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Cover Page Footnote

I am thankful to two ‘blind’ reviewers and to Dr. Priscilla Spears, in particular, for their comments and suggestions.

"Time is a game played beautifully by children." ~*Heraclitus*

Children's Imagining and Understanding of Time: A Montessori Perspective

Cynthia Brunold-Conesa*

Introduction

In the words of J. J. Piaget quoted by Sauer (2019): "*Is our intuitive grasp of time primitive or derived? Is it identical with our intuitive grasp of velocity? What if any bearing do these questions have on the genesis and development of the child's conception of time*?"

To echo Piaget's query in simpler terms: How does a young child understand the concept of time? They know, for example, what "time to leave for school," "time for lunch," and "bedtime" signify in terms of known or well-rehearsed schemas and in *syncretic* fashion (Piaget, 1946; Werner and Kaplan, 1963; Friedman, 1978). For Werner and Kaplan (1963), the process of understanding "time" from clusters of events associated with daily tasks (Piaget's *schemas*) is intimately felt as a *syncretic* or wholistic (subjective) experience, only later in development understood abstractly (*discrete,* or objective thinking). The development of an understanding of "time" corresponds to Werner's and Kaplan's (1963) process of "*distancing*," or increasing separateness of a nascent 'self' from the environment.

Gruber's, Block's, and Montemayor's (2022 and in this issue) distinction, explication, and final synthesis between the *veridical* and an *illusory* nature of time is pertinent to philosophical and cognitive distinctions between objective and subjective time. These distinctions, when understood and applied to curriculum development, make the difference between effective and extemporaneous, off-the-cuff approaches where in the latter little thought is given to the importance of children's understanding of time—how it develops.

Along this developmental continuum, some children spontaneously intuit or learn, to varying degrees, that the almost imperceptively moving hands on a clock or the changing numbers in a digital display somehow represent that time is moving, although they might not necessarily understand the concept of the *passage of time*. Most young children understand what is meant by now, later, yesterday, today, and tomorrow. (Specifically, Piaget thought (1946) that time and space correlated, in a conjoined perceptual manner, so that early insights about the passage of time could be inferred from the actual motions of objects in space.) But the notion of a week, a month, or a year might be more difficult to grasp, and time measurements like century, age, epoch, period, era, and eon are so far beyond a child's life experience that they are unimaginable at certain stages of development.[1] The coming and going of primary care figures, early on in development, or the passing of time in daycare, is mostly *syncretically* experienced (Zvonkovic, Swenson, & Cornwell, 2017):

[1] To the extent that some adults may never reach Piaget's theorized *Formal Operations Stage*, abstract thinking, then one can appreciate why some subjects and concepts in science dealing with, for example, geological time, may remain difficult to grasp even in adulthood.

> This research demonstrates difficulty children experience, as they hold close to loving their parents and feeling that they have a good quality relationship with their parents, yet they acknowledge that they want more time with their parents and sometimes express uncertainty about how much their parents value the time with them. The poignancy of the contrast between the family image we hold and the way children experience family time is illustrated in this research.

However, in older children, nascent ideas about "time telling" or the practical application of timelines to multiple subject areas becomes a constructivist and associative nexus for collating a multitude of facts that otherwise might seem out of context and piecemeal—chaotic even.

Montessori Education: Timelines

The scientific understanding of natural processes is underscored by ideas of relative temporality, timing, abstracted time, and inferred time. To borrow from the previously cited authors, one can approach "knowing" nature from veridical (objective) or illusory (subjective) perspectives. With these differences in mind, it is easier to recognize when children (and adults) are making *illusory* errors of time, for example a *telescoping effect* (*backward* and *forward*), respectively, judging recent events as having taken place in a deeper past than veridical confirmation suggests, or judging deep past events as having occurred more recently (Janssen, Chessa, & Murre, 2006).

In order to optimize and assist with the natural development from *syncretic* (subjective) to *discrete* (objective) forms of thinking, children in the Montessori classroom are introduced to the concept and passage of time through the use of timelines—an essential material in the Montessori classroom and a central component of the curriculum.[2] From the Early Childhood years through Elementary, timelines are used by the child in their studies of biology, geography, geology, history, and even math and language. Let's take a closer look.

Beginning in the Early Childhood years, the child may construct a linear depiction of their personal history with one photo from each year of their life. These are often shared during birthday circles. This is a *syncretic* exercise with only minimal allusion to abstract time—a personal timeline. As other children create and share their own timelines, children begin to notice similarities, like how several children learned to walk at age one, or began school at age three. Through these experiences, children get a sense of human growth and change, thereby visualizing the passage of time through the lens of their personal development. Children at this age may also begin to learn the days of the week and the months of the year.

In the Elementary years, children may continue their personal timelines, learn to "tell time" from clocks, and solidify their understanding of the days of the week and months of the year through the stories behind their names together with linear and cyclical visual representations. Additionally, a series of timelines is used to illustrate major events and phenomena, including, for example, the Big Bang, the development of life on Earth, and the evolution of humans. These timelines are used in conjunction with the Montessori Great Lessons—a framework within which the child studies a variety of topics in mathematics, geometry, language, history, geography,

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[2] See David Elkind's (1967) comparison of Piaget's and Montessori's ideas and approaches: Piaget and Montessori. *Harvard Educational Review*, 37(4), 535–545.

biology, astronomy, chemistry, and more. The five Great Lessons, usually delivered each year throughout the elementary years, fuel the imagination such that the child can begin to conceptualize such big ideas as the formation of the universe, evolution, and the history of writing and numbers. All the lessons of the Montessori elementary curriculum are effectively extensions of the Great Lessons—the hub of the curriculum. This paper focuses on the first two Great Lessons which, more so than the latter three, address phenomena that have occurred in deep-time and is therefore the most challenging to grasp.

The First Great Lesson—The Origin of the Universe

A deeply rooted psycho-biological adaptation, common to most animals, including humans, is a sense of time passing and also timing, during behaviorally contextualized, associative schemas. (Ng, et al., 2021). Universally so, human cultures are keen on highlighting the beginning and the end of times, with eschatological thinking being a common feature of mythology and science (Byock, 2005; Ćirković, 2003). "Just-so" stories across many cultures are meant to be impressionistic lessons, albeit simplistic descriptions, of how things "came to be" (Arnaud, 2015).

Moreover, declaring, in a *syncretic* manner, that Earth is only six thousand years old, is an example of an *illusory* (subjective) perception of time and also a bias: an example of a *telescopic effect* (*forward*). Without a scientific appreciation of "deep time" children may persist in their underestimation of grand time scales into adulthood. The first Great Lesson centers on the origin of the universe and Earth's early history and is usually given near the beginning of the school year in order to provide the framework for all the lessons and studies that follow. It presents the scientific account of how time, space, and energy—the observable universe—began (what is traditionally referred to as the "Big Bang"). The teacher gives a dramatic, impressionistic lesson, usually in a darkened room, telling the students a story about a time long before their grandparents and their grandparents' grandparents were alive, long before dinosaurs existed, before the oceans and even the Earth were formed, long before there were stars. First, a deflated balloon marked with numerous dots is blown up to symbolize how space expanded, how the universe stretched (the era of inflation). A black balloon filled with gold stars and glitter, and dramatically popped at the right point in the story, demonstrates the dispersal of the first particles of matter.

A follow-up activity gives an impression of the life cycle of a star—stellar nucleosynthesis—by laying out a series of concentric circles, each one representing the production of a chemical element (hydrogen, helium, carbon, oxygen, etc.) via large-scale nuclear fusion reactions. While greatly simplified, this activity helps children grasp how "all the species of chemical elements [were produced] from perhaps one or two simple types of atomic nuclei" (Britannica). Again, an impressionistic lesson is given to help children conceptualize a huge, deep-time process that takes place on a cosmic scale, each stage lasting millions of years. Our sun, for example, only a middle-aged star (about 4.5 billion years), is still mostly hydrogen and helium. Finally, a series of experiments allows children to explore the types and properties of matter, including chemical changes, mixtures, compounds, and reactions, as well as atoms and molecules. To help children imagine the great spans of time involved in these processes,[3] the first Great Lesson utilizes one linear and one circular representation of the past ~14 billion years:

- Counting Back to Time Zero – A 100-foot black ribbon representing the passage of time from the Big Bang to the birth of the solar system, the origin and development of Earth, the evolution of life, and finally, a tiny strip of white at the end symbolizing the time of human habitation relative to Earth's entire history.
- The Clock of Eons – a circular timeline based on Earth's Geologic Time Scale, wherein each of Earth's eons is given a relative period on a 12-hour analog clock. We can imagine Earth's formation occurring at 12:00 a.m., and each subsequent hour symbolizing approximately 375,000,000 years. Although the material highlights the length of Earth's eons rather than the development of life, we point out to children that the first life appears around 2:30, the emergence of eukaryotes at about 6:20, and multicellular life at 9:00. From working with this material, children learn the names and characteristics of Earth's four major eons, the eras within the last—the Phanerozoic Eon—and the periods, epochs, and ages therein. Like the long, black ribbon, this material gives an impressionistic lesson on the relatively miniscule time hominids have occupied the planet—about 30 seconds of the 12-hour representation of Earth's existence.

The lessons utilizing both the black ribbon and the clock of eons are considered impressionistic in the sense that they convey the vast, almost unimaginable span of time that passed before the first life appeared on Earth and, especially, the first hominids. Human habitation on Earth is a relatively few fleeting seconds, and yet the human impact on the planet has been transformative, mostly in negative ways (see discussion of the proposed Anthropocene Age in the next section--Monastersky, 2015).

The first Great Lesson is intended to evoke awe and humility, striking a sense of wonder in the minds of children and inspiring the study of a wide range of ideas in astronomy, meteorology, physics, geology, and geography. For example, students might choose to explore the geologic cycle and plate tectonics; older students the periodic table of elements, atmospheric composition, the classes of stars and their relative color and temperature. This lesson, together with subsequent experiments and other activities, gives children the big picture as a framework within which—armed with the intellect and imagination characteristic of this age group—they can make sense of and integrate the details across disciplines.

It should not be assumed that all children's understandings of the passage of time across thousands, millions, and billions of years is equally or uniformly apprehended--understood.[4]

The Second Great Lesson—The Evolution of Life on Earth

While the development of complex life is represented on the Clock of eons (about the last 90

[3] Great teaching materials abound with which to instruct children about "geological time." For example, this website at U. Berkeley: https://ucmp.berkeley.edu/education/explorations/tours/geotime/gtpage1.html

[4] Aldo Leopold's (1949) a Sand County almanac can be a great introduction to seasonal changes—and to the study of *phenology*.

minutes) and is briefly discussed as part of the First Great Lesson, that time span—the Phanerozoic Eon—is the focus of the Second Great Lesson, the development of life on Earth.

Although the Phanerozoic Eon spans less than 10% of Earth's total age, it encompasses 540 million years—again, a vast amount of time for a child to conceptualize. To this end, the timeline of life is utilized, a long chart that illustrates the evolution of life on Earth, from the first complex life about 540 million years ago to modern mammals including early humans, which are shown at about 2.8 million years ago. Again, appealing to children's imagination is key to their grasp of these big ideas.

The timeline chart is divided into three eras: the Paleozoic Era, the Mesozoic Era, and the Cenozoic Era. Each era is further divided into periods, illustrating when major organisms first appeared. Some timelines show the extinction of species. Major ice ages and other geological phenomena such as plate tectonics and volcanic eruptions are represented, providing additional context for filling in the details. (Absent from most Montessori timelines of life is a clear picture of the evolutionary history of organisms and relationships between branches of life. Additionally, some Montessori timelines are inaccurate and/or obsolete and should not be in use. We address both these issues below. (See also Brunold-Conesa, 2022a, 2022b; Spears, 2022)[5]

From the clock of eons, we take the Phanerozoic Eon and zoom in on the timeline of life to show the relative time span and major characteristics of its three eras (Wiki Phanerozoic):

- The Paleozoic Era, including six periods: Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian. "The Paleozoic features the evolution of the three most prominent animal phyla, arthropods, mollusks and vertebrates, the latter of which includes fish, amphibians and the fully terrestrial amniotes (synapsids and sauropsids)." Of great interest to children is the idea of the Cambrian Explosion, in which lifeforms rapidly diversified, producing "the first representatives of all modern animal phyla." The Paleozoic is the longest of the three eras on the timeline, lasting approximately 287 million years.
- The Mesozoic Era, including three periods: Triassic, Jurassic, and Cretaceous. "The Mesozoic features [the rise of angiosperms,] the evolution of crocodilians, turtles, dinosaurs (including birds), lepidosaurs (lizards and snakes) and of mammals." While younger children, especially, get excited studying dinosaurs as part of their timeline work, a good timeline also illustrates the proliferation of gymnosperms and ferns, a greenhouse-type climate, and the breaking up of Pangea. The Mesozoic is the second-longest of the Phanerozoic Era, lasting approximately 186 million years.
- The Cenozoic Era, including the Paleogene and Neogene Periods. The Cenozoic, "is Earth's current geological era, representing the last 66 million years of Earth's history. It is characterized by the dominance of mammals, birds, and flowering plants." The proposed Anthropocene Age is brought into lessons and discussions with older

[5] One way to augment these lacunae are many instructive US National Park Service materials, including *Deep Time and You*: https://www.nps.gov/teachers/classrooms/deep-time-and-you.htm and also this link suggested by Dr. Spears: https://deeptime.info

> elementary and secondary students and includes studies of the increasing human impact on land use, ecosystems, biodiversity, species extinction, and climate warming.

Many Montessori teachers are beginning to recognize the dynamic nature of biological science and the need to update curricula as new information becomes available. About this need, science educator Dr. Priscilla Spears writes (2022):

> Biology has come a long way since the mid-20th century. Not only are two, five, or six kingdoms obsolete, but the whole idea of kingdoms is not what it once was. If you still use five or six kingdoms as your main lesson on the diversity of life, it is time to move those materials to the history of biology and move on. The Tree of Life provides the framework now, and the three kingdoms (fungus, animal, and plant) that are still valid are not the organizing framework for the diversity of life. Instead, they are major branches among many others on the Tree of Life. Biologists have extended classification to include the relationships between all kinds of life. Shared common ancestry drives classification, not just physical appearance.[6]

Biology is the focus of the second Great Lesson, with extended study opportunities not only in botany and zoology, but also fungi and microorganisms—archaea, bacteria, and protists—including classification and work with living or preserved specimens. Additionally, as the timeline of life represents the diversity of life, children study ideas in ecology such as habitats, systems, trophic levels, adaptation, and conservation. And while it introduces the big idea of life on Earth, the timeline of life is not the focus, but rather the point of departure for individual exploration in related areas.

Conclusion

Understanding one's family geneology via historical and archival methodologies can be augmented by the now-available gene kits. Who our ancestors were beyond the generations that memory alone can keep track of can be an exciting discovery for people of any age.

Discovering, for example, that many of us carry .5-2% of neanderthal genes, or any other genes associated with archaic human groups, leads to all sorts of very interesting inquiries about deep time, genetics, and evolutionary processes, in short, to a plurality of notions about what it is to be "human."

Circling back to Piaget's original question, "*Is our intuitive grasp of time primitive or derived?*", one could agree that both nature and nurture aspects of "understanding time" are intimately intertwined throughout our development. However, the capacities and abilities to think logically and abstractly (Piaget's *concrete* and *formal operations* stages, respectively) coincide with educational opportunities that require a more informed appreciation of the passage of time in the universe, our solar system, our planet. Even now, while reading these lines, it takes 60-90 *ms* for these word images to be registered in our primary visual cortex and longer to be understood—to be "actionable" (Thorpe, Fize, & Marlot, 1996). Verily, nervous systems exhibit intrinsic temporality. Irrevocably, time engulfs us, within and without. ֍

[6] For additional and relevant blogs by Dr. Spears see: https://big-picture-science.myshopify.com/blogs/news

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Other articles by Cynthia Brunold-Conesa: https://amshq.org/Search?q=cynthia%20brunold-conesa

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