

# Evolution of brain and culture: the neurological and cognitive journey from *Australopithecus* to Albert Einstein

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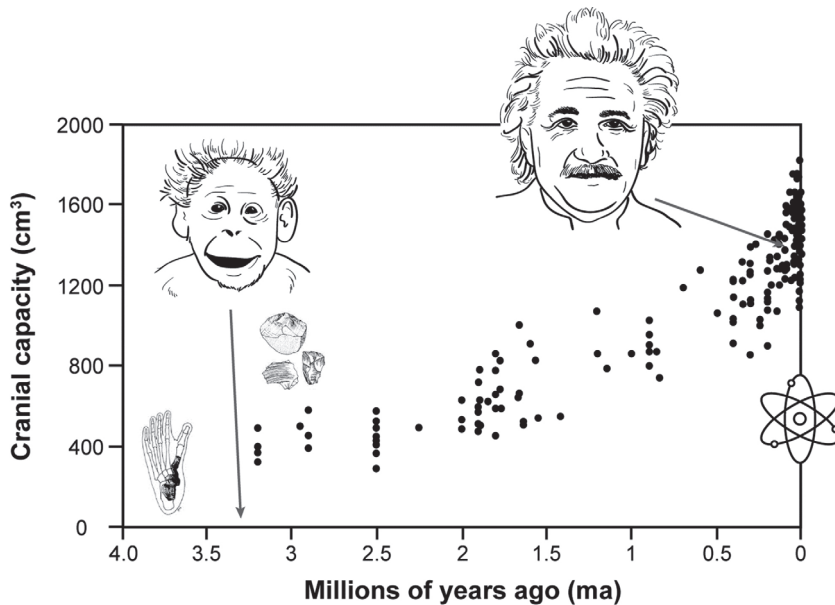
**Summary** - Fossil and comparative primatological evidence suggest that alterations in the development of prehistoric hominin infants kindled three consecutive evolutionary-developmental (evo-devo) trends that, ultimately, paved the way for the evolution of the human brain and cognition. In the earliest trend, infants' development of posture and locomotion became delayed because of anatomical changes that accompanied the prolonged evolution of bipedalism. Because modern humans have inherited these changes, our babies are much slower than other primates to reach developmental milestones such as standing, crawling, and walking. The delay in ancestral babies' physical development eventually precipitated an evolutionary reversal in which they became increasingly unable to cling independently to their mothers. For the first time in prehistory, babies were, thus, periodically deprived of direct physical contact with their mothers. This prompted the emergence of a second evo-devo trend in which infants sought contact comfort from caregivers using evolved signals, including new ways of crying that are conserved in modern babies. Such signaling stimulated intense reciprocal interactions between prehistoric mothers and infants that seeded the eventual emergence of motherese and, subsequently, protolanguage. The third trend was for an extreme acceleration in brain growth that began prior to the last trimester of gestation and continued through infants' first postnatal year (early "brain spurt"). Conservation of this trend in modern babies explains why human brains reach adult sizes that are over three times those of chimpanzees. The fossil record of hominin cranial capacities together with comparative neuroanatomical data suggest that, around 3 million years ago, early brain spurts began to facilitate an evolutionary trajectory for increasingly large adult brains in association with neurological reorganization. The prehistoric increase in brain size eventually caused parturition to become exceedingly difficult, and this difficulty, known as the "obstetrical dilemma," is likely to constrain the future evolution of brain size and, thus, privilege ongoing evolution in neurological reorganization. In modern babies, the brain spurt is accompanied by formation and tuning (pruning) of neurological connections, and development of dynamic higher-order networks that facilitate acquisition of grammatical language and, later in development, other advanced computational abilities such as musical or mathematical perception and performance. The cumulative evidence suggests that the emergence and refinement of grammatical language was a prime mover of hominin brain evolution.

**Keywords** - Baby-the-trendsetter, Evo-devo trends, Language evolution, Motherese, Neurological reorganization, Obstetrical dilemma.

## Introduction

Despite the well-known fact that humans evolved relatively large brains compared to their bodies (relative brain size, RBS), it is less appreciated that a similar trend occurred during the

evolution of many groups of mammals (Jerison, 1973; Radinsky, 1978). Radinsky's observation about these parallel increases in RBS is as true today as it was nearly four decades ago (Radinsky, 1979, p. 24): "Elucidation of the



**Fig. 1 – The evolution of bipedalism, brain size, and culture. By the time of Little Foot (~3.7 ma), bipedalism had been evolving for several million years, long before brain size started to increase ~ 3.0 ma. Between the time of the Dikika infant (*Australopithecus afarensis*) and Albert Einstein, brains evolved in size and internal connectivity, while material culture blossomed from stone tools to the products of the Atomic Age. Brain size for individuals, represented by cranial capacity in cubic centimeters (cm³), from Nick Matzke of National Center for Science Education ([www.ncseweb.org](http://www.ncseweb.org)).**

factors responsible for the widespread evolutionary trend of increase in relative brain size in mammals, and for the extreme to which that trend was carried in humans, remains a fascinating unsolved problem.” The persistence of this puzzle is not for lack of attempts to solve it, however, at least in the case of humans. Since Darwin theorized a feedback between “the conscious use of language and the development of the brain ...[that] reacted on the mind by enabling and encouraging it to carry on long trains of thought” (Darwin, 1871, p. 57), numerous scholars have speculated that the increase in both absolute and RBS during hominin evolution resulted from selection for behaviors that required intelligence. Each researcher tended/tends to focus on one particular behavior that was hypothetically favored by natural selection, thus resulting in selection for its underlying neurological substrates. The list of proposed “prime movers” for brain evolution is long (see Falk, 1980 for review). Besides

language (Jerison, 1991; Falk, 2004a), nominees have included tool production (Darwin, 1871), warfare (Pitt, 1978), hunting (Joseph, 2000; Krantz, 1968; Lee & DeVore, 1968, Washburn & Lancaster, 1968), labor (Kochetkova, 1978), Machiavellian intelligence (Byrne & Whiten, 1988), food gathering (Slocum, 1975; Lovejoy 1981; Zihlman, 1989), and social intelligence (Dunbar & Schultz, 2007).

The proposed prime movers of hunting and gathering are particularly well known. Nearly half a century ago “Man-the-hunter” was hypothesized to be the prime agent of human evolution (Lee & DeVore, 1968). Feminist anthropologists responded by proposing “Woman-the-gatherer” as an alternative (Slocum, 1975). Although hunting and gathering were of paramount importance during most of hominin evolution, little evidence suggests that either activity was *the* prime mover of hominin evolution, let alone brain evolution. The present paper posits

that three consecutive evolutionary-developmental (evo-devo) trends began in prehistoric infants (“Baby-the-trendsetter,” Falk, 2017) as a chain reaction to selection for bipedalism. Below, I hypothesize that these evo-devo trends profoundly influenced the subsequent trajectory of hominin neurological and cognitive evolution. As shown in Figure 1, this remarkable evolutionary journey is manifested in a record of increasingly complex material and cognitive products ranging from the manufactured stone tools of australopithecines to discoveries in theoretical physics that spawned the modern Atomic Age.

## Brain size, bipedalism and cognitive evolution

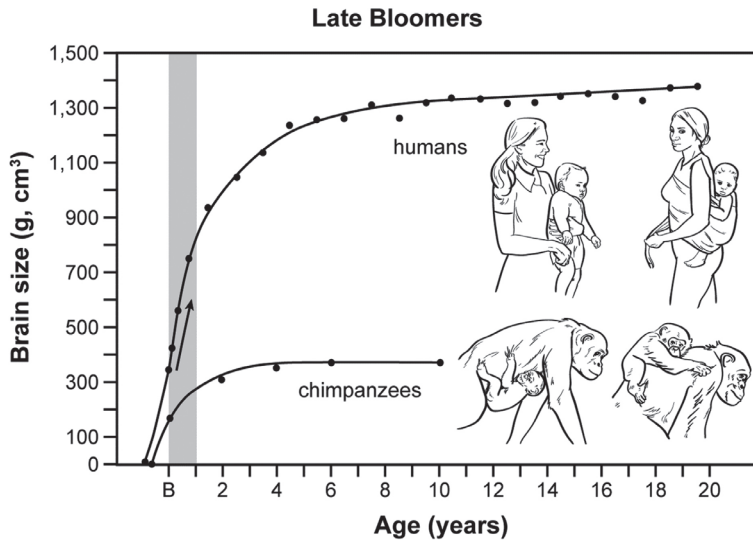
### *Brain evolution and culture*

Although hominin and chimpanzee lineages appear to have diverged from a common ancestor around 5–7 million years ago (ma), the earliest part of the hominin fossil record is murky. Fig. 1 provides an overview of hominin evolution during the last ~ 4.0 million years. Until the Neolithic revolution in food production began ~ 12,000 years ago, hominins made their livings foraging, scavenging, hunting, and gathering. Not much is known about hominin brain size prior to 3.5 ma, although the apelike cranial capacities of ~6–7 ma *Sahelanthropus* (Zollikofer *et al.*, 2005) and ~ 4.4 ma *Ardipithecus* (Suwa *et al.*, 2009) suggest that brain size remained conservative until around 3.0 ma, at which point the volume of the braincase (cranial capacity) and mass of the brain began to increase through time, reaching a plateau in *Homo sapiens* that is three to four times the sizes associated with australopithecines and extant apes. Figure 1 shows that contemporary skull/brain size is highly variable, as was the case, to some degree, for cranial capacities of the earliest fossil hominins (australopithecines) that are represented by multiple specimens.

The position of the foramen magnum in 6.0–7.0 ma *Sahelanthropus* (Brunet *et al.*, 2002), the morphology of the femora in ~ 6.0 ma *Orrorin tugenensis* (Senut *et al.*, 2001) and the morphology of the feet in ~3.7 ma *Australopithecus* (“Little

Foot”, Granger *et al.*, 2015) indicate that the evolution of bipedalism began well before hominin brain size started its upward trajectory, perhaps even at the inception of hominins. Stone tools from Kenya (Harmand *et al.*, 2015) and cutmarks on fossilized bones from Ethiopia (McPherron *et al.*, 2010) suggest that production of stone tools had begun by 3.4 ma, and may have coincided with the prehistoric takeoff in hominin brain size. As noted, the record of material culture became more complex as brains increased in size and organizational complexity, spanning from simple knapped tools in australopithecines to the advanced technology of modern humans. Despite the frequently heard admonition that “correlation does not imply causation,” correlation also does not imply that two variables *lack* a causal relationship, and it seems reasonable to suggest that brain evolution and advances in material and cognitive culture were functionally related (Fig. 1).

Human brains are uniquely adept at perceiving and processing discrete aspects of sensory stimuli, (re)combining them into meaningful sequences using unconscious (learned) algorithms, and executing both ‘bottom-up’ (automatic) and higher-order “top-down” (executive) behaviors in response to these stimuli (Miller & Wallis, 2009; Grodzinsky & Nelken, 2014). Many, if not all, unique human endeavors in the arts and sciences rely on evolved cortical networks that support segmental, sequential, hierarchical, and analytical processing (Anderson, 2014; Falk, 2009), as does linguistic perception and performance (Kuhl, 2004; Mesgarani *et al.*, 2014). Of the numerous behaviors proposed as *the* prime mover of brain evolution, the only one that is unique and universal in humans is symbolic grammatical language (Falk, 2009, 2016), although when it originated remains an open question. Because language occurs universally in all normal humans, whereas proficiency in the arts and sciences does not, these various endeavors are likely to have emerged on the coattails of natural selection for language. For this reason, consideration of the extremely rapid higher-order neurological machinery entailed in grammatical language is particularly relevant for discussions of brain evolution.



**Fig. 2 - Trend 1: Late bloomers.** Physical maturation became prolonged (delayed) during hominin evolution, causing infants to take longer to achieve milestones such as crawling, standing, and walking. Consequently, prehistoric offspring, similar to modern ones, failed to develop an ability to cling unaided to their mothers. This was an evolutionary reversal because all extant monkey and ape infants develop such an ability. As illustrated, the responsibility for attaching infants to caregivers eventually shifted from the former to the latter.

### *Three sequential evo-devo trends triggered by bipedalism*

Bipedalism originated between 5-7 ma, perhaps because it improved hominins' foraging efficiency (Lieberman, 2015). Ongoing selection for walking upright eventually affected the anatomy of the entire skeleton, including that of co-evolving hands and feet (Rolian *et al.*, 2010). The fossil record shows that a significant consequence of bipedalism was that hominin feet eventually became weight bearing organs instead of grasping ones. Although the details regarding the precise timing of the various anatomical changes that occurred throughout the skeleton as bipedalism became refined are still being worked out, comparative analyses show that by the time of australopithecines hands and feet had lost important adaptations for grasping (DeSilva, 2017), consistent with the hypothesis that the development of posture and locomotion became delayed compared to ape infants as selection for bipedalism progressed (see Falk & Schofield,

2017, for further details). This is the **first evo-devo trend** (Fig. 2). Because modern babies conserve this ancestral trait for being late bloomers, their attainment of first-year milestones such as holding the neck up, crawling, and standing is delayed compared to chimpanzee infants (Plooij, 1984). In fact, "human infants spend prolonged periods—months—coping with objects and navigating surfaces after achieving each postural milestone in development" (Adolph & Berger, 2006, p. 191). The extreme motor delay in human infants has caused some to refer to them as "secondarily altricial" (Smith & Tompkins, 1995, p. 270) or, more simply, "helpless."

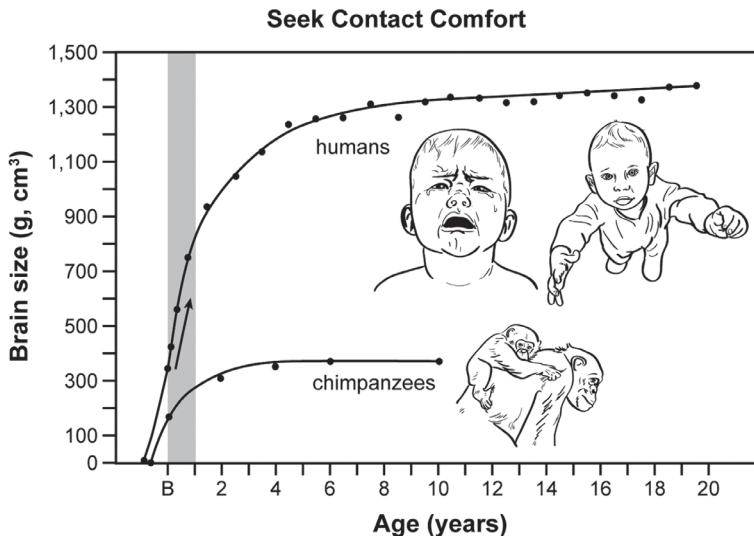
As a consequence of this first trend, hominin nurslings failed to develop an ability to cling unsupported to their mothers' bodies (DeSilva, 2017) - a failure that has been inherited by modern infants. This was a significant evolutionary reversal because such an ability develops in all living monkeys and apes (Ross, 2001). Because their babies were physical late bloomers, the

responsibility for keeping nursing infants attached to caregivers, especially mothers, eventually shifted from the infants to the caregivers themselves. Although the fossil record is mute on such maternal behavior, it seems reasonable to speculate that it began to emerge during the early evolution of bipedalism when feet (including those of infants) began to lose their grasping ability, likely before hominin brain size began to increase. Before the invention of baby slings (Wall-Scheffler *et al.*, 2007), helpless nurslings must have been carried in caregivers' arms and on their hips and, for the first time in prehistory, would have sometimes been put down *nearby* (in stark contrast to the distant baby-parking that some prosimians engage in) as mothers used their hands for other activities (Falk, 2004b, 2009, 2016). (DeSilva [2017] argues persuasively that alloparenting would also have developed in australopithecines as a strategy for coping with infants who could not cling to their mothers.) Although the fossil record cannot reveal exactly when and how it developed, the practice of putting infants down nearby, which is familiar to women in industrialized societies who routinely put their babies down on blankets or in nearby playpens or baby seats, does not occur in monkey or ape mothers with nursing infants. It had to be invented.

As any parent will attest, alert babies frequently signal displeasure when they are put down, and comparative studies of living primates show that it is a good bet that prehistoric ones did too (see Falk 2004b, 2009 for details). In industrialized societies that tend to encourage independence by separating or isolating infants (e.g., in their own bedrooms), babies are provided with proxies for direct mother/infant contact, including pacifiers, blankies, swaddles, baby slings, and rockers. Although the fossil record does not preserve behavior, it is likely that prehistoric mothers whose babies were unable to sustain clinging were the originators of stimuli that are still used to soothe and hush unhappy infants, including physical placaters (hugging, rocking, bouncing, picking them up) and vocalizations (lullabies, shushing), and, further, that ancestral babies' need for contact comfort led to

a **second evo-devo trend** in which infants sought such comfort using evolved signals (Fig. 3). These signals consisted of new behaviors, including derived ways of crying (Small, 1998; Soltis, 2004) that are retained in contemporary infants who shed emotional tears a few months after birth (Provine *et al.*, 2009) and develop melodies in their cries that contribute to the emergence of babbling, which, in turn, precedes and contributes to the acquisition of speech (Wermke *et al.*, 2007). A significant aspect of this second evo-devo trend is that babies' signals would have prompted reciprocal give-and-take gestural (prolonged eye contact) and vocal communication with caregivers – an important prerequisite for the evolutionary emergence of conversation (Falk, 2004b, 2009; Bancel & de l'Etang, 2013).

After it emerged, bipedalism continued to be refined for several million years. By around 3 ma, *Australopithecus africanus* was walking with an efficient, extended lower limb, similar to contemporary humans (Barak *et al.*, 2013). Around then, brain size began to increase in the hominin fossil record (Fig. 1), reflecting the **third evo-devo trend**, in which growth of the brain accelerated markedly during infants' last gestational trimester and first postnatal year, then increased more slowly until brain size leveled off in adults (Fig. 4). This early brain spurt - still seen in modern humans - is the mechanism whereby the brains of our species grow to become three to four times the size of adult ape brains (Passingham, 1975; DeSilva & Lesnik, 2006, 2008; DeSilva, 2017). The fossil record of (mostly) adult cranial capacities together with brain growth curves that have similar shapes in species of New World monkeys, Old World monkeys, apes, and humans (Schultz, 1941; Passingham, 1975) strongly suggest that the early brain spurt is also the mechanism that facilitated the increase in average brain size as hominins continued to evolve. If so, the continuing trend for increasingly accelerated early brain growth boosted brain growth curves of subsequently living hominins successively higher over time, as illustrated by the placement of Taung on Figure 4 as well as Schultz's discussion of likely growth curves for *Sinanthropus* (*Homo erectus*) and Neanderthals (Schultz, 1941).



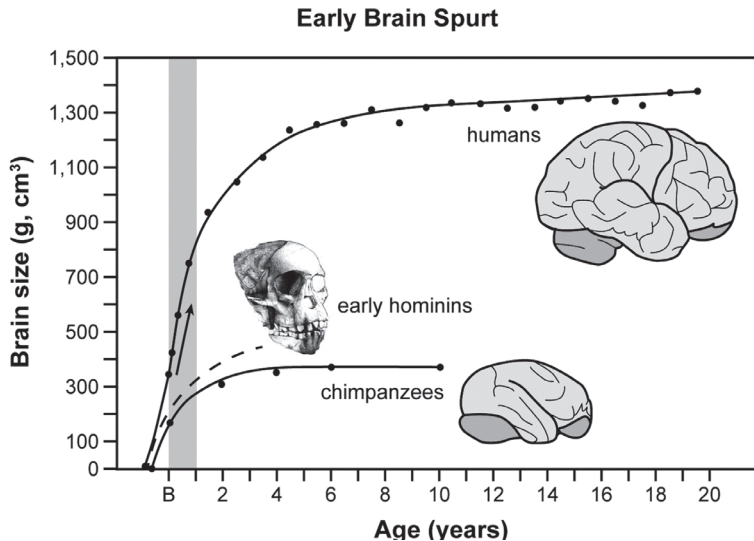
**Fig. 3 – Trend 2: Seek contact comfort.** Hominin infants who lost the ability to cling independently to mothers developed vocal and visual signals (e.g., shedding emotional tears) to prompt caregivers to pick them up or deliver other proxies for contact comfort (e.g., soothing vocalizations, rhythmic bouncing). These signals paved the way for reciprocal communication between infants and mothers and the eventual emergence of motherese, which seeded the first language.

Comparative studies suggest that as hominin brains evolved in size their neurological architecture became reorganized (Holloway *et al.*, 2004) in a global manner that entailed differential elaboration of association cortices and increased brain lateralization (Dart, 1929; Falk, 2014b). Further, research of Barbara Finlay and colleagues on how neurons are generated during development suggests that the evolutionary increase in hominin brain size may have been related to ongoing selection for specific traits because sizes of different brain structures (excepting olfactory bulbs) are contingent upon the size of the whole brain in mammals including primates (Finlay & Darlington, 1995; Finlay *et al.*, 2001; Kaskan & Finlay, 2001). More specifically, the researchers found that the longer cytotogenesis occurs for a particular structure in the brain during development, the larger that structure will become, but so will others. As a result of this developmental constraint, most parts of mammalian brains enlarged together regardless of the specific behavior(s) that were targeted by natural selection (see Falk,

2014a for further details.) An underappreciated fact about Finlay's model is that it leaves wiggle room to accommodate independent variation in brain regions of species that may have evolved in association with adaptive behaviors, such as hominin prefrontal association cortices mentioned above (see also Oxnard, 2004). Bottom line: selection for enlargement of brain structures related to an adaptive behavior frequently drags most of the brain along so that "by far the most useful predictors of structure sizes are the sizes of other brain structures" (Finlay *et al.*, 2001, p. 268). The trick, of course, is to identify the specific selective factors (behaviors) that were responsible for the linked global enlargement of the hominin brain. As noted above, the emergence and refinement of grammatical language is a good candidate for one such behavior.

Whatever its causes, the ongoing increase in hominin brain size caused parturition to become increasingly difficult because of the morphology of hominin bony birth canals that had been selected for millions of years earlier in





**Fig. 4 – Trend 3: Early brain spurt.** The most rapid brain growth occurs during an individual's last trimester of gestation and first year of life (arrow), after which growth continues but decelerates until it levels off at adult size. Over time, accelerated brain spurts pulled growth curves of subsequently living hominins higher, indicated here by the hypothetical growth curve for the > 2.0 ma infant Taung (*Australopithecus africanus*). Data for chimpanzees (cm<sup>3</sup> cubic centimeters) and humans (g, grams) from Passingham (1975); B, birth; ages of individuals are in years.

conjunction with bipedalism. Specifically, this pelvic morphology constrained the size of the heads (brains) that viable term fetuses could attain as brain size continued to evolve, thus giving rise to the "obstetrical dilemma" (OD) (Washburn, 1960). According to this interpretation, bipedalism had an indirect, rather than direct, effect on the eventual emergence of the obstetrical dilemma (see Falk, 2017 for details; but see Rosenberg & Trevathan 2001, 2002 and Trevathan & Rosenberg, 2016). Although the OD placed a limit on the brain size of viable term fetuses that may have impacted gestation length as well as metabolism of fetuses and newborns (Dunsworth, 2017), it seems reasonable to attribute the greater proportion of post-natal brain growth that occurred in hominins compared to other primates (DeSilva, 2017) to brain evolution in association with selection for adaptive behaviors, rather than to direct selection for associated homeostatic factors. As noted, the interesting question is why hominin brains evolved to be so large and the specific role

that prehistoric infants played in this remarkable evolution. In any event, as most women who have given birth will attest, the obstetrical dilemma is real. Further, it is likely to truncate the future evolution of brain size, which implies that, from now on, brain evolution is likely to depend extensively on neurological reorganization (Hofman, 2014).

#### *Neurological reorganization*

The kinds of processes that were involved in the evolution of neurological reorganization in hominins may, to some degree, be revealed by examining the neurological remodeling that accompanies the early brain spurt in modern babies as their brains establish connections through myelination and selective pruning of synapses. Neonates begin to learn the building blocks of language by perceiving the statistical and prosodic regularities of their native languages, which creates neural networks for higher-order linguistic computations (Kuhl, 2000, 2004). Six-month-olds can distinguish

the approximately 800 consonants and vowels in all of the world's languages, but by the end of their first year their perception has become selectively tuned to the roughly 40 speech sounds from their native language (Kuhl, 2000, 2004). It seems likely that the developmental pruning in infants' perception of speech sounds during their first year is related to the synaptic pruning that occurs at the same time babies' brains are growing, myelinating, and establishing higher-order networks.

Infants' acquired ability to recognize and produce the elementary sounds of their native language develops into a full capacity for language as they continue to mature, which depends on exquisitely evolved and uniquely human neurological networks. Neurons in the brain's superior temporal gyrus (STG) participate in the initial stages of high-order auditory processing of speech sounds in a complex and extremely rapid manner that shows both spatially distributed and more localized selectivity to specific aspects of sounds that "together appear to give rise to our internal representation of a phoneme" (Mesgarani *et al.*, 2014, p. 1009). For example, perception related to sequential analyses like those entailed in voice onset time appears to be more widely distributed in STG than perception of other more localized aspects of speech such as manner of articulation ("plosive," "sonorant," etc.). This suggests that the rules for assembling basic phonetic units into bigger units depend on more widely distributed networks (Grodzinsky & Nelken, 2014). In addition to decoding speech, "operations involved in building complex expressions—sentences with rich syntax and semantics—are relatively localized in parts of the left cerebral hemisphere... even if the neural chunks that support them may be as large as several cubic centimeters" (Grodzinsky & Nelken, 2014, p. 979).

Although sensory (perceptual) and motor (speech) aspects of language entail regions from all lobes of the brain (e.g., see Bruner, this volume), speech, like other top-down (higher-order) executive activities, depends largely on the prefrontal cortex, which facilitates planning and coordinating complex sequences of behavior in

light of diverse information (including affective limbic tags) from other parts of the brain (Miller & Wallis, 2009, p. 104). Because the complex neurological substrates that underpin human linguistic cognition begin to develop prenatally and continue to do so as modern babies undergo their postnatal brain spurt, it is reasonable to speculate that neurological reorganization related to processing complex acoustic stimuli was a selective factor underlying the emergence of the third evo-devo trend.

*The three evo-devo trends eventually sparked the elaboration of systematic higher-level neurological processing exemplified by language.*

As detailed elsewhere (Falk, 2004b, 2009, 2016), the evo-devo trends described above probably triggered the prehistoric emergence of motherese (also called baby talk, infant-directed speech, musical speech, or parentese), which paved the way for the evolution of symbolic language and the neurological substrates that support it. Although mother and infant monkeys and apes occasionally exchange relatively simple vocalizations (contact calls), nonhuman primate mothers do not expose their infants to a more-or-less continuous stream of melodious vocalizations, unlike human mothers who begin baby talking to their infants from the moment they are born (Trevathan, 2011). Despite an earlier literature to the contrary, motherese is universal among humankind (Bryant & Barrett, 2007; Falk, 2009) and, like language itself, must have emerged at some point after the chimpanzee and hominin lineages split. Human babies are born speechless but are well on their way to talking by the end of their first year. The motherese infants hear helps them learn and produce the elements of their native languages in a sequential, age-appropriate manner (Monnot, 1999; Dehaene-Lambertz *et al.*, 2006). Baby talk emphasizes vowels and accentuates individual syllables, words, and phrases, which helps young infants learn to parse speech streams. Further, the clarity of motherese that babies are exposed to is linked to their later development of speech discrimination skills (Liu *et al.*, 2003). Infants who excel at perceiving speech sounds at seven months



have larger spoken vocabularies and more complex speech when they are older (Tsao *et al.*, 2004). It is especially significant that exposure to motherese helps infants learn the conventional rules for constructing words and combining them into phrases and sentences (grammar) (Karmiloff-Smith, 2001) in various languages, including English, Italian, French, Serbian, Polish, and Russian (Farrar, 1990; Kempe & Brooks, 2001). As we have seen, such higher-order linguistic processing depends upon extremely rapid and complex computational abilities that evolved as hominin brains increased in size and reorganized internally.

### **From *Australopithecus* to Einstein: summary and conclusions**

This paper hypothesizes that selection for bipedalism initiated a series of three trends in the development of prehistoric infants that had a profound domino effect on the course of human evolution. However, it is important to acknowledge the limitations regarding our ability to confirm certain key aspects in this chain of reasoning. Behaviors do not fossilize and, until we get the time machine, inferences about the interactions of prehistoric mothers and infants must rely mostly on comparative primatological, psycholinguistic, and ethnographic data. Similarly, speculation about the origin of baby slings is unlikely to become informed by an archaeological record. The fossil record of hominins generally has a paucity of infants and juveniles, and contains relatively few specimens of any age during its first several million years. With luck, this will change and new data can be brought to bear on hypotheses regarding evolution of hands, feet, overall skeletal changes associated with long-term refinement of bipedalism, and ontogenetic brain growth curves in different hominin species.

Despite these limitations, comparative research on life histories and behavioral primatology suggests that physical maturation during prehistoric babies' first year became delayed (trend 1), which eventually led to an evolutionary loss (reversal) of infants' ability to cling

independently to their mothers (Ross, 2001). Consequently, prehistoric hominin babies were periodically deprived of direct physical contact with caregivers, which prompted babies to seek contact comfort from caregivers by using derived signals (trend 2), including new ways of crying and other evolved vocalizations/gestures that eventually led to intense reciprocal mother/infant interactions, hypothetically seeding the eventual emergence of motherese and, subsequently, protolanguage (Falk, 2004b, 2009).

The last evo-devo trend to emerge was for accelerated early brain growth (trend 3), which facilitated successive evolutionary increases in the sizes of hominin brains as well as changes in neurological organization. This hypothesis is supported by numerous data from the fossil record and comparative functional neuroanatomy. For example, between the time of *Australopithecus* and *Homo sapiens*, brains evolved to be three to four times larger than ape brains (Passingham 1975; DeSilva & Lesnik, 2006, 2008; DeSilva, 2017). Further, certain parts of the brain increased differentially in size and complexity, especially in executive regions of the prefrontal cortex (Semendeferi *et al.*, 2011), which is evident in the fossil record of hominin endocasts (Falk, 2014b) as well as in the morphology of brains of modern humans, exemplified by the reorganized but not particularly large cerebral cortex of Albert Einstein (Falk *et al.*, 2013).

The hypothesized relationship between the invention of motherese and the emergence of the first language is consistent with the fact that contemporary motherese is universal and bootstraps modern infants' acquisition of language, facilitated during the first year of life by brains with an evolved facility for extremely rapid unconscious statistical processing of acoustic stimuli (Kuhl, 2000, 2004). As we have seen, the incredibly complex cognitive and neurological machinery that supports language became derived in humans in association with certain evo-devo trends, and it is likely that many of the cognitive and technological innovations that distinguish *Homo sapiens* emerged in conjunction with and/or on the coattails of these trends.

If so, Sergei Rachmaninoff was able to write his *Rhapsody on a Theme of Paganini*, Marie Curie had the insight to formulate her theory of radio-activity, and Albert Einstein was able to crystalize path-breaking discoveries in theoretical physics thanks, ultimately, to Baby-the-trendsetter!

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