipedia and Google Books, especially where it was needed to find interpretations of obscure technical terms. But first and foremost heavy use of Google Machine Translation (GMT) was made. While this technology has improved much, especially recently, it is of course still not possible to use it to translate most texts without a fair amount of post editing. This is even more true for older texts such as Kempelen's. However it still proved very useful in helping suggest appropriate translations for words and short phrases, and for that purpose it was extensively used. This point fits well into a historical approach to language and speech technology from the 18<sup>th</sup> Century, including the work of Kempelen, right up to the digital speech and language systems of the 21<sup>st</sup> Century, of which GMT is one such instance [8]. GMT is, in fact, a natural descendant of Kempelen's work on understanding human speech, and it is only fitting that it should now be used to help make Kempelen's pioneering efforts accessible to a broader audience.

Figure 2 shows as an example page 57 of the German original print and its commented translation.



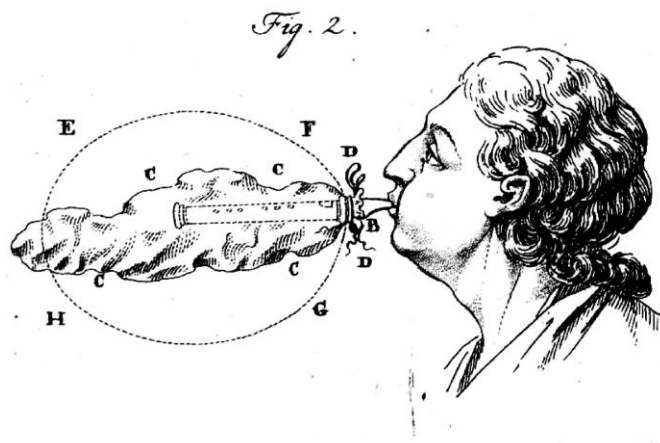
**Figure 2.** Page 57 of the "Mechanism" in the original typesetting (German version) on the left, the same page in the commented version translated into English.

## 6 Observations and Curiosities

During our intensive analysis of the “Mechanismus” we came across some facts that seem remarkable to us.

### 6.1 Speech production

First of all, Kempelen’s sober view on speech production is remarkable. Although he was not the first to deal on an empirical basis with this topic, his consistency and frankness is as astonishing as his illustrations that almost always are striking and witty. For instance he explains how voiced plosives anatomically could be articulated in a similar way to that done in the 20<sup>th</sup> century [10]. His illustrations are perfect examples not only of his skill in etching copper plates but also of his ingenuity of finding catchy examples (Fig. 3). To explain the physiological processes of articulating voiced plosives Kempelen asks the reader to imagine a recorder that is inserted into a pig’s bladder except for the mouthpiece. Blowing into the recorder a sound will be heard as long as the air pressure inside the bladder is not equal to the air pressure outside of it.



**Figure 3.** Figure 2 of Kempelen’s Table XI showing the illustrative model of the articulation of voiced plosives.

Regardless of Kempelen’s often brilliant explanatory approaches there are some passages of his book that are hard to understand even for linguists with experience in reading archaic German. This sporadically may display Kempelen’s own uncertainty of some aspects but is mostly due to a use of language that is very different from the one today. Besides grammatical constructions that are unusual from a modern perspective, several words had then a more or less different meaning and/or connotation than they do today.

### 6.2 Extra-linguistic knowledge

For the understanding of some specific ideas “extra-linguistic” knowledge is needed. For instance Kempelen compares the German umlaut vowels (ä, ö, ü) to the “semitones of the piano”. To understand this (striking) analogy one has firstly to know that alterations of musical notes in German are named with a suffix added to the stem note (i. e. “C#” is called “Cis”). Secondly umlaut letters in black letter originally were written by putting a small “e” on top of the “stem letter”. So an umlaut vowel is “extended” similarly to an altered musical note.

Comparing the book with respect to its diction and orthography with Kempelen’s letters and notes, it is hard to believe that all these originate from the same author. The “Mechanismus” often makes an almost modern impression in his spelling and diction while Kempelen’s letters are typical examples of the “blurred” diction of the 18<sup>th</sup> century. In fact the

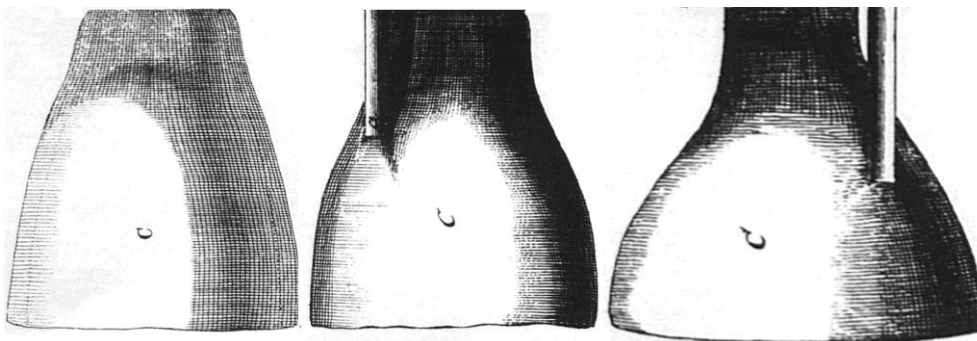
text of Kempelen's book seems to be revised by the publisher to some extent. This is due to the language reform that was performed in Austria around 1780 based on the ideas of Johann Christoph Gottsched.

### 6.3 Book subscribers

Kempelen's book was published by *praenumeration*. At the beginning of the book a list of subscribers is given: 122 by name and 73 "unnamed subscribers". In the advertisement for the *praenumeration* it is explicitly said that copies will be printed only for the subscribers [9].<sup>5</sup> Amongst the named subscribers we could find names like the later Tsar Paul I of Russia and his wife, the archduchess Maria Christina of Austria, and her husband, and many other nobles and magnates. We find also several private scholars but almost no scholars that are well known today. Nevertheless we know of some, such as Georg Christoph Lichtenberg, Justus Christian Loder and Gottlieb von Windisch, who owned a copy of Kempelen's book. Also the dedicatee of the "Mechanismus", Ignaz von Born, is not listed. His portrait is shown on the frontispiece of the book (often this illustration being erroneously taken as that of Kempelen) with a Latin dedication meaning "His and nature's friend, Ignaz von Born – the author". Ignaz von Born died very shortly after the publication. It is not known why Kempelen dedicated his book to Born. The copper-plate engraving used for the frontispiece was not made by Kempelen but comes from Johann (or Joseph) Georg Mansfeld following a miniature by Heinrich Friedrich Füger. Born had commissioned this miniature shortly before his death, and then sent copies of the engraving to various persons, including Kempelen.

### 6.4 Copper plates

The remaining 26 copper plates were made by Kempelen himself. In general they show a fine understanding of the engraving technique. Nonetheless for some of the figures Kempelen seems to have had trouble with the correct representation of the third dimension. Also some of the representations seem to have been made with less care than others (e.g. the depiction of his organ-like prototype on Tab. XVII). Neither the mechanics of the keys nor the bellows could have worked as shown there. Kempelen's depiction of the "mouth" of the final version of his speaking machine is peculiar as well. It is shown in three tables (Tab. XXIII–XXV) in the original versions, see Fig. 4 here. Its cross-section, from representation to representation, assumes an increasingly curved form, while its dimensions remain the same.



**Figure 4.** Kempelen's depiction of the speaking machine's mouth-funnel on tables XXIII, XXIV and XXV of the "Mechanismus" (from left to right).<sup>6</sup>

<sup>5</sup> Due to similar but better documented cases of *praenumeration* it is very likely that some of the subscribers purchased more than one copy.

<sup>6</sup> Experiments with replicas of the speaking machine made by the first author show that the exact shape of the mouth funnel is less relevant for the sound quality.

## 6.5 Phonetic alphabet

Kempelen's attempt to develop a kind of phonetic alphabet on the base of the established set of characters of the German alphabet inevitably failed from a modern point of view. An example is the assignment of the letter <I> to the German vowels [i] and [ɪ] but also to the consonants [j] and [ɨ] (as allophones of /j/ as in *Jagd*). The letter <J> could then be used to represent the sound [ʒ]. In French this sound is in fact represented by exactly this letter, but in the other languages that Kempelen treats, it is not. On the other hand, he associates the voiceless counterpart [ç] with the orthographic representation <SCH>, which in turn is a unique feature of German. This mixture of different orthographic and phonetic notations often causes some confusion for today's readers who have a background in phonetic transcription. Nevertheless, it must be borne in mind that the first clear-cut separation of graphemes and phonemes was achieved only by the Prague school in the 1920s. It is clear from Kempelen's formulations that he was well aware of the problematic nature of his approach, but apparently adopted it for practical reasons rather than introducing an abstract and purely phonetic-based alphabet.

## 7 Errors

There are few serious mistakes in Kempelen's book. Besides a number of typographical errors, that could not be attributed to him but to the typesetter, there are also some content-related mistakes. The two most relevant occur as part of one line of argumentation and were taken over from the same reference. In chapter 2 Kempelen argues that language was not given by God but invented by humans and that there was no *Urlanguage* from which derives every existing language. To demonstrate this he compares the numerals 1 to 10 from twelve very different languages "of peoples who live far from each other and could not have had any knowledge of each other". If these languages derived from one single *Urlanguage* there should be fundamental similarities in their basic vocabulary such as numerals.

He presents the numerals for Korean and "Formosan" but also for Hungarian, Turkish and Khoisan languages. His source was the "Oriental and Occidental A, B, C-Book" by Benjamin Schulze from 1769 [11]. The examples given by Schulze [11] are predominantly accurate for most languages, although the pseudo-phonetic transcription sometimes has marked defects which certainly make identification of the evidence difficult at times. For the Korean number examples a curious mistake occurred: the separate native Korean and Sino-Korean numbers were mixed to a single "doubled" one.

A particularly amusing case is the fallacy that relates to "Formosan" that snared Schulze [11], and by inheritance Kempelen. Fritz & Schulze clearly used as their source the fraudulent work "An Historical and Geographical Description of Formosa, an Island Subject to the Emperor of Japan" written by a certain George Psalmanazar in 1704 [12]. Unfortunately Psalmanazar had no knowledge of the land that he described including the language. The examples of the Formosan language, like everything else in the book, were a pure invention and have nothing in common with actual Austronesian Formosan languages.

## 8 Conclusion

Kempelen's "Mechanismus der menschlichen Sprache" was a milestone of early phonetics and remains famous today. Besides the pioneering content of the book, its style of writing is often enthralling and entertaining in the best sense of the word. Though it was conceptualized for a different purpose it can be considered as a textbook for basic elements of linguistics.

When we decided to make a new, transliterated and translated edition of Kempelen's book that could be usable as well as useful for many researchers, we were aware that we would have to solve various types of problems. But we had not expected the great diversity of challenges that finally arose. First of all various editorial questions had to be solved in a way

that makes the text easily readable but also keeps as much meta-information present in the book as possible. And in regards to content we found several difficulties. Some passages are hard to understand. And even if the fundamental line of argument is obvious it sometimes can be very challenging to explain it in other words or to translate it faithfully into another language.

Kempelen's disclosure of the construction of his speaking machine was not entirely voluntary. He felt compelled to do so to keep the critical voices silent. But nonetheless the "Mechanismus" and especially its fifth chapter on the speaking machine can be seen as an early form of open source publication: The operating principle was disclosed to a degree that allows a fundamental analysis of this approach. This is a clear difference from contemporaneous approaches like, e.g., that of Christian Gottlieb Kratzenstein, who published only a very vague description of his "vowel organ" that is hardly sufficient for a precise reproduction.

In addition, when one has dealt intensively with Kempelen's book one comes across a multitude of secondary aspects that nonetheless throw a light on the conditions of its origin and thus help to improve its understanding.

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