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Archeoacoustics through acoustic reconstruction in a systematic mapping study

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Abstract

A new term has been noticed mapping scientific studies and proceedings of International Conferences regarding acoustics: Archeoacoustics. In 2019 Aachen hosted the 23rd International Congress on Acoustics – ICA, which had a special session dedicated to this expression yet only a few works were presented. This expression comes from recently researches carried out concerning archaeological acoustics, in which acoustical behavior of spaces can still be measured or, mainly, rooms that are virtually recreated and analyzed through acoustical simulations in order to understand the behavior in different periods. Mapping shows Archeoacoustics used both to reconstruct and assess spaces that no longer exist and also for some where the architecture has been remodeled or even the use of the space has change which implies in acoustical variations. This term incited the curiosity on the subject, which allies architectural acoustics to building and society's History. A systematic mapping study (SMS) showed a gap of this kind of research in Brazil, which can contribute significantly to preservation the Brazilian architectural heritage and History. Thus, Archeoacoustics became the research theme for doctoral thesis of one of the authors. Which for this research freely translated to Portuguese as Arqueoacústica once the aim of this research is to map studies in Brazil. This paper shows the systematic mapping study of the subject and the potential of studies for other researches to develop in Brazil.

Keywords: archeoacoustics; architecture; churches; intangible cultural heritage; virtual acoustic reconstruction; systematic mapping study (SMS).

PACS: 43.55.-n; 43.55.Br; 43.55.Fw; 43.55.Gx.



1. INTRODUCTION

The term Archeoacoustics comes from yet recently researches carried out concerning archaeological acoustics, in which acoustical behavior of spaces can still be measured or, mainly, rooms that are virtually recreated and analyzed through acoustical simulations. It is an interdisciplinary research field focused on acoustical aspects of artifacts and the archaeological sites, in order to understand the behavior in different periods, once it make possible to save and recover cultural heritage of the sound of the historical sites that have been lost or whose characteristics have been modified through time. [1] Digital modelling, virtual reality and augmented reality contribute to increase researches in archeoacoustics. Exceptionally when related to buildings the acoustical virtual reality can be a great instrument that make possible to reconstruct the sound in rooms or buildings that have disappeared or changed significantly over time. In recent years, several research projects have been carried out with this goal, in order to maintain and try to save cultural heritage. In 2019 the International Congress on Acoustics – ICA, had for the first time a special session dedicated to this expression yet only a few works were presented. (Figure 1)

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Figure 1: Dedicated session to Archeoacoustics on ICA 2019.

Reviews based on informal literature are a relevant start for researches. However, present a lack on scientific accuracy on the process of the investigation. Those based on processes that are more rigorous make the review reproducible and impartial for anyone interested in the research field. [2] This work presents a systematic mapping study regarding archeoacoustics related to architecture, buildings and churches and the potential of

studies for other researches to develop regarding this field of studies in Brazil.

2. SYSTEMATIC MAPPING PROTOCOL

A Systematic Mapping Study (SMS) is a process to identify, categorize and analyze existing relevant literature on a research topic. The aim of a SMS is to achieve an overview on a specific research topic, present a fair assessment of current literature, find and identify gaps and then pull together some evidence for future research. The resultant material of a SMS is a roll of publication on a research area that allows finding research gaps and adherence trends once it involves search the literature to identify the studied topics. In other hand, the Systematic Literature Review (SLR) focuses on gathering and synthesizing evidence, through systematic reviews that provides analysis to answer specific questions.

However, these systematic processes of studies have some similarities in the search and studies selection they differ in terms of purpose, thus the research process is different. A SMS is mostly concerned about structure a research area while a SLR considers the evidences and strengths. The differences regards the research questions, analysis on literature, quality evaluation, and results.

The choice to conduct a SMS is justified, as the main topic of archeoacoustics is broad concerning multiple areas as architecture, human history, speleology and historical sites. This work conciliates the fields of archeoacoustics, architecture, cultural heritage, churches, worship and virtual acoustic reconstruction.

Systematic studies are valuable as provide an overview of the literature, finding out research opportunities, learning from studies and giving baselines to assist new research efforts. [3]

The systematic mapping planning (Figure 2) establish the plan to be used as a core to conduct the SMS. Once research questions are defined, they reflect the objective intended to achieve. The definition of the scope helps reaching initial boundaries and as a guideline for the research. Establishing search strategy as selecting sources

as indexing services, publication venues; help finding primary studies, as well as search strings. The quality criteria of these sources must be take into account. After that, selection criteria are used to select the primary studies that are relevant to answer the research questions and exclude irrelevant.

After this step, four others follow. The strings are used to search for relevant material on the basis according to the strategy. Then, a selection criteria is applied to select relevant initial studies. For further analysis, it's used titles, abstracts, introductions, and conclusions review for better relevance.

Next step follow the extraction and classification of data through a scheme built, where studies are classified aiming to provide of a set of results to address the research questions. Moreover, as final step the analysis and mapping when the extracted information and the visual maps are built. [4]

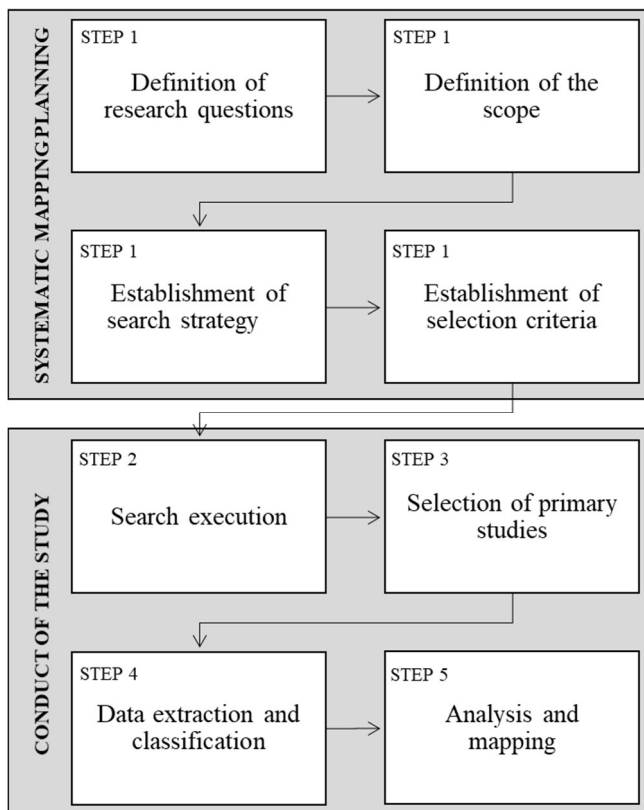


Figure 2: Systematic mapping process.
(Adapted Salama, 2017)

3. SYSTEMATIC MAPPING STUDY

Starting the systematic mapping in the first step taken, research questions were set in order to guide the search. These questions helped to define the right scope, best search strategy and search criteria to allow the mapping study.

3.1 Systematic mapping planning

The research questions started to be set after the finding that on the proceeding of ICA 2019 for the first time a special session was dedicated to archeoacoustics. However, with only a few works presented. Once being ICA one of the most relevant conferences on acoustics, and only five papers presented, how was the scenario in Brazil? If anything happens to Brazilian's historical buildings how will the relevance of acoustical cultural heritage be taken care? Are the restorations being carefully develop regarding acoustics?

A non-systematic mapping of key-words turned into a chosen list of which was going to be used as the search start. Key-words were truncated in order to obtain a wider reach among the findings concerning the possibilities of writing. However, varying the writing ended up in different search results interfering in the search. So it was decided to keep both versions. (Table 1)

The databases chosen as relevant in this first work were SCOPUS, WEB OF SCIENCE and AVERY INDEX TO ARCHITECTURAL PERIODICS.

After a first search, among these key-words where then selected those with better adherence to the research [5] and to answer the research questions. So eleven key-words were selected as adherent to this SMS and then searches combining then were taken. (Table 2)



KEYWORDS			
"acoustic documentation"	"archeoacoustics"	"church* restoration"	"room acoustic*"
"acoustic* parameter*"	"archeological acoustics"	"cultural heritage"	"sound measurement*"
"acoustic simulation"	"architectur*"	"digital heritage"	"virtual 3d acoustic*"
"acoustical fieldwork"	"architectural acoustics"	"heritage acoustic*"	"virtual acoustic reconstruction"
"acoustic* heritage"	"architectural history"	"historical acoustic*"	"virtual acoustic"
"acoustic* measurements"	"auralization"	"historic* church*"	"virtual simulation"
"acoustic* preservation"	"auralization fieldwork"	"indoor acoustic*"	"worship"
"acoustic* surveying"	"catholic church* architectur*"	"intangible cultural heritage"	"worship place*"
"archaeoacoustic*"	"church"	"listening experience"	"worship space*"
"archaeologic* acoustic*"	"church* acoustic*"	"performance space"	
"archaeological acoustic*"	"church* architectur*"	"religious building*"	

Table 1: Key-words truncated for a wider search.

KEYWORDS			
"archaeoacoustic*"	"archeoacoustics"	"church"	"virtual acoustic reconstruction"
"archaeologic* acoustic*"	"archeological acoustics"	"cultural heritage"	"worship"
"archaeological acoustic*"	"architectur*"	"intangible cultural heritage"	

Table 2: Key-words adherent to this SMS.

base	search	findings
Scopus	"archaeologic* acoustic*"	13
	"archaeological acoustic*"	16
	"archeoacoustics"	13
	"archeologic* acoustic*"	15
	"archeological acoustic*"	15
	"archaeologic* acoustic*" OR "archaeological acoustic*" OR "archeoacoustics" OR "archeologic* acoustic*" OR "archeological acoustic*"	28
	"archeological acoustic*" AND "cultural heritage"	2
	"archaeological acoustic*" AND "cultural heritage"	2
	"archaeologic* acoustic*" OR "archaeological acoustic*" OR "archeoacoustics" OR "archeologic* acoustic*" OR "archeological acoustic*" AND "cultural heritage"	4
	"archaeologic* acoustic*" AND architectur*	6
	"archaeological acoustic*" AND architectur*	9
	"archeologic* acoustic*" AND architectur*	9
	"archeological acoustic*" AND architectur*	9
	"archeoacoustics" AND architectur*	8
	"archaeologic* acoustic*" OR "archaeological acoustic*" OR "archeoacoustics" OR "archeologic* acoustic*" OR "archeological acoustic*" AND architectur*	4
	"archaeologic* acoustic*" AND restoration	0
	"archaeological acoustic*" AND restoration	0
	"archeoacoustics" AND restoration	0
	"intangible cultural heritage" AND acoustics	29
	"intangible cultural heritage" AND acoustic*	30
	"intangible cultural heritage" AND (acoustics OR acoustic*)	30
	"virtual acoustic reconstruction"	6
	"virtual acoustic reconstruction" AND architectur*	5
	"cultural heritage" AND (acoustic* OR "virtual acoustic* reconstruction")	341
	"cultural heritage" AND (acoustic* OR "virtual acoustic* reconstruction") AND architectur*	100
	"cultural heritage" AND (acoustic* OR "virtual acoustic* reconstruction") AND church*	32
	"cultural heritage" AND (acoustic* OR "virtual acoustic* reconstruction") AND worship	13
	"cultural heritage" AND (acoustic* OR "virtual acoustic* reconstruction") AND (worship OR church*)	39
	"cultural heritage" AND (acoustic* OR "virtual acoustic* reconstruction") AND (worship OR church*) AND architectur*	23
	"cultural heritage" AND (acoustic* OR "virtual acoustic* reconstruction") AND (worship OR church*) AND architectur* AND (archaeoacoustic* OR archeoacoustic* OR "archaeologic* acoustic*" OR "archeologic* acoustic*")	0

Table 3: Initially search on SCOPUS with the selected strings highlighted.

3.2 Conduct of the study

The search on the databases chosen as relevant in this first work were SCOPUS, WEB OF SCIENCE and AVERY INDEX TO ARCHITECTURAL PERIODICS. [6] [7] [8] The searches were revised on 24.06.2022, remotely using UNICAMP VPN access available for students. Initially SCOPUS were

used in order to find the best relation among the words to use during the search. Excluded from this selection, all the outlier searches, without results or too discordant relating to the sample. After, it ended up on six search strings to be replied to the other databases. (Table 3)

Table 4: All the findings among the three databases without any restriction.**Table 5:** Worldwide findings from 2018 to 2020.**Table 6:** Findings from 2018 to 2020 refined only to Brazil.



Without any kind of sort, 188 papers had adherent results to these strings. While searching those strings on AVERY there was a doubt if they were correct because the results were none, till the last one which had one result, so they were considered correct to be applied. (Table 4)

In sequence, a time restriction was set as a filter in all databases. Only papers published between 2018 and 2022 were considered. For that a total of 98 papers were filtered as adherent to the strings. (Table 5)

As the matter of this work was find works developed in Brazil, the last restriction applied was regarding to the country. After that, the results presented only 4 papers. (Table 6)

Once the initial aim of this systematic mapping study was to reach works developed in Brazil, those four papers were then selected to analyze. In this moment, with the comparison of those four papers, all of the strings and databases reached the same paper. [9]

Although this paper is adherent to the strings, both title and abstract make it clear it does not have any references to buildings or architecture. The paper found regard acoustical studies of speleology, not even concerning Brazilian caves. The reference shown as Brazil regard the research institute of one of the authors. (Figures 3 and 4)

1 Cross-Modality Information Transfer: A Hypothesis about the Relationship among Prehistoric Cave Paintings, Symbolic Thinking, and the Emergence of Language

Miyagawa, S.; Lesure, C. and Nobrega, V.A.
Feb 20 2018 | FRONTIERS IN PSYCHOLOGY 9

Early modern humans developed mental capabilities that were immeasurably greater than those of non-human primates. We see this in the rapid innovation in tool making, the development of complex language, and the creation of sophisticated art forms, none of which we find in our closest relatives. While we can readily observe the results of this high-order ... Exibir mais

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Figure 3: Paper found after all filters applied.

FRONTIERS IN PSYCHOLOGY

Volume: 9

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Resumo

Early modern humans developed mental capabilities that were immeasurably greater than those of non-human primates. We see this in the rapid innovation in tool making, the development of complex language, and the creation of sophisticated art forms, none of which we find in our closest relatives. While we can readily observe the results of this high-order cognitive capacity, it is difficult to see how it could have developed. We take up the topic of cave art and archeoacoustics, particularly the discovery that cave art is often closely connected to the acoustic properties of the cave chambers in which it is found. Apparently, early modern humans were able to detect the way sound reverberated in these chambers, and they painted artwork on surfaces that were acoustic "hot spots," i.e., suitable for generating echoes. We argue that cave art is a form of cross-modality information transfer, in which acoustic signals are transformed into symbolic visual representations. This form of information transfer across modalities is an instance of how the symbolic mind of early modern humans was taking shape into concrete, externalized language. We also suggest that the earliest rock art found in Africa may constitute one of the first fossilized proxies for the expression of full-fledged human linguistic behavior.

Palavras-chave

Palavras-chave de autor: symbolic thinking; language; cave art; archeoacoustics; Khoisan

Keywords Plus: BLOMBOS CAVE; SHELL BEADS; ROCK ART; EVOLUTION; COGNITION; NEANDERTHAL; FOXP2; ACQUISITION; DIVERGENCE; DEMOGRAPHY

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Figure 4: Abstract showing no relevance to the work.

4. CONCLUSIONS

This work produced a mapping study regarding a primary overview of researches found on the subject acoustic reconstruction of architectural buildings, which allies architectural acoustics to building and society's History. The protocol followed intended to bring up recent studies about the subject and it's appliance in Brazil. These databases chosen presented a lack of relevant results, which can contribute to open the search on the gray literature as conferences proceedings, Google Scholar, Research Gate and Academia. The results found through this SMS showed a gap of this kind of research in Brazil, which can contribute significantly to preservation the Brazilian architectural heritage and History.

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