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Living in the Model

The Cognitive Ecology of Time—A Comparative Study*

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Abstract. Time is at once familiar and mysterious, its status in the physical universe being uncertain and contested. Time seems to be fundamental to both biology and to the world of human experience. It seems certain that human beings in all cultures experience time, and have ways of linguistically referring to relations between events in time. It has been proposed by some cognitive scientists that there is a natural, transcultural conceptual domain of time. Cultural conceptions of time, however, vary considerably. I present anthropological linguistic data from a study that my colleagues and I conducted in an indigenous Amazonian community. Concepts of time are cultural and historical constructions, constituted by schematic time interval systems, and embodied in language and culture dependent symbolic cognitive artefacts. "Living in time", I contend, is to live in a model. Time is both artifactual model and cognitive niche, made possible by the wider biocultural niche of language.

Keywords: Amazonia, Anthropology, Cognitive Artifact, Language, Niche Construction, Linguistics, Time

1 Introduction: Time in Cosmos, Life and Mind

Time is familiar, but not something we usually think of as a friend. It is not just that it is part of our everyday lives. Time seems somehow to be above and beyond everyday life, giving it pattern and structure, intermeshing it with the lives of others. The measure of time governs our every waking moment, time is precious, its passage is relentless, what remains of it is ever-diminishing. But time is also mysterious. Its nature, even its very existence, defy consensus in cosmology, physics and philosophy.

Isaac Newton [1] believed time, like space, to be absolute and infinite: "Absolute, true, and mathematical time, in and of itself and of its own nature, without reference

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to anything external, flows uniformly and by another name is called duration. Relative, apparent, and common time is any sensible and external measure (precise or imprecise) of duration by means of motion; such a measure—for example, an hour, a day, a month, a year—is commonly used instead of true time." In this famous passage, Newton asserted the metaphysical reality of Time as an independent dimension of the universe, a position that commanded consent for centuries until challenged, almost simultaneously, in physics by Einstein's Special Theory of Relativity [2] and in philosophy by McTaggart [3]. Newton also availed himself of a metaphor, of the "flow" (or "passage") of the River of Time [4], whose status would later prove as troublesome for relativistic anthropological linguistics as it had for relativistic physics. Benjamin Lee Whorf formulated what he called "The Principle of Linguistic Relativity" [5] on the basis of his analysis of concepts of time and temporality in the Native American Hopi language. The Hopi speaker, he said, "has no general notion or intuition of *time* as a smooth flowing continuum in which everything in the universe proceeds at an equal rate, out of a future, through a present, into a past; or, in which, to reverse the picture, the observer is being carried in the stream of duration continuously away from a past and into a future" [6].

Einstein himself believed time to be an illusion, engendered by consciousness: in the relativistic space-time Block Universe, past and future are equally real, and an objective present does not (and cannot) exist. As Einstein's contemporary, the mathematician Minkowski put it, "Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality" [7].

Not everyone is convinced by the denial of "passage" in the deterministic Block Universe. The reality of the Arrow of Time—the reality, that is, of irreversibility, whether in thermodynamics, in biological evolution or in the individual lifespan—has been invoked by many theorists in defence of the reality of time and the present moment, and of the felt asymmetry of past and future. The idea that the future is as determinate as the past is difficult to reconcile with a fundamental condition of the intelligibility of our social lives: that we are, as agents, accountable for our past acts, but cannot be held responsible for that which we have not (yet?) done.

Unfortunately, the relationship between determinism and indeterminism in physics is no more settled than the problem of time itself. It certainly lies way beyond the scope of this chapter to attempt any resolution of the problem of time in general. My aim is more modest: to explore the way our concepts of time and temporality have emerged in history and culture as fundamental constituents of human cognitive ecology; and to make strange the taken-for-grantedness of these concepts by inviting the reader to view them through the lens of the very different understanding of time in an indigenous Amazonian culture. At the end of this journey in time and space, after our brief encounter with Amazonian time, I will address again Whorf's question of the relation between language and thought; and I will suggest that, seen in the long perspective, it is "our time", not "their time", that stands out as exceptional.

1.1 Finding Ourselves in Time

Whatever its ultimate status in the physical universe, there can be no denying that time is a foundational part of the experiential, phenomenal life-world. It is important, however, to try to distinguish this temporal aspect of experience, which we can perhaps assume to be transcultural, from the highly culturally variable conceptualizations of time that we shall explore in following sections. In particular, in describing temporality in experience, we should avoid as far as possible (or at least be cautious about) the use of metaphors, not just of "flow" and "passage" (which imply motion "in time" analogously with motion in space); but also of stative "location in time". The reason for this prescriptive injunction will be become clear: it is not transculturally, we shall see, the case that time is conceptualized as spatial, or as being "like" space.

Time as experienced is made up of the properties of events, which have two basic, perceptible aspects: duration and succession (or sequential order). Duration is temporal extension. Succession is temporal position. In stating this, we are, indeed, immediately inviting, if not relying on, an analogy between duration and spatial extension, and succession and spatial position (in front/behind, before/after). The analogy between temporal succession and spatial order was, of course, the basis for McTaggart's famous distinction between two temporal series, the 'A'-series and the 'B'-series [3]. Events, then, are in some respects like objects; but they are also different. Objects are located in space, and endure, however fleetingly, in time. They have properties like mass and energy. Events are "located" in time, as well as in the space occupied by the objects involved in the event, having properties of duration and succession. Furthermore, we employ temporal (event) landmarks to orient ourselves in time, just as we employ spatial (object) landmarks to orient ourselves in space. However, while spatial landmarks are employed in the service of literal navigation in space, involving physical motion, we cannot physically travel in time, and our temporal navigation is entirely conducted in the mind and in linguistic discourse.

Temporal duration words include adjectives such as "long" and "short", but also measured time intervals such as "ten seconds" and "four months". Temporal landmarks include adverbials such as "today", "yesterday" and "tomorrow", but also named times of day (midnight, three-thirty), dates (22nd June) and other calendrically structured events (Easter, my birthday, Graduation day). We can take as our starting point the plausible-seeming hypothesis that all human beings, transculturally, experience events and inter-event relationships in terms of duration and succession [8]; but that the particular words and concepts denoting temporal duration and temporal landmarks, although they may be based in universal human experiences such as awareness of the diurnal cycle, are based in specific cultural and civilizational traditions, and to that extent are language and culture-specific.

2 Concepts of Time in History and Culture

2.1 The Clock and the Calendar

A striking exemplar of a medieval clock is shown in Figure 1. Such clocks can be found throughout North-West and Central Europe.

Fig. 1. A medieval clock in Lund Cathedral

Early church and cathedral clocks lacked faces, and sounded the hours by the ringing of bells [9] but later ones incorporated clock faces schematically representing cyclic time intervals—in the case illustrated, not only the hours of the day, but also months and years. The circular form of the clock face iconically represents the cyclic schema which organizes the numerically (ordinally) based time intervals. Although clock hours and calendar intervals are a much older invention than the mechanical clock itself, dating to the Babylonian civilization, these time intervals were dependent upon number notation, as well as upon the astronomical observations measured and notated. Number notations themselves are derived from linguistic number systems whose origins are to be found in counting practices.

It is well known that the cultural dissemination of "calendar time" (which was important in the computation of saints' days), and later "clock time", had profound effects upon medieval and early modern European societies, enabling the accurate determination and registration of both religious festivals and working time [10]. What is perhaps less appreciated is the extent to which the invention and cultural evolution of the calendar and the clock have transformed human cognition, not least by constituting a novel cognitive domain of abstract "Time as Such" [11, 12]. By this, I mean precisely that notion of time, familiar to us as much as it was to Isaac Newton, that metaphorically situates or encompasses the events that occur "in time", and their time of occurrence, analogously to the way that space situates or encompasses objects and their locations.

The universality of concepts or categories of space and time has been a key trope of Euro-American thought since the philosophical reflections of Immanuel Kant [13]. Present-day cognitive science has adopted this hypothesis (although, in many cases, the hypothesis has been more of an unexamined assumption), postulating the existence of a universal cognitive domain (TIME) that (equally universally) recruits its structuring resources from the cognitive domain of SPACE. However, as I have argued above, although both the phenomenological experience of time, and the linguistic encoding of temporal inter-event relationships in lexicon and grammar, may be supposed to be human transcultural universals, the cultural conceptualization and linguistic expression of time intervals (that is, lexicalized concepts of intervals of temporal duration) is widely culturally variable. Much anthropological linguistic research has addressed variability in calendric systems, and in the social practices of "time reckoning" [14, 15] that are dependent on, and realized through, such calendric systems. There has also, however, been another largely unexamined assumption that has informed this research: that however much they may vary, time interval systems are in all cultures cast as some kind of recurrent calendar.

2.2 Time Interval Systems, "Passage" and Space-Time Metaphor

Numerically based calendric systems can be regarded as organizing *Time-based time intervals.* Time-based time intervals (such as "Clock Time" and "Calendar Time") are those whose boundaries are constituted by the segmentation and measurement of "Time as Such". Examples of Time-based time intervals are hours and weeks. Although time-based time intervals are based upon natural (astronomical) cycles of events, they are conventional and their duration is derived from counting in a number system.

Time-based time intervals can be distinguished from *Event-based* time intervals. Event-based time intervals are those whose boundaries are constituted by the event itself. In this sense, there is no cognitive differentiation between the time interval and the duration of the event or activity which defines it, and from which in general the lexicalization of the time interval derives. The reference event is often natural (such as 'spring', eg "let's take a holiday in the spring"), but sometimes conventional (such as 'coffee break', eg "let's discuss this during coffee break"). The event-based time

interval may be characterized as a change of state (eg 'sunrise'), as a stative event attribute (to use an example from the Amondawa language discussed below, the word *ara* means 'daylight'); or as an activity. The lexicalization may be metonymic or 'pars pro toto', as in Amondawa *pojiwete*, 'when we start work, morning' [16].

Expressions such as "let's take a holiday in the spring", employing locative prepositions to situate one event in temporal relation to another event, are ubiquitous in Indo-European languages. Not only prepositional constructions, but also verbs of motion are employed to conceptualize and express events in time, and their relationship to other events, and the experience of subjects in relation to events. "The summer passed quickly", "your exams are coming up" and "her vacation is approaching" are examples of linguistic constructions in which events "move" along a time line with respect to the phenomenological "now" of the experiencer (the speaker, the addressee or a third party, respectively). A different construction type conceptualizes the experiencer as moving along the time line with respect to static or fixed events, as in: "I left the things of childhood behind", "you are coming up to your exams", "he is past his prime". Constructions of the first type have been called "Moving Time", and of the second "Moving Ego" [17].

Moving Time and Moving Ego constructions are two variants of what we might call the generic, metaphoric "Passage Construction". Passage constructions can be used with reference to either Event-based time intervals ("the summer has gone by") or Time-based time intervals ("the Friday deadline is approaching"). Not only prepositional and other locative constructions for talking about time and temporal relationships, but also Moving Time and Moving Ego constructions have been found to occur in a wide variety of the languages of the world [18]. It has been suggested that this prevalence of using terms and constructions whose primary, more basic meanings relate to spatial location and motion, to express concepts of time and temporal relations, attests to a human cognitive universal. Fauconnier and Turner [19], for example, claim that "Time as Space is a deep metaphor for all human beings. It is common across cultures, psychologically real, productive and profoundly entrenched in thought and language." It is this strong universalist claim that Whorf anticipated and challenged, at least with respect to the "Passage" metaphor and its linguistic expression, in his analysis of the Hopi language. It is a claim that is also thrown into question in the light of research my colleagues and I carried out on concepts of time, and the language of space and time, in the culture and language of the Amondawa, an indigenous Amazonian community speaking a Tupi Kawahib language [11, 12].

2.3 Time in the Amondawa language

Our findings can be summarized as follows. First, we found that the Amondawa language has a rich variety of lexical and grammatical resources for conceptualizing and expressing spatial relations and spatial motion [20]. Amondawa employs a system of locative postpositions with meanings not unlike those of English or French locative prepositions. It expresses spatial motion in a way more akin to Romance languages such as French or Spanish, than to Germanic languages such as English or German,

using “path conflating” verbs of motion like *sauter*, rather than generic motion verbs with satellite particles, such as *go out* [21]. Although some interesting features of the Amondawa language led us to propose modifications of previous linguistic typologies of spatial motion, the language presented no characteristics that were radically different from those described for other languages and language families. It certainly could not be maintained that the language of space in Amondawa, and the resources afforded by it for conceptualizing and expressing spatial relations and spatial movement, is in any respect impoverished in comparison with, say, English or Italian.

Our findings regarding the language of time in Amondawa, however, presented a startlingly different picture. Our data suggest that this language presents a counter-example to the often-assumed universality of space-to-time metaphoric mapping. Amondawa speakers who are bilingual in Portuguese, while able to understand space-time metaphoric constructions in Portuguese, insist that such constructions do not exist in Amondawa, even though the equivalent spatial motion constructions exist [11]. We established in our research that the non-existence in Amondawa of space-time metaphoric constructions is not a consequence of their being ungrammatical; nor is it a consequence of a generalized lack of metaphor in the language. Rather, it seems that space-time metaphorical mapping has simply not emerged, or been “invented”, in this language. Why might this be the case?

Other findings, relating to time interval concepts in Amondawa, may hold the clue as to why space-time metaphors are absent in the language. The first thing to note is that Amondawa is one of many Amazonian languages that are known to have very restricted number systems. Small number system languages generally lack numerals above four of five; Amondawa is typical of such languages, in having only four numbers, with larger numbers being indicated by lexical and intensifying variations on words meaning “many”. Clearly, a calendar of the kind that we are familiar with, involving weekly, monthly and annual day counts, simply cannot be constructed in a small number language such as Amondawa. Unsurprisingly, therefore, Amondawa lacks a calendric system in which days of the week or months of the year are enumerated.

More surprising, however, is the complete lack in Amondawa of names for the basic lunar and/or solar time interval units that are often considered to be transculturally universal: weeks, months and years. Amondawa has no words for any of these time intervals, all of which, when enumerated, are what I called above Time-based time intervals. As far as we could establish in our investigations, the only time interval units based on natural cycles in Amondawa are day, night and the two seasons, dry and rainy. There is no superordinate “year” in Amondawa, composed of a dry season/rainy season combination.

None of this means that the Amondawa life world is one in which time is absent. The language, while it lacks (like many other languages) a verbal tense system, possesses a nominal aspect system that can mark objects as having a certain status belonging to the past or future (rather as in English, for example, we can talk about an “ex-husband” or a “wife-to-be”). Furthermore, events can be designated as occurring

in the future or the past relative to a deictic present, similarly to English "yesterday" or "tomorrow", and "then"; one event can be expressed as being co-temporaneous with another; and narrative sequences can inter-relate events sequentially. Nonetheless, even if the Amondawa have a similar phenomenological *experience* of time as a "passing" of events, and even if for them, as for us, duration is a fundamental quality of experience, it seems that they do not *think about* or *talk about* time in the same way that "we" (inheritors of a millennia-long tradition of time measurement, and of the progressive implementation of the clock and calendar as fundamental regulators of social life) think about it and talk about it.

Perhaps the most important clue to this difference is that there is no word in Amondawa translating or corresponding to English *time*, or Portuguese or Italian *tempo*. Amondawa lacks not only Time-based time intervals, but also an abstract concept of time, or what I have called above "Time as Such". What I am suggesting is that the absence of enumerable, Time-based time intervals in Amondawa, and the corresponding absence of a calendar, amount to the absence of a symbolic cognitive model [22] that culturally and historically potentiates the invention (or cultural-historical construction) of the cognitive-conceptual domain of "Time as Such".

The consequence is that the concept of 'time' has no lexicalization, and the schematization of the domain of time as motion through an imaginary and metaphorical "space", either cyclical or linear, a schematization that appears to us natural and self-evident, is absent from the Amondawa repertoire of cultural schemas. In short, the conceptual domain of abstract and reified "Time" is not a human cognitive universal, but a cultural and historical construction, constituted by schematized time-based time interval systems, reflection upon which is language and culture dependent.

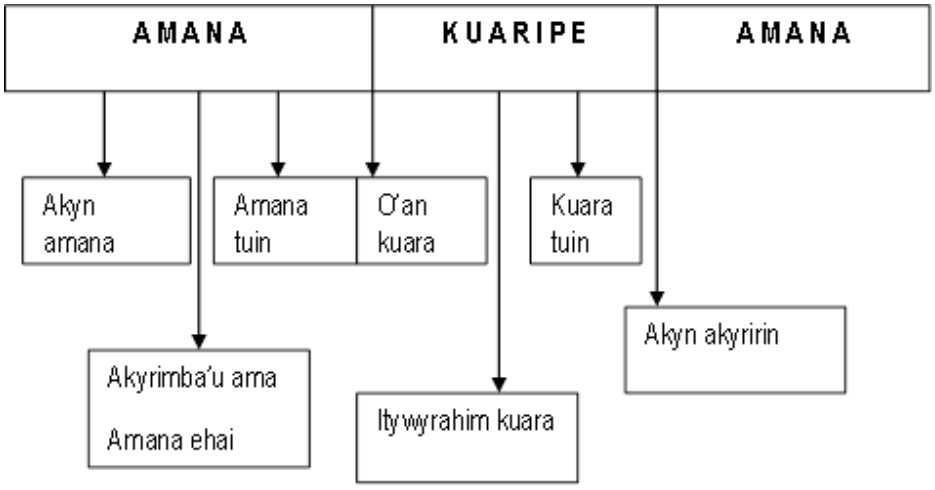

Fig. 2. The Amondawa Season Schema: a rectilinear depiction of a speaker's sequence

Once again, we should not mistake the absence of a specific mode of domain-constituting schematization for a generalized lack of cultural schemas for time intervals. Amondawa does indeed have a system of seasonal time intervals, with 3 sub-intervals embedded in each of the two superordinate seasons, 'Amana' (*rain* = rainy season) and 'Kuaripé' (*in the sun* = dry season). The subdivisions correspond to the beginning, middle and end of each of these seasons (Figure 2).

Neither should it be supposed that Amondawa speakers are incapable of, or especially resistant to, making mappings between temporal and spatial schemas. Figure 2 is based upon a spatialization task that we carried out with Amondawa speakers, in which they placed paper plates representing seasonal sub-intervals on the ground [11, 12]. Participants had no difficulty in completing this task, although their representations were curvilinear rather than rectilinear.

Subdivisions of the day are based upon activities that typically and normatively take place at certain times. Although the Amondawa are attentive to the position of the sun at different times of the day, these positions are indicators of socially-structured time intervals, rather than points or positions in a count series. Interestingly, Amondawa participants rejected the circular, or cyclical, depictions of their day/night schema shown in Figure 3, presented to them by researchers, as being incorrect representations.

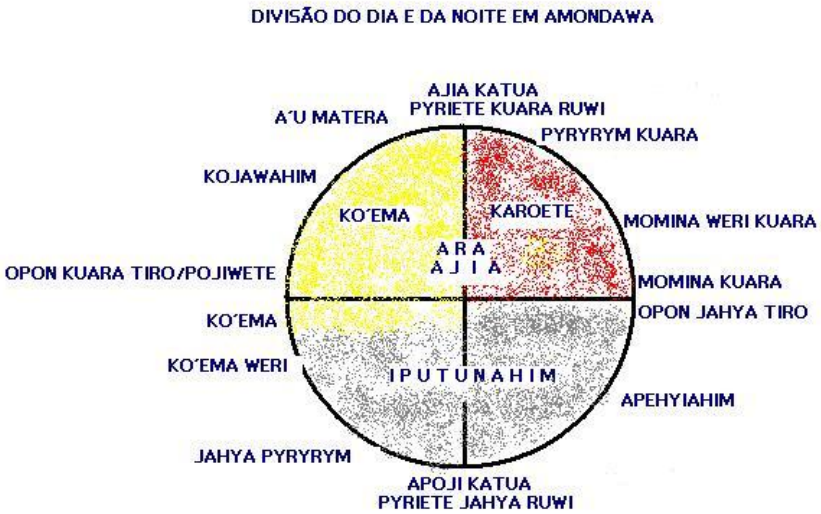

Fig. 3. Divisions and subdivisions of day in night in Amondawa: a cyclical representation rejected by Amondawa speakers

It is also interesting to note, from the point of view of indigenous theories of human development, that in the absence of a large number system, the Amondawa do not entertain cardinal chronologies such as ages of individuals. Life stage changes are

marked by individuals changing their proper names, in an onomastic system involving the adoption of names from an inventory that marks not only "age" (life stage), but also gender and moiety (sub-clan) affiliation [11, 12].

In summary, time, in the Amondawa language and culture, is based not on countable units, but on social activity, kinship and ecological regularity. The absence of artifacts such as clocks and calendars, I suggest, is the motivating reason behind the absence of the cultural-cognitive concept of 'Time as Such'; and it is in the absence of these artifacts that we should also seek the reason for the absence of space-time metaphoric mapping in the Amondawa language.

Although this interpretation of these research findings remains, at this stage, a hypothesis, it is consistent with account Benjamin Lee Whorf's account, cited in Section 1, of conceptions of time in the Hopi language and culture. He claimed, recall, that the Hopi speaker "has no general notion or intuition of *time* as a smooth flowing continuum in which everything in the universe proceeds at an equal rate, out of a future, through a present, into a past; or, in which, to reverse the picture, the observer is being carried in the stream of duration continuously away from a past and into a future." In other words, Whorf claimed that Passage (Moving Ego and Moving Time) construals of time were absent in Hopi, just as we claim that they are also absent in Amondawa.

Such effects of language and culture on thought in no way imply an absence of universal cognitive capacities [23]. In fact, our data clearly demonstrate that even when entrenched, habitual, regular linguistic space-time mapping is *absent*, the cognitive capacity for construing temporal concepts in terms of spatial arrays is present in Amondawa speakers; indeed the tasks that we administered *depend upon* the language informants' capacities to make such construals. The explanation we have advanced quite explicitly does *not* propose any generalized absence of the capacity for cognitive space-time mapping on the part of speakers of Amondawa (or any other human group).

In short, the hypothesis my colleagues and I are advancing is that the cognitive domain of "Time as Such" is not a transcultural universal, but a historical construction based in social practice, semiotically mediated by symbolic and cultural-cognitive models for time-based time interval reckoning, and subsequently entrenched in lexico-grammar. Linguistic space-time mapping, and the recruitment of spatial language for structuring temporal relations, is consequent on the cultural construction of this cognitive and linguistic domain. In the consolidation of constructive process, the invention and perfection of certain kinds of artifacts, clocks and calendars, has been of fundamental importance. Clocks and calendars, I shall now argue, exemplify a more general class of artifact that has been of fundamental importance in the evolution of the human cognitive niche [24, 25].

3 Symbolic Cognitive Artifacts

Language, as many authors have maintained, is grounded in embodied interactional relationships between developing human organisms and their material, social and symbolic surround. Language, and the cultural practices and processes that language supports, are traditionally designated in anthropology and archaeology as symbolic culture, in contradistinction to the ensemble of human artifacts that make up material culture. This dichotomy between material culture and symbolic culture has had the unfortunate consequence that the meaningfulness and social-cognitive agency of the world of material, artifactual objects has been under-investigated [26]. As I shall demonstrate in this section, all artifacts have semiotic, as well as physical, properties. I will go on to argue that language is not only grounded in human interactions with material culture, but is also the symbolic ground of a special subclass of artifacts that I designate **symbolic cognitive artifacts**. This subclass can be defined as comprising those artifacts that support symbolic and conceptual processes in abstract conceptual domains, such as time and number.[1]

Examples of symbolic cognitive artifacts are notational systems (including writing and numeric notations), dials, calendars and compasses. Symbolic and/or cognitive artifacts [31] have been plausibly proposed as key components of human cognitive evolution, in virtue of their status as external representations of cultural and symbolic practices [32], and embodiments of the "ratchet effect" [33] in cultural evolution. While not demurring from this perspective, I will attempt to advance the argument further, by proposing that symbolic cognitive artifacts have the status of agents of change in cultural-cognitive evolution, and are not mere repositories of prior changes in practices and cognitive structures and strategies. Cultural and cognitive schemas organizing at least some conceptual domains (including that of time) may be considered, I shall argue, as *dependent upon*, and not merely expressed by, the employment of symbolic artifacts in cultural and cognitive practices.

3.1 Artifacts, cognition and signification.

All (human) artifacts are cognitive, inasmuch as they embody human intentionality [28, 34]. However, the semiotic properties of artifacts have received scant attention. In general, artifacts have the following characteristics:

- Artifacts are made, not found. Although found objects may be used as tools, as with for example the sticks that chimpanzees use for "fishing" termites; or as constituents of artifacts, as with stones used by humans to construct dwellings and walls, artifacts (including artifactual tools) are produced by labor.

[1] "Symbol" and "symbolic" are notoriously polysemous and contested concepts. In accordance with Karl Bühler's classification [27], symbolicity is here understood in terms of the semiotic, pragmatic and intersubjective logic of communicative representation [28, 29], not on the typology in the Peircian sense [30] of the relationship between sign and object.

- Artifacts embody intentionality, conceptualization and imagination. An artifact is made according to a plan or design that involves the conceptual or imaginative representation by the maker of the finished article. It is this characteristic that distinguishes true artifacts from quasi-artifacts, and as far as we know the only species that produces true artifacts is homo sapiens, or as our species has also been aptly named, *homo faber*.

- Artifacts have canonical functions [28] that are physically realized in the design features (or culturally produced affordances) of the artifact. The canonical function of an artifact is equivalent to the use value [35] for which it was designed: its socially-standard function. Non-artifactual (natural) objects or materials (such as wood or stone) may have use-values, but only artifacts have canonical functions. The canonical function of the artifact is embodied in the artifact. For example, the canonical function of a knife is to cut, the canonical function of a cup is to contain. The artifact can therefore be seen as embodying functional or relational concepts, such as CUTTING or CONTAINMENT, and these concepts are precisely those that are the objects of the design intentions of the maker.

- Artifacts signify their canonical function to a user who has the cognitive capacity to recognize the artifact as a token of a particular type [36]. The mode of signification that is intrinsic to the artifact is that of "counting as" [37]. For example, a particular object (token) counts as a cup (type) if the perceiving subject recognizes the design features of the object (being a solid of a certain size and shape, having a cavity affording containment) as being those of a cup. This recognition of the signification relationship of "counting as" is a case of "perceiving as"—the subject perceives the object *as* a cup. If the object is not perceived as a token of a type having a canonical function, then it cannot be said to count as that type for the subject.

- To count as a type of artifact it is necessary for an object not only to afford the canonical function of the type (eg containment), but for this to be the intentionally designed canonical function of the token. For example, a half coconut shell can be used as a cup, but that does not make it a cup, unless it is intended to count as a cup, by virtue either of context or of baptismal naming.

- The counting as relationship, and the canonical function that defines the artifactual type, are normative and cognitive. They are aspects of normative and socially complex cognition. Canonical function depends upon, but is not reducible to, the physical properties of the object, since it is only by virtue of some subset of its physical characteristics (those that enable the object to be perceived as and used as a token of the artifactual type), and of their signifying value for the subject/agent, that the object counts as that artifact. We can thus compare artifacts with "institutional facts" [37], such as that a person is someone else's sister-in-law, a social relationship that is also irreducible to the properties of the person's physical body.

The characteristics listed above make it clear that artifacts are cognitively and semiotically complex. Artifacts (ranging from tools and vessels to notations and images) can be "read" (in the sense of "perceived as"), but (unless they are textual artifacts) they are not texts.[2] The canonical functions that are served by artifacts are diverse, since they may be implicated in a wide range of cultural practices, both sacred and profane, including ritual, ornamentation, representation and narration, as well as technology. Artifacts can support both non-representational practices (such as cutting and sewing) and representational practices (such as drawing and signposting). Although not all artifacts are representational (bear in mind that artifacts do not represent, or *stand for*, their canonical function, rather they *signify* it by *counting as* the type defined by that function), some artifacts (such as pictures and texts) are representational, embodying the semiotic "standing for" function in addition to the counting as function.

My prime concern here is with technological artifacts, that is tools or tool complexes, whose canonical functions involve the amplification of the natural physical and/or mental powers of the agent – "Conceptualization of artifacts is a form of empowerment" [36] p. 311. Technologies may be classified in terms of the different kinds of powers that they amplify: motor (e.g. the hammer); perceptual (e.g. the telescope or telephone); or cognitive (e.g. the abacus). There is also, however, a further dimension in the typology of technological artifacts, namely the dimension of augmentation *vs* constitution of the powers of the agent. Some technologies amplify the powers of the agent by augmenting already existing capacities and practices. For example, a bow and arrow augments the muscular power of the agent, enabling the arrow to be projected further and with a higher velocity than would be possible by throwing. Other technologies amplify the agent's powers by potentiating and constituting entirely new practices. For example, a needle and thread potentiate sewing, a practice that would be impossible without the use of the technology, which can therefore be considered as constitutive of the practice.

The comparison between signs (including the signs of language) and tools has often been made. Karl Bühler [27], influenced by the functionalism of Prague School linguistics, proposed the Organon (Greek=tool or instrument) Model of language. Lev Vygotsky [38] also viewed signs as instruments, not only enabling communication between individuals, but also transforming intra-individual cognition. Lev Vygotsky regarded the analogy as resting on the fact that both sign and tool support mediated activity; but he also distinguished between their modes of mediation in that, while tools are "outer directed", transforming the material world, signs are "inner directed", transforming and governing mind, self and behavior [38] pp. 54-55. Vygotsky emphasized the importance of semiotic mediation in transforming cognition and cognitive development, focusing on the internalization of conventional signs originating in contexts of discursive practice. He attributed great importance to the formative role of language in the emergence of "inner speech" and "verbal thought", but his employment of the concept of semiotic mediation also encompassed the use of non-

[2] This is an important *caveat*, distancing this analysis from post-modernist theories.

systematic signs, including objects-as-signifers. He paid little attention, however, to the role of culturally produced, linguistically grounded symbolic cognitive artifacts.

Although I do not wish to advocate a unicausal technological determinist view of history, it is important to note that the socio-cultural consequences of practice-constituting technologies, and combinations of technologies, may be profound. Benedict Anderson [39] discusses the emergence in the 16th-17th centuries of what he calls "print capitalism". Mercantile capitalism based upon trade was not new, but the rapid dissemination of information made possible by print media, such as shipping lists and newspapers, potentiated the emergence of the limited stock company, a new institutional form that transformed the world, ushering in the first era of economic globalization.

We might refer here, too, to the rather earlier invention of double-entry book-keeping as an accounting device permitting accurate recording and balancing of profits, losses, liabilities and assets. Double entry book keeping is a good example of the specific kind of artifact that I have referred to above as a symbolic cognitive artifact, the fundamental form of cognitive technology. Double entry book-keeping is a technique for the ordering of symbolic (numeric) information, in such a way that it permits the checking and auditing of accounts. It is not only desirable for individual traders, but it also provides necessary evidential support for the trust-based interpersonal relations involved in joint financial enterprises. Like other symbolic cognitive artifacts, it is a tool for thought [40] that is transformative of both the individual mind and the shared, intersubjective mind.

To qualify as symbolic, an artifact must have a representational function, in the Bühlerian sense. All artifacts, as I pointed out above, have a signifying status, inasmuch as they functionally "count as" instances of the artifact class of which they are a member, to use Searle's expression [37]; and their material form signifies their canonical function [41, 42]. However, to be a *symbolic* artifact, the artifact must also represent something outside itself, through a symbolic sign function realized or embodied in the artifact. All such sign functions are ultimately grounded in language, although, as we shall see, they also frequently incorporate iconic relations.

The class of symbolic cognitive artifacts can now be defined as comprising those artifacts—which may either be entirely symbolic, such as number systems, or may embed or "anchor" symbolic information in material structures, such as dials [43]—that support symbolic and conceptual processes in abstract conceptual domains. Examples of symbolic cognitive artifacts are notational systems (including writing and number), dials, calendars, clocks and compasses. A key property of symbolic cognitive artifacts is thus that they are both linguistically grounded and conventional. Symbolic cognitive artifacts may be motivated by natural facts, and the human phenomenological experience of these facts, (eg the orbit of sun or moon; the number of fingers on a human hand), but they are not determined by them (witness, for example, the variety of arithmetical bases for number systems).

To return to Vygotsky's distinction, symbolic cognitive artifacts are both "outer" (or world) and "inner" (or mind) directed. They are tools that afford and augment human interactions with the natural and social world; and they are simultaneously signs that mediate those interactions (Fig. 4). Intentionally designed symbolic cognitive artifacts, just as much as language, are constitutive parts of the human cognitive niche, and are of fundamental importance in human cultural-cognitive evolution. They are special instances of the *extended embodiment of cognition* [44]. The symbolic systems and conceptual schemas that they support permit the socio-cognitive practices (and the reproduction of these practices through inter-generational transmission) constituting a segment of the life world of individual and group [45]. The invention and use of symbolic cognitive artifacts is a crucial (and species-specific) aspect of the "ratchet effect" [33] in human cultural evolution.

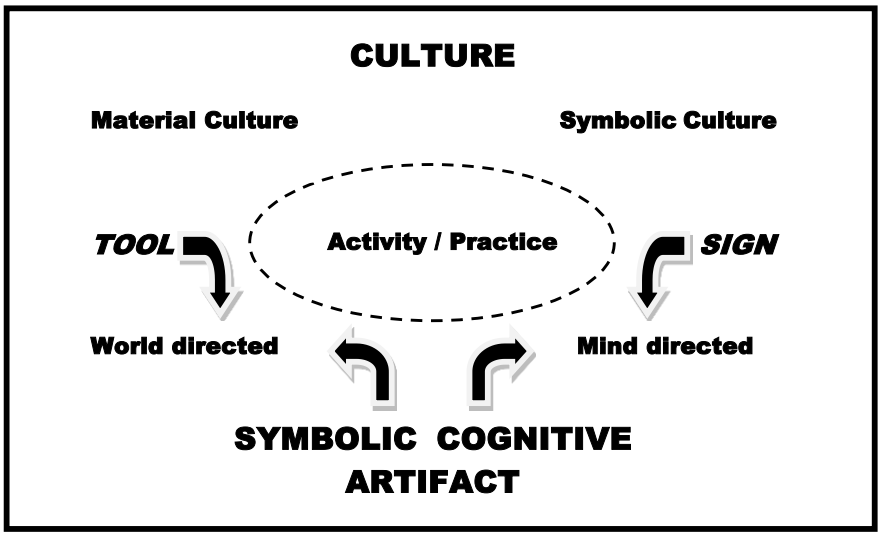

Fig. 4. The bi-directionality of mediated action employing symbolic cognitive artifacts.

3.2 Language as a biocultural niche and the evolving human semiosphere

Language is the primary and most distinctive constituent of what the Russian semiotician Yuri Lotman called the "semiosphere" [46]: the universe of signs. Signs, as we have seen, are both transformative cognitive tools, and constitutive of specifically human cultural ecologies. The semiosphere can also be viewed, from the perspective of niche construction theory [47], as the semiotic dimension of the human biocultural complex. The self-constructed human biocultural complex both favoured, in prehistory, the emergence and elaboration of language [48]; and, because language is co-constitutive of that niche itself, was fundamentally transformed by language into a symbolic biocultural complex, or semiosphere, introducing a fundamental disconti-

nuity with non-human cultures. This discontinuity has been amplified by the consolidation, through language, of human culture as a fundamentally symbolic order.

Language as a biocultural niche is developmentally and processually interdependent with the "technosphere" of material artefactual supports for acting and for learning through social interaction and social practice. The human semiotic capacity, in collaborative synergy with human constructive praxis, has been the fundamental driving force, in the prehistoric and historical time scale of sociogenesis, of the evolution of human culture and extended human embodiment through the synergistic interplay of semiosphere with technosphere. As Merleau-Ponty put it, "The body is our general medium for having a world … Sometimes the meaning aimed at cannot be achieved by the body's natural means; it must then build itself an instrument, and it projects thereby around itself a cultural world" [50], p. 146.

This does not imply any need to postulate universal, pre-determined evolutionary pathways. Rather, we need to situate language and cognition in the social ecology of what Pierre Bourdieu called *habitus*: "a subjective but not individual system of internalized structures, schemes of perception, conception and action common to all members of the same group." A crucial component of *habitus* is constituted by the cognitive symbolic artifacts which, both *grounded in* and *grounding* language structure and language use, serve to develop and expand the uniquely human semiotic biocultural complex.

4 Living in Time: Inhabiting and Co-habiting Habitus

In speaking and thinking about model-based thinking and reasoning, we tend naturally to adopt a kind of mediated intentional stance: we try to understand how understanding the model will help us to understand the domain that is modeled, that is, the domain that the model is "about". This domain, we suppose, is in most cases and to varying extents mind-independent, or at least model-independent. Whatever the criteria of adequacy we favor—correspondence, or pragmatic optimization, or coherence with other models—we tend to think of adequacy as approximation to a best fit between model and domain, and of ourselves as independent arbiters of this best fit, standing outside the model-domain relation.

In the case of the time interval systems of clock and calendar that I have addressed in this article, these assumptions simply do not hold. The time that we inhabit is an artifact, a fiction in a way, which is itself the product of the artifacts that our ancestors have invented. Time, we might say, is a cognitive meta-niche, a necessary regulative order for the reproduction of the multiplicity of other cognitive-cultural-material niches that support our activities, practices, communications and reflections. But it is also a cognitive construct, assembled through the spatialization and reification of temporal experience. As Newton pointed out, our secular time-based time interval systems are themselves, ultimately, event-based: clock time and calendar time are derived from the actual motion of celestial bodies. However, when employed to regu-

late social and economic life, clock and calendar impose a fictive and conventional structure on mundane, terrestrial event time, "freezing" temporal passage into regimes of activity-mapping and time-planning.

The reifying fiction of "Time as Such" is further entrenched in linguistic structure, in "Passage" constructions, and idiomatic usage, in which "time is money", "time is scarce", people are time-poor, and time endlessly presses up against us. The symbolic cognitive artifacts of clock and calendar have changed our minds along with the niches our minds inhabit, and there is no going back in time. And yet, a moment's reflection will tell us that the event-based habitus of the Amondawa, however strange it seems to us when we first encounter it, is the one that has formed the matrix of temporal experience for most human societies. Human beings have lived in small-scale, face-to-face, technologically simple societies for most of the history and prehistory of our species. It is our fast-tracked, globalized, 24/7 turbo-capitalist society that is the exception; and it is we who live by, and have internalized, its insistent imperatives and mind-forged deadlines who are the real (speed-) freaks. Artifactual Time as Such has colonized the niche, and the niche in turn has colonized our minds.

Is that last sentence, too, just a metaphor? If symbolic cognitive artifacts have the effect (as I have argued) of changing both world and mind, is it enough to think of them as mere "tools" for the realization of human deliberative intention, or are they themselves agents? Many discussions of distributed and extended cognition focus on the effects of artifacts on cultural evolution in terms of the externalization of information storage, and the enhanced accuracy of transmission of knowledge and social memory. I would argue that this, while important, is not the whole story. Symbolic cognitive artifacts are not just repositories, they are also agents of change, constituting new domains and potentiating new practices. We can acknowledge that the agency of artifacts is ultimately dependent on human agency, without which artifactual agency would neither exist nor have effect; but it would be wrong to think of artifactual agency as merely derivative, as being like a kind of glorified transmission-belt for human agentive intention. Artifactual agency, I suggest, at least in some cases, is *co-agency*. Co-agentive artefacts play an ever-expanding role in the human biocultural niche, and this poses a real challenge both to our understanding of the nature of knowledge and to our understanding of the nature of ethical and social responsibility in science.

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