HALF LIVES OF KNOWLEDGE. A Media-Archaeological Point of View

[Lecture for session „RK&M Loss and Recovery of Knowledge", Workshop *Preservation of Records, Knowledge and Memory across generations (RK&M)*, Paris, Nuclear Energy Agency (NEA) der OECD, 12.-14. September 2012]

abstract

abstract

In the discussion of how long knowledge can be expected to last, and in what form, for the immediate future the human factor seems to be determinant (Marcos Buser). But regarding the challenges and chances of maintaining knowledge across emphatic temporal distance, and in respect to the options of reconstructing lost or damaged knowledge, an "archaeological" perspective (in its various meanings ranging from the academic discipline up to Foucault's *Archéologie de Savoir* and even media-archaeology) is useful which focuses on the non-human agencies of knowledge traditions. Media theory here is helpful since it addresses both the philosophical (epistemological) and the engineering (techno-mathematical) questions involved. The present focus is on nuclear energy both as medium and as subject of knowledge reflection, with a special accent on the delicate relation between technology and time.

For the analysis of the techno-logics of knowledge tradition, a focus on both the material (technical) forms which are subject to physical entropy and on the immaterial (logical), almost time-invariant codes of transmission is required: the physical *versus* the symbolical mode, material embodiment ("markers") *versus* logical implementations (archives). In this context "symbolic" does not refer to symbolism in its iconological sense of metaphorical meaning (such as the much discussed "markers" on nuclear waste sites[1]), but to discrete characters in coding information (ranging hitherto from alphabetic letters and Arabic numbers up to the binary code of Zeros and Ones embodied as Low

---

[1] See the OECD Radioactive Waste Management publication *More than Just Concrete Realities: The Symbolic Dimension of Radioactive Waste Mangement* (2010)

and High voltage levels in electronic computing). The current shift from material memory as cultural premise to techno-mathematics as the dominant form of cultural communication corresponds with a different kind of tempor(e)ality: cultural memory once intended for eternity transforms into an on-going practice, economy and aesthetics of short-term intermediary storage: repeated data migration, "the enduring ephemeral"[2].

In every act of cultural transmission, there is a symbolical (code) level on the one hand which is time-invariant, and an entropical, temporally decaying ("historical") physical reality on the other. Let us take as an example for symbolical tradition the allegory of history as painted by Anton Raphael Mengs on the ceiling of the room which links the Vatican museum (materially) to the Vatican library (the regime of symbolic signs).

Cultural analysis in the media-archaeological way

My statement intends to analyze both the material forms of cultural tradition which are subject to physical entropy and the immaterial, almost time-invariant codes of transmission: the physical vs. the symbolical mode, material embodiment ("markers") vs. logical implementations (archives). The shift from archaeological materialities as cultural premise to techno-mathematics as the new form of enculturation corresponds with a different kind of tempor(e)ality: cultural memory once intended for eternity transforms into a perpetual practice of short-term intermediary storage: repeated data migration, "the enduring ephemeral"[3].

"Writing vs. Time": Lossless tradition in the symbolic code?

In every act of cultural transmission, there is a symbolical (code) level on the one hand which is time-invariant, and an entropical, temporally decaying ("historical") physical reality on the other. Let us take as an example for symbolical tradition the allegory of history as painted by Anton Raphael Mengs on the ceiling of the room which links the Vatican museum (materially) to the Vatican library (the regime of symbolic signs).

_____

[2]   See Wendy Chun, The Enduring Ephemeral, or The Future Is a Memory, in: Erkki Huhtamo / Jussi Parikka (eds), Media Archaeology. Approaches, Applications, and Implications, Berkeley / Los Angeles / London (University of California Press) 2011, 184–203

[3]   See Wendy Chun, The Enduring Ephemeral, or The Future Is a Memory, in: Erkki Huhtamo / Jussi Parikka (Hg.), Media Archaeology. Approaches, Applications, and Implications, Berkeley / Los Angeles / London (University of California Press) 2011, 184–203

There is another 18th century allegory of the mechanisms of cultural transmission, the frontispiece of Lafitau's publication *Moeurs des sauvages Ameriquains* (1724). This image confronts archaeologically silent, but enduring material artefacts with the discursive, but transient murmur of historiography. The viewer is confronted with

<...> the encounter of writing and time in a closed space littered with "vestiges" coming from both Classical Antiquity and the New World. One holds the pen, the other the scythe, <...> which approach each other without ever touching, asymptotically. History deals with relics which can be seen, and seeks to supply explanations; ancient *things* which have become mute throught the degradation owing to time may to some extent become clearer <...>.[4]

Michel de Certeau enhanced this allegory by drawing the configuration of Chronos and Clio abstracted to a diagram where the supposed prologued lines of the curved scythe and the linear pen become vectors. Diagrams (as defined by Charles Sanders Pierce) in fact turn out to be the most appropriate form of knowledge tradition, since they do not depend on iconological representation while at the same time being evidential for reasoning.

Directly deciphered in terms of mathematics, the pen-line (as x-axis) becomes the asymptote of the scythe as hyperbel (on the y-axis). There is no point where the function touches or traverses the x axis itself: no convergence between material and symbolic phenomena of time.

In Lafitau's front cover illustration, the allegorical figure of Chronos is endowed with a weapon (the scythe) indicating devastation with time – in fact „noise" which happens in the temporal channel of transmission (to rephrase it in terms known from transmission engineering).[5] Such material loss of information is compensated by the female allegory of Clio „writing" history: copying of symbolic letters is an almost lossless technology of tradition.

Tradition here means the separation of signal from noise by means of symbolic transcription. When we have ("received") a message which has somehow become scrambled with another, unwanted message (which we call noise), the challenge lies in "unscrambling these and restoring the original message with as little alteration as

---

[4] Annette Lavers (rev.), on: Michel de Certeau, Writing versus Time, in: Rethinking History. Time, Myth, and Writing, ed. M.-R. Logan / J. F. Logan, New Haven: Yale French Studies 59 (1980), in: History and Theory XXII, 3 / 1985, 330f

[5] Claire Mays (NEA), in fact, points out that the scythe is not just a weapon but an agricultural tool as well; invasive cutting of agricultural plants is the condition of re-growing it. The scythe thus gives an extra sense to the dialectics of forgetting and re-generation (without memory).

possible, *except perhaps for a lag in time*"[6] - which is the problem of filtering.

Towards the non-human observer: The media-archaeological point of view

Media archaeology is a method of enquiring into cultural time which is not limited to the historical (narrative) approach, that is: taking not exlusively of the human point of view on culture, but the perspective of technologies as well which themselves become active "archaeologists" of knowledge. Technological media machines produce articulations that do not necessarily need a human observer or translator any more in order to communicate between themselves.

Symbolic decoding (alphabetic "reading" and linguistic "undertanding" of the semantics of these strings of charactes) of an ancient Codex (e. g. the law code of emperor Theodosius) is not enough to grasp its historical significance, the historian R. G. Collingwood writes in *The Idea of History* (1946, 283). One must rather know and "re-encact" (not just analyze) Theodosius' contextual "situation".

On the other side, human "reading" becomes more and more machine-dependent. A groove on a vinyl record might still be "read" by a skill human interpreter (at least roughly), just like a slide of a micro-film compresses a text. Electronic recording (be it acoustic or optic signals, or textual symbols) requires refinded technology to be accessible for humans at all. Media archaeology is more akin to the gaze of the optical scanner that to that of the anthropological observer.

Communication addressed to the future needs to take into account such non-human readers.

The RK&M research project articulates as the aim for long-time depositories of nucelar waste hat the "final disposal does not depend on human presence and intervention in order to fulfil its safety goal".

Is this nessecary anti-hermeneutic, or does it lead to a re-freshed hermeneutics?

According to Hans-Georg Gadamer[7], the temporal gap which separates two cultural times makes it impossible for the latter to re-access the former unless they are linked by a common horizon of tradition ("wirkungsgeschichtlicher Zusammenhang"), e. g. a continuum of

---

[6]   Norbert Wiener, Time, Communication, and the Nervous System, in: Annals of the New York Academy of Sciences, Bd. 50, 1948/50, 197-219 (205; italics W. E.)

[7] Hans-Georg Gadamer, Wahrheit und Methode, Tübingen 1972

cultural sense from Homer to Heidegger.

The "humanistic" paradigm relies on the a-temporality of symbolically coded communication between distant spaces and across temporal distances. But beyond such human understanding, Karl Popper declared a "third world" of knowledge which exists even in the absence of humans. The subjectivist point of view takes a book without reader for a meaningless object:

But logarithmic tables can be generated by a computer and be printed. These numbers may probably never be read by humans on earth. But each of these numbres contains what Popper calls "objective knowledge"[8].

Temporal invariance: the "humanistic" co-originality

Epistemology without a knowing subject (Popper) deals with a world of knowledge without a knowing (human) subject, reminding of Plato's theory of anamnestic knowledge.

"Even though this <...> world is a human product, there are many theories in themselves and arguments in themselves and ronblem siguations in themselves which have nerver been produced or understood and may never be produced or understood by men" <Popper 1979: 116>.

Popper imagines two apocalyptic scenarios: All machines and tools will be destroyed, as well as all human knowledge about such devices; only libraries survive and the human capacity to learn from them (depending on the reading / decoding / alphabetic capacity / literacy); thus the cultural world can be re-activated.

In an alternative thought experiment, even all libraries are detroyed: "there will be no re-emergence of our civilization for many milennia"[9].

Let us remember a scenario which actually happened: the destruction of the ancient library of Alexandria (which included, next to book rolls, a machine park and academic laboratory as well). Since knowledge was already embedded in machines, geometries und letters around the ancient world, the physical loss was a damage, but surprisingly not an epistemic loss, not desctructive to technical and cultural knowledge), since most of such mathematics and machines has been re-invented independently since several times.

---

[8]   Popper 1972 / 1984: Karl R. Popper, Objektive Erkenntnis. Ein evolutionärer Entwurf, 4. Aufl. Hamburg (Hoffmann & Campe) 1984, 118f
[9]   Karl R. Popper, Objective Knowledge. An Evolutionary Approach, Oxford, 2nd. ed. (Clarendon Press) 1979, 108

"One of the main reasons for the mistaken subjective approach to knowledge is the feeling htat a book is nothin gwithout a reader: only if it is understood does it reallys become a book; otherwise it is just paper with black spots on it" <Popper 1979: 115>. But "a wasps' nest is a wasps' nest even afte rit has been deserted" <ibid.>. "Moreover, a book, or even a library, need not even have been written by anybody: a series of books of logarithms, for example, may be produced and printed by a computer" <ibid.>. Popper insists on the "possibility or potentiality" of such prointed characters in a book of being understood, "and this potentiality of disposition may exist without ever being actulaized or realized" <116>.

"We may imagine that after the human race has perished, some books or libraries may be found by some civilized successors of ours (no matter whether these are terrestrial animals, which have become civilized, or some visitors from outer space). These books may be deciphered. They may be those logarithm tables never read before <...>. <...> it is sufficient that it might be deciphered <...> in order to belong to the third world of objective knowledge <...>." <116>.

"Knowledge in this objective sense is totally independent of anybody's claim to know" <Popper 1979: 109>. Even if the knowledge of so-called Pythagoras' early Greek physical experiments with the vibrating string (the monochord) or his mathematical reasoning with drawings of geometrical bodies ("Der Satz des Pythagoras") had been completely oblitterated by loss or destruction in the process of tradition, the rules would inevitable be re-invented. There is a co-presence which takes place in the physical/mathematical world, different from the contextual and discursive relativity of cultural (historical) human activity.

Introduction

Since the emergence of physical thermodynamics, statistical mechanics and mathematical stochastics in the 19th century, a paradigm shift for notions of cultural transmission took place. The humanistic trust into secure transmission of knowledge has since been replaced by the notion of improbabilities of transmission. Transmission of knowledge within the temporal domain, understood here in reverse to space-bridging communication channels, takes place in materially embodied and symbolically encoded forms. In this context "symbolic" does not refer to symbolism in its iconological sense of metaphorical meaning (such as the much discussed "markers" on nuclear waste sites[10]), but to discrete characters in coding information (ranging hitherto from alphabetic letters and Arabic numbers up to the binary code of

---

[10] See the OECD Radioactive Waste Management publication *More than Just Concrete Realities: The Symbolic Dimension of Radioactive Waste Mangement* (2010)

Zeros and Ones embodied as Low and High voltage levels in electronic computing).

The very notion of "record" might be questioned in media-archaeological terms. The RKM *Glossary of Key Terms* defines a record as "an object or a selected piece of data / piece of information that has been committed to a medium". "Medium" is the term assigned by Claude Shannon's communication engineering to the channel of transmission. Let us understand communication here not in its vulgar sense as meaningful exchange but more formally as a sequence of signals and/or symbols. More specifically, information theory requires that something unknown is transmitted. In techno-mathematical terms, information theory which deals with temporal (in-)variances is close to correlation analysis. In order to compare a signal (*s*) at a (much) later *punctum temporis* with itself (*s'*), a correlator is required, which is based on means to store and to delay the signal.[11]

Thus regeneration and relays are required. Different from traditional transmission as endurance where the massages was confined to one materiality (such as inscriptions in stone, or letters in the postal system), in dynamically encoded symbolic transmission the embodiment of information as signal may be variously *transduced*, i. e. change from one form of energy into another.

Information transmission (different from previous body- or paper-bound material messengers) is almost independent from its material signal (as defined in Norbert Wiener's *Cybernetics*).

In order "to counter the passage from negentropy to ultimate entropy", Thomas Sebeok proposed a "relay system" of information transmission, in fact a kind of creating intervals by sampling: "to divide the 10,000-year epoch envisaged into manageable segments of shorter and, resumably, reasonably foreseeable periods" <Sebeok 1985: 464> which he counts by generations of humankind which would update the message periodically like relays in an electric (or even horse-borne) communication channel.

Cultural knowledge is context-dependend (the so-called "historical" variable); that is why the RKM *Glossary of Key Terms* demands for a record that it is "kept together with the appropriate context and structure for later use"; whereas physical and mathematical laws claim invariance against temporal change in terms of ergodic behaviour.

The term *ergodic* defines "a stochastic process in which every sizable subsequence is the same statistically, and every state will occur in the long run"[12]. Ergodic theory had its origins in the work of Boltzmann in statistical mechanics problems where

---

[11] See F. H. Lange, Correlation Techniques, London (Iliffe Books) / Princeton, New Jersey (van Nostrand Company) 1967
[12] Glossary of "Neural" Terms, in: Kohonen 1995, 253-281 (261)

time- and space-distribution averages are equal.

To what extent is the model of "tradition" as transfer in the time-based channel reliable for long-term persistance of records – be it "direct" or "indirect transmission", passing the record from one generation to another, known from oral literature cultures (Homer in ancient Greece, or more recently *guslari* in Serbia and Montenegro) or as data "migration" in digital preservation of records (defined as dual-track strategy in the RKM *Glossary of Key Terms*)?

This leads to a rather a-historical model of co-originness ("Gleichursprünglichkeit"): "Cultural differences arise because different environmental vues evoke different innate information" <Boyd / Richerson 2005: 424>. Agriculture, e. g., was invented independently many times <ibid., 355>.

"Culture is not based on direct replication but upon teaching and imitation. The transmission of culture is temporally extended."[13]

The notion of "migration" itself points to a current shift of emphasis which is essentially connected to the discourse and physics of nuclear waste deposits: For long time already, the occidental fixation on "end"archives (eternal storage) has been replaced by the notion of intermediary, temporary, even ephemeral storage, the "Zwischenlager", leading to intermediary storage in permanence, thus: dis-locating the storage elements ("migrating" them in due intervals).

[Let us look closer at the notion and term "final storage" (German *Endlager*), especially in German. The philosopher G. W. F. Hegel once proclaimed the "end of (art) history", but not in a catastrophic sense, but as coming-to-end, that is: From now on, aesthetics will continue, but not essentially change and transform into unknown figures.]

Static continuous permanence (Bergsonean time) is being replaced by a dynamic concept of repeated actualisation: endurance by refreshing which is not only a principle in contemporary electronics (the electronic image in television and video; memory administration in computers) and communication technologies ("sampling"); this corresponds with the practice of archiving the Internet as well, as performed by the wayback-machine of the Internet Archive

To what degree is the endurance of knowledge dependent on material resistance to entropy? Direct transmission without intermediary agencies relies on the material endurance of records. In order to keep it meaningful (since "much cultural information is semantic knowledge"[14]), the medium itself here has to be made the message

---

[13]   Robert Boyd / Peter J. Richerson, The Origin and Evolution of Cultures, New York u. a. (Oxford UP) 2005, 378
[14]   Boyd / Richerson 2005: 423

(McLuhan), independent of its original semantic content.

"The architecture of the church may help store information about the rituals performed within. Without writing, however, the ability of artifacts to store culture is quite limited. <...> many artifacts are very difficult to reverse-engineer" <Boyd / Richerson 2005: 423>.

"The vast store of information that exists in every culture cannot simply float in the air. It must be encoded in some material object" <Boyd / Richerson 2005: 423>. But what if information is not encoded ("written") in material storage media, but performed as modulation of dynamic signals, like speech or music in electro-magnetic radio transmission? Charles Babbage, the inventor of a mechanical proto-computer in Victorian London, once declared: "The air itself is one vast library, on whose pages are forever written all that man has ever said or woman whispered."[15]

Let us separate physical from logical permanence of documented information - between the (media-)archaeological monument and the historical document. "The European (Nordic) concept of preservation apparently relies on archival means and methods. To ensure a long term preservation of knoledge the U.S. researchers on the other hand focus on the use of markes or 'monuments' on the sites of the nucelare waste repositories" <Fryksén 1996: 326>.

"Knowledge" in the RKM *Glossary of Key Terms* is defined as "the ability to understand and utilize the available data, information and records". The reader here obviously is meant to be human, but what if future readers are rather "robot historians" (as suggested by Manuel DeLanda)? Let us extend this definition to Karl Popper's "third world of knowledge" as an inherent, physically or mathematically implicit form of knowledge in latency (waiting to be recovered or to be self-revealing (much beyond Polanyi's rather sociological notion of "tacit" knowledge). The alternative model to knowledge tradition thus is co-origin ("Gleichursprünglichkeit"), that is: the emergence of a same (or similar) knowledge anew at any given time, independent of its culturally transmitted knowledge (as indicated by the monumental formulaic "m = E/c^2" inscription at the COVRA nuclear site, The Netherlands which will faint parallel to the nuclear half-time, but implicitely remain intact as natural law).

Charles Sanders Peirce describes diagrammatic reasoning as such: "Similar experiments performed upon any diagram constructed to the same precept would have the same result."[16]

In order to decipher messages sent within the world of techno-

---

[15] The Works of Charles Babbage, hg. v. Martin Campbell-Kelly, Bd. 9: The Ninth Bridgewater Treatise. A Fragment, 2. Aufl. 1838, London (Pickering) 1989, Kapitel IX, 36

[16] Charles Sanders Peirce, Collected Papers, Bd. II: Elements of Logic, Cambridge, Mass. (Harvard UP) 1932, 350 <prüfen!>

mathematical knowledge itself, it requires something like a "robot historian" as defined by Manuel DeLanda in his book *War in the Age of Intelligent Machines* (1991).

- - -

Mathematical knowledge here replaces semiotic decipherment.Semiotics as a branch of communication deals with the study of "the formulation and endoding of messages by sources, the transmission of these message sthrough channels, the decoding and interpretation of these messages by destinations, and their signification" <as defined in Sebeok 1985: 451>.

The "mathematical theory of communication", though, is not concerned with the "semantics" of the transmitted signals; that is why "noise" here is not just a distortion but as well a possible source of information (just like in secret coding).

Nuclear time: radio-active memory

The essence of information is neither matter nor energy; in the RKM *Glossary of Key Terms* it is defined as "organized data that may or may not be recorded on a medium". Still it is dependent of signal embodiment either as matter (invasive "inscription", "record") or as energey (electro-magnetic waves as carrier for modulating radio signals).

Radio-active memory represents a special case which demands for more radical, daring theories and "radio"-based operations of knowledge transmission which is not limited to human understanding excluisvely any more.

Nucelar waste differs from previsously known material artefacts which are meant to be preserved for cultural memory by tradition in that it is matter which actively remains dangerous. This corresponds with a need for active (if not to say radio-active) memory. Active memory is known from the religious context as imperative memory, like in Judaism (*zachor*)[17] and Catholicism ("Tut dies zu meinem Gedächtnis").

In the case of radio-active deposits, we are not dealing with immobile materiality or passive symbolic codes, but with matter which is emits signals actively. Nucelar waste, by definition, is "radio" active; so why not take the radiation itself as basis for continuous signalling? "Every form of physical energy propagation can be used as a channel for conveing messages" <Sebeok 1985: 459>.

Sonification might be an option of indicating the degree of radio-

---

[17] Yosef Hayim Yerushalmi, "Zachor: Erinnere Dich! Jüdische Geschichte und jüdisches Gedächtnis", Berlin (Wagenbach) 1988

active decay itself - and not just "acoustically" coded images as
in the case of the Voyager disc or acoustic records from noises,
sound and ethno-music recorded on earth.

In the case of the copper discs attached to both Voyager space
satellites (launched in August and September 1977) which was
intended to carry messages from the earth to extra-terrestrial
intelligence, the gold-protected aluminium record cover itself has
been not only inscribed with diagrams to visually communicate
information about human civilization but contained (and still
contains, on its voyage in outer space) some ultra-clean Uranium
238 with a radio acticity of abpout 0,00026 mircocurie. Its steady
decomposition into its "daughter isotopes" turns it into a kind of
radio-active clock, with a half live of about 4,51 billion years.
An extra-terrestrial intelligence, by measuring the remnants of
this sample might calculate and infer the time which has passed
since that sample of Uranium had been fixed to the record cover.[18]

This kind of communication rests on natural, not cultural
(arbitrarily coded) laws, on physical invariances - just like the
mathematical formulas engraved and encoded onto the disc cover
attached to the two Voyager satellites in 1977, just like the
Search for Extraterrestrial Intelligence (the SETI project)
involves the networked scanning of radio-astronimical noise to
detect improbable messages inbetween, a future intelligence will
detect such a regular noise pattern.

Present research detects far-distant echoes of the universal Big
Bang - which in fact is tracing re-verberations. Let us take
"radio" in its original, media-archaeological sense, thus turning
its meaning into a tool for knowledge transmission. Radiation is a
form of communication which transmits itself (creating its own
"media" channel, the electro-magnetic waves).

The nuclear time clock (Ernst Jünger)

In his book on the ancient art of time-keeping by sand - the hour
glass - (a critique of the wheel-driven mechanical clock), Ernst
Jünger reminds of tempor(e)alities which transcend the reach of
mechanical clocks.[19]

Geological chronometry counts ultra-long temporal periods from
layers of geological formations. A similar physics-based
chronometry is based on the radiation caused by physical decay.
The notion of "half time" in radio-active matter refers to the

---

[18] Carl Sagan et al., Signale der Erde. Unser Planet stellt sich
vor, München / Zürich (Droemer & Knaur) 1980, 41
[19] Alexander Rose from the Long Now Foundation insists that
mechanical time keeping endures and is reconstructable,
different from electronic clocking devices.

temporal interval in which the activity of a given radionucleid is reduced to its half; that is: half of the atomic kernels have been transformed - while emitting ioniciszing rays - into another nucleid. This temporal interval may range from micro-seconds to trillions of years; according to this range, the measuring tools and methods vary. "Die Erde wird als Uhr betrachtet, von der man die Weltzeit abliest" <200>. Jünger notifies the dialectic re-turn of such "elementary time" in clocks driven by atomic oscillations (quartz, atoms, electrons)[20] - which means measuring time from within the physical world, rooted within its measures and rhythms instead of simply being symbolic, that is: arbitrary cultural enactments.[21]

Depositories of radioactive waste embody a kind of "hot" nuclear clock indeed; the half-time values of radiation decay of uranium itself may serve as a long-time counter which - communicated *as* and *by* radio waves - is the message of the nuclear medium.

---

[20] Ernst Jünger, Das Sanduhrbuch, Frankfurt/M. (Vittorio Klosermann) 1954, 200

[21] "Diese Einheiten sind neu, aber sie sind zugleich uralt <...>. Sie beruhen nicht auf willkürlicher Setzung, sondern auf der Entdeckung kosmischer Rhythmen und Maßstäbe" <Jünger 1954: 202>.