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Reconsidering the history and context of information science

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Abstract
This paper initially presents the current context of Information Science, as its nature is perceived by contemporary definitions. These definitions are inextricably linked up the modern Information and Communication Technologies. Nevertheless, this context is historically criticized herein, by presenting examples of the past that demonstrate the evolution of information processing alongside the evolution of contemporary technologies. Consequently, a new context is proposed that includes the diachronic human efforts on processing information for achieving/ensuring communication between them. This new proposed context expands the definition of Information Science, in order to include a related group of Arts and Sciences, making it more of a scientific umbrella term that describes the field of human communication tools, concepts and practices. In this respect, the associated field is termed in plural, namely, Information Sciences.

Keywords: information science, informatics, communication, semiotics

1. Introduction
The history of sciences, both generally and regarding specific ones, is a field of study in its own right [1]. The history of every science outlines its context, as well as its ideological and conceptual trends [2]. More general ideological positions are also expressed, as for example in the case of cultural evolution or Mathematics, like the conception of “Ex Oriente Lux”. According to this conception, every cultural and scientific progress originates historically from the Orient and particularly from the Middle East [3]. These conceptions had been formulated in the past and due time became rigid, by ignoring modern discoveries or the reconsideration of older sources from a novel perspective. The work of Konidaris [3] highlights in the scientific field of Mathematics the general mentality of historical/archaeological studies, characterized by ideological intent (research driven by geographical, national/anti-ethnic or personal motives), bias and dogmatism, selective use of sources (whatever opposing is silenced), interpretation of ancient facts with modern criteria, fragmentary and non-interdisciplinary study, hasty drawing of general conclusions from limited data, linearity (instead of cyclicality) of historical events, connection of distant historical events without finding intermediates, etc. The above mentality may lead to apophenia [4]. The history of the evolution of scientific thinking is a field of research that deserves more attention, and any documented work is a useful contribution in this direction. After all, constructive dialogue (scientific or not) takes place mainly through contradictions.
Considering the afore-mentioned conceptions, the overall scope of this study is to highlight the ingenuity of our ancestors in solving problems of information processing and communication with their contemporary technology. In particular and within this process, the history and context of Information Science is reconsidered, by analyzing its fundamental concepts. These concepts may lead to the connection of other scientific disciplines together, forming a group of closely related fields of study. The argumentation herein is initiated by presenting the current context of Information Science and proceeds with the proposal of a revision, based on the inference of historical evidence and content definitions.

2. The Current Context
Among the very first definitions of Information Science is the one of Borko [5], stating that:
"Information science is that discipline that investigates the properties and behavior of information, the forces governing the flow of information, and the means of processing information for optimum accessibility and usability. It is concerned with that body of knowledge relating to the origination, collection, organization, storage, retrieval, interpretation, transmission, transformation, and utilization of information. This includes the investigation of information representations in both natural and artificial systems, the use of codes for efficient message transmission, and the study of information processing devices and techniques such as computers and their programming systems. It is an interdisciplinary science derived from and related to such fields as mathematics, logic, linguistics, psychology, computer technology, operations research, the graphic arts, communications, management, and other similar fields. It has both a pure science component, which inquires into the subject without regard to its application, and an applied science component, which develops services and products."
This definition is sufficiently abstract and comprehensive at its first part, for a diachronic study of this discipline. Indirectly though in terms of tools (“devices”) emphasizes the usage of computers and their programming. It also accurately mentions other related fields (mathematics, management), having Information Science perceived as their interdisciplinary derivation. Finally, it covers both theory and applications. The term “Information Science” is associated as well with the term “Informatics”, although the latter is now referring more to the applications of Information Science in various fields, occasionally with or

without computers [6].

Although many historians of Information Science determine its historical "inauguration" in 1895 [7], this term became more popular towards the end of the 20th century [8]. Nevertheless, it has been recognized that the associated practices are much older [9]. In this respect, a systematic reconsideration of context will be attempted herein, presented in the next section.

3. The Proposed Context

The proposed context initially considers the confirmation of independence of the theoretical concepts from the devices. The afore-mentioned definition of Borko [5], regarding Information Science, refers to "the study of information processing devices and techniques such as computers and their programming systems". In terms of devices, this definition is correctly not exclusive to modern computers, although indirectly their predominance is detectable. Indeed, the technological evolution on the field of devices may result in information processing tools that will differ from modern digital computers as much as they differ from previous analogical machines [45, 46]. Characteristic examples of the technological trends on new computing devices are the quantum processors [47] or the artificial organic brains, alias "wetware" [48]. This conceptual independence allows for the inclusion of any kind of information processing tools and practices, thus extending their study to the far prehistory of humanity.

The crucial part of the definition of Information Science is the "… investigation of information representations in both natural and artificial systems, the use of codes for efficient message transmission …". This part clearly and undoubtedly points towards Semiotics, namely, the study of signs, symbols and the production of meaning that can be communicated via any of the senses [10, 11, 12]. Therefore, Semiotics constitutes the very conceptual foundations of Information Science, where its historical evolution may be unfolded from.

3.1 Language

The first kind of signs, information transmission practice and means of communication to be considered is sound and consequently language. The usage of language for information transmission and communication, with or without sounds, has been recognized as a widespread practice in many species, although only humans [13], dolphins [14] and potentially other cetaceans [15] have been recognized so far to use sophisticated language structures, like syntax. The prehistoric societies were based on oral tradition for information storage and retrieval [16]. There is a lot of debate on the first language of humans, called the Language of Homo Sapiens or Proto-Sapiens [17]. The two relevant opposing theories on Proto-Sapiens are that of monogenesis [18], according to which all human languages originate in one proto-human language, and that of polygenesis [19], arguing against the former.

3.2 Graphic Arts

The first known technological evolutions towards information representation and storage was due to Chemistry and especially to the properties of certain substances suitable for painting (different colours), as well as the discovery of materials hard enough for engraving. This technological evolution is evident to cave-wall/rock painting and engraving. A few most representative examples of this technological advancement are the prehistoric ones of Sahara Desert in Chad, Central Africa, the oldest being dated 12,000 years ago [20]. Both the older engravings over there and the newer rock paintings, as in Manda Guéli Cave of the Ennedi Mountains [21], are more than an artistic expression of their creators. They can be seen as open books, depicting many kinds of animals of economic interest to hunter-gatherers' and pastoral societies, which, by the way, are mostly absent from the modern local habitats. The usage of Graphic Arts survived for millennia in information processing until relatively recently, as exemplified by a few Amerindian languages [22, 23]. Eventually, the pictures became pictograms and subsequently written signs [22], evidently in the ancient scripts like the Egyptian Hieroglyphics, the Sumerian Pre-Cuneiform and Protocuneiform [24] or the syllabograms of the Minoan Crete [25]. Besides the evolution of writing systems, Graphic Arts have been and are still used in other forms of information transmission. Such an ancient manifestation of this usage is the seals, widely used throughout Bronze Age in the entire Middle/Near East, Indus Valley and Crete [26, 27]. Those seals had been a type of heraldry, for marking merchandise to denote the ownership, origin or authentication.

3.3 Writing Systems

Once again regarding language, the first indisputable writing systems had been devised for data management in its modern sense. Such a system of data management included not only the standardized set of signs, known as script, for the representation of information but also the contemporary technology of data storage/retrieval, along with the relevant recording practices and techniques. The invention of clay processing and the usage of wedges for writing allowed the massive production of tablets for information management, by the Sumerians, the Akkadians, the Babylonians and the Cretans of Bronze Age. To mention a few examples:

- Sumerian tablets have been discovered (the oldest related ones at least since 2600 BCE) with recordings of the sizes of adjacent land estates [28], a contract for the purchase and sale of a house and the adjacent plot [29] and "the delivery to some central storehouse of bales of bundled reeds, some of which were then set aside for tax payments." [30].
- The famous Babylonian tablet, designated "Plimpton 322" (dated around 1800 BCE), with mathematical calculations in rows and columns, regarding numbers related to the Pythagorean theorem [31].
- The tablets of Linear A script (and of Linear B, later on) from Minoan Crete, recording commercial transactions, namely, locations, persons, goods, quantities and payments [32].

Apart from the equivalence of data, the contemporary recording practices were also identical to the modern ones. The information was recorded in organized databases [33], either in lines of text, as in the leaf-shaped tablets of Linear-B from Pylos [34], or arranged in tables with rows and columns [35], with semantics identical to the modern ones [30]. The lines of text and the rows of tables were engraved on the tablets. In this respect, the so-called scribes of antiquity were actually accountants and administration

clerks [36]. Even the mode of engraving followed a similar to the modern one evolutionary path. The Sumerian pre-cuneiform pictography evolved to the cuneiform script, through a digitization of engraving (by the usage of wedges), and to the Cretan Protolinear script in an analogue manner, through a simplified and abstract linearization of pictograms [27].

3.4 Music

Besides language, sounds have been used for the transmission of messages through Music, after the invention of musical instruments. From the Ancient Greek paean [37], sung before and after a victorious battle [38], to the British broadcasting in the 2nd World War [39], specific information/messages have been transmitted in the battlefields (e.g., march, stop, retreat etc.) by musical instruments, predominantly the trumpet and drums.

3.5 Mathematics

As an application of Semiotics, Mathematics preceded scripts, in general. The oldest archaeological discovery of arithmetic recording, so far, is a baboon's bone from Swaziland with 29 notches engraved on, dated 37,000 years ago. It seems that it was used as a Lunar calendar, considering its similarity to the rods that are still used nowadays by the San people of Namibia. The next such case is that of a wolf's bone from Moravia (Czech Republic), dated 32,000 years ago, having 56 notches engraved in groups of five, plus one after the fifth group [29]. Gradually, sophisticated sets of signs had been devised for the representation of numbers and numbering systems, in Sumer, Egypt, China, India, Arabia, Greece, Rome or Latin America by the Mayans [28, 29]. These signs and numeral systems had been used for commercial transactions, to record goods in storage, for astronomical calculations, for date recording and data management in general, as elegantly demonstrated by the numeral systems of Bronze Age Crete [40]. In this respect, to quote Mitakidis [41]: "In the future of Informatics as a mathematical science; time will tell up to which point the reverse will be true." The argumentation herein proposes that this time has come.

3.6 Devices

Finally, let's consider diachronically the computing devices and information processing tools. The first primitive ones have been mentioned earlier: bones of animals. Given the time of usage, this was innovative enough. Once again, the invention of clay processing gave rise to revolutionary innovations in information technologies. Such early technologies have been found in the Sumerian city of Uruk, consisting of inscribed clay artefacts, like tokens, bullae and hollow balls. A representative case is the circular clay token for a sheep, having a cross engraved [42]. The image of this token, being a circle enclosing a cross, became initially the Sumerian sign ATU 761, which meant "sheep", and eventually the Cretan Protolinear sign that renders syllable CA/KA, preliminary designated P021 [43]. This particular sign is found both in Linear-A script (designated LA 29) and in Linear-B script (designated LB 77). The sheep was called /ga-n/ in Sumerian, with -n silenced in the stand-alone word [25]. The Ancient Greeks made use of sophisticated hand-powered analogue computers, as it is proved by the Antikythera mechanism [44]. Yet, the most common type of calculator had been the abacus, like the one discovered in Salamis island in 1846. It is a marble plate, having a table of many columns engraved, some representing powers of ten and others fractions. On this table, pebbles and pillars were placed, accordingly [29]. A similar device had been the Roman abacus, which evolved in the one known nowadays [28]. Since then:

- The Scotchman mathematician John Napier (1550-1617) invented an abacus, called "the bones of Napier" (1617), being a table for calculating multiplications [29].
- The British William Oughtred (1574-1660) invented the logarithmic ruler, after improving an invention of Edmund Gunter. Its present form is owed to the French Amédée Mannheim [29].
- In 1623, the German Wilhelm Schickard (1592-1635) invented a mechanical calculator, called "calculating clock", capable of performing the four basic arithmetic operations [29].
- The French mathematician Blaise Pascal invented an analogue calculator, named "Pascalina" (1642), capable of performing addition and subtraction of numbers [28].
- The Englishman Samuel Morland (1625-1695) invented an "arithmetic instrument", adopted to calculations for the English monetary system. His invention was published in 1673 and it was small enough to be carried inside a pocket [29].
- In 1694, the German philosopher and mathematician Gottfried Wilhelm Leibniz (1646-1716) invented a "mechanical arithmetic engine", capable of performing the four basic arithmetic operations [28].
- In 1725, the French Basile Bouchon introduced the programming of loom through a perforated tape. Later on, his assistant Jean-Baptiste Falcon improved this machine by replacing the tape with a set of perforated cards. In 1740, the engineer Jacques de Vaucanson added a revolving drum for automating weave and, based on his design, Joseph Marie Jacquard (1752-1834) introduced his famous weave machine through perforated cards, in 1803 [29].
- In 1822, the Englishman philosopher, mathematician and inventor Charles Babbage (1791-1871) designed the "Difference Engine" that had never been completed, while in 1834, with the assistance of Ada Augusta Byron Lovelace, he started the designing of the "Analytical Engine", which had never been built then [29].
- After reading an article about the Difference Engine, the Swedish Georg Scheutz (1785-1873) and his son (Edvard) invented a mechanical calculator that was presented in 1843 [29].
- In 1844, the American inventor Samuel Mors (1791-1872) used for the first time a telegraph that he had designed, to transmit a message encoded in his renowned binary code, the "Morse code" [39].
- In 1890, the American inventor and statistician Hermann Hollerith (1860-1929) invented an electromechanical calculator with perforated cards, for processing census data. His initial company (Tabulating Business Company) was renamed to International Business Machine (yes, it's IBM), in 1924 [28].
- The Irish accountant Percy Ludgate invented a calculator (1903) similar to the one of Babbage, which was powered though by electricity instead of steam [29].
- The Spanish mathematician, engineer and inventor Leonardo Torres y Quevedo invented an

electromechanical automated chess-player, named "El Ajedrecista", in 1911 [29].

- In 1923, the German inventor Arthur Scherbius invented the cryptographic engine "Enigma" that was used by the German Armed Forces in the 2nd World War, for transmitting encrypted messages [39]. The efforts of the British intelligence services to achieve the cryptanalysis of the Enigma messages led to the invention of Colossus, in 1943 [39], a direct ancestor of modern computers.
- In the same era, other calculators had been invented and produced like the "Brunsviga" (1927), the "Mercedes Euklid" in 1935 [28] or the first electromechanical computer, the Harvard Mark I (completed in 1943), by the American engineer Howard Hathaway Aiken with the support of IBM [29].
- From 1935 to 1939, the German engineer Konrad Zuse built the legendary "Z" series of general-purpose programmable computers [29].
- Finally, the last device to be mentioned herein is the other direct ancestor of modern computers, the Electronic Numerical Integrator and Computer (ENIAC), also being a general-purpose programmable computer, completed in 1945 [29].

The previous long list of computing devices demonstrates information processing tools and contemporary technologies that had been invented before what is perceived nowadays as a computer. They may had a more limited domain of functionality and applications, compared to modern information processing needs and capabilities, nevertheless, they were the product of ingenuity of their inventors and they served well their contemporary needs of data management. Therefore, it is fair to claim that Information Science is much older than inferred by the definition of Borko [5] or the suggestion of Rayward [7].

4. Conclusions

Summarizing the herein argumentation, the current definition and context of Information Science does not give much credit to the diachronic efforts of human ingenuity in processing and disseminate information. In addition, it regards Information Science as a derivative of other pre-existing and combined sciences. In this historical respect, a new context is proposed that alters the designation of Information Science towards a fundamental umbrella term for a group of Arts and Sciences, related to communication tools and information processing. The definition of this group, better named Information Sciences, may include Semiotics and its applications, like Linguistics, Mathematics, Graphic Arts, Music, Informatics and Computing in its fundamental repertoire, as its scientific and technological branches of study.

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