Behavioral Development Bulletin
2016, Vol. 21, No. 2, 165–175

1942-0722/16/$12.00 http://dx.doi.org/10.1037/bdb0000033

Successes in Cultural Evolution Raises the Variability in Humans' Highest Stage Attained

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The model of hierarchical complexity characterizes behavior 1-dimensionally, by representing its order of hierarchical complexity. It results that interspecies behavior can be directly compared. From interspecies comparisons, 1 intriguing question is why humans evolved the most, attaining the highest average stage and the highest variability in the highest stage attained by adults. We hypothesize that population growth has been a major factor for shifting upward the average stage of development of humans, which, reciprocally, was a perquisite for cultural evolution. We also consider competition and selection as core processes that go hand-in-hand with the rise in stage. Results show that population growth and rise in stage are strongly positively correlated. The emergence of a metasystematic Stage 13 individual is possible with an increase of the population from 2 to 161 individuals; a paradigmatic Stage 14 individual emerges with an increase from 161 to 4291; and a crossparadigmatic Stage 15 individual emerges with an increase from 4,291 to 289,855 individuals. We discuss that acceleration of population growth might be a fundamental measure accounting for the rise in stage. We deduce that agricultural practices were, then, fundamental for liberating human evolution. Although we do not have sufficient data for quantifying the reason behind the highest variability in the highest staged attained by human adults, we suggest that variability increases with the increase in average stage of a species. Finally, we draw some conclusions in regards to current populations, predicting that India might witness the next wave of innovations.

Keywords: stage of development, cultural evolution, population growth, agriculture

The model of hierarchical complexity is a mathematical model of task difficulty that has been extensively shown to underlie the laws that govern behavioral development in humans. The behavioral assessment rationale of this model is based on quantifying the tasks to be solved, rather than classifying the behavior that is generated to solve them. It is assumed that if a task is solved, then the behavior that solves it (behavioral stage) obeys to the same quantification assigned to the task. Hence, this hierarchical complexity measurement is detached from any mentalist conception of reasoning abilities, that is, it does not rely on what the specific mental strategies are to solve a problem, it only assesses which order of complexity problems are solved. This nonmentalist property makes this model applicable to quantifying and classifying any action or behavior, which applies, of course, to classifying and quantifying the behavioral pattern of all species besides humans (Commons, 2006; Commons & Jiang, 2014).

From interspecies comparisons, it is shown that humans attain the highest average stage of development, estimated to be between abstract Stage 10 and formal Stage 11 (average Stage 10.5), and that they show the highest variability in the highest stage attained in adulthood (ranging from primary Stage 8 to metacross-paradigmatic Stage 16; Commons et al., 2014). Contrarily, other species show a relatively stable average stage, lower than humans (Miller, Commons, Commons-Miller, & Chen, 2016).

Portions of this article were presented at the Society for Research in Adult Development, Saturday, June 18, 2016, Salem State University by Sofia Ferreira Leite and Michael Lamport Commons (Beth Israel Deaconess Medical Center, Harvard Medical School, Commons@tiac.net).

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In the present work, we account for stage of development at an evolutionary scale. Our objective is to address why humans have attained an average stage higher than other species, and to discuss a plausible interpretation for why they also show the highest variability in the highest stage attained in adulthood.

Here, the role of cultural evolution and the Darwinist mechanisms of competition and selection are considered core processes that go hand-in-hand with the rise in stage. According to the model of hierarchical complexity, it has been most likely that a higher stage individual produced solutions to solve more complex tasks, which dictated selection and increased cultural success, which introduced more adaptive memes in the society, which acted as attractors for forthcoming inventions. Cultural evolution resulted from such self-repeating process, leading to better adaptation conditions over times, the later leading to population growth. In turn, population growth would have been one of the axes of this evolutionary spiral, once that more individuals mean the possibility of more variability. Ultimately, this evolutionary process is shown to be fractal: cyclical and in expansion.

Based on this rationale, we hypothesize that the evolutionary rise in stage can be modeled as a function of human population growth. The highest stage of development is here a dependent variable of population growth, and an independent variable for determining cultural success, cultural evolution and, of course, selection. Cultural evolution is not considered in the model because it lacks a quantitative measurement approach.

Assuming that the evolutionary rise in stage is majorly due to population growth implies taking a probabilistic perspective over evolution. We will not discuss the biological underpinnings of emergent variability—whether it be due to mutations or a combination of genetic information with current memetic information. Either we will discuss the natural conditions that imposed some survival needs or the sociopolitical background of unfolding historical periods, both of which have definitely dictated the direction of innovations and evolution to a great extent (Farrington, 1944). We will restrict our approach to the fact that more individuals mean a likelihood of more diversity or variability and that more diversity means more competition and more selectivity. Extending this argument will show that a higher staged individual must, at some point, emerge, rather than be taught. Innovations cannot be taught. Hence, the emergence of a higher staged individual, here delineated in its probabilistic dimension, led to solutions to more complex problems that, in turn, introduced more adaptive memes in a society.

Our argument is organized as follows. We will first introduce the most relevant concepts put forward by the model of hierarchical complexity and how they relate to the present matter. Afterward, we will approach how the rises in stage and cultural evolution are intertwined components of an evolutionary process, illustrating how cultural evolution has provided communities with memes that increased the chance for population growth.

Stage of Development According to the Model of Hierarchical Complexity

The model of hierarchical complexity is a mathematical theory of general development that has been shown to characterize human behavior according to its order of complexity, which is shown to be hierarchical in its nature. The strongest contribution of this model is the definition of a major variable, called the order of hierarchical complexity, which characterizes tasks and actions.

The order of hierarchical complexity of a given task is represented by a scalar. If the task is solved correctly, the behavior is represented by the same scalar value and is said to match the same order of hierarchical complexity of the task; this same scalar value defines the developmental stage where that behavior falls. The rule for characterizing behavior is that an individual's stage is defined in terms of the highest order task that the individual can solve, at least once, in any domain of activity. The correlation between the order of hierarchical complexity of items predicts how well humans do on those items with correlations of over .95 (Giri, Commons, & Harrigan, 2014).

A higher order of complexity task is defined in terms of two (or more) lower order tasks, which are nonarbitrarily coordinated by a rule R. The order of hierarchical complexity is, thus, defined as the number of recursions needed to reach the single elements that compose the task. Theoretically, if we isolate that the least possible number of elements required for hierarchical integration to occur is two, we assume that hierarchical complexity grows with a constant scaling ratio of two.

According to this model, first, it is intuitive to understand that stage of development goes back to characterize actions that correspond to automations performed over single elements, or single stimuli, usually called automatic behavior or reactions. For instance, the model of hierarchical complexity rationale allows that the simplest forms of life are considered, namely cyanobacteria (automatic Stage 1). Also, given that the order of complexity of a task is the representation for classifying behavior, this approach gives no room for an interpretative or mentalist perspective. Tasks and actions form ordered pairs of the same complexity, with a one-to-one correspondence between them. Two further consequences follow: any task and any action can be assessed, whether it is human behavior, nonhuman animal behavior, or machine behavior/ actions. All types of actions/behavior can be directly compared. For the present matter, we are concerned with comparing interspecies behavioral data (Commons & Jiang, 2014; Miller et al., 2016).

Following this rationale for assessing behavioral stage of development, at a cross-sectional perspective, a higher staged individual will be able to solve more hierarchically complex tasks or problems. At adulthood, individuals achieve their peak in behavioral stage, with some individuals achieving higher stages than others. The average stage among humans is shown to be in between the abstract Stage 10 and the formal Stage 11 (Commons et al., 2014). This variability is the greatest among humans as compared to other species (ranging from primary Stage 8 to metacross-paradigmatic Stage 16). To our knowledge, chimpanzees are the species that achieve the highest stage after humans, primary Stage 8 or concrete Stage 9. Also to our knowledge, they are the only species that shows a variability of one stage in the highest stage attained. A proportion between the highest stage and variability seems to link both these examples, which will be further detailed ahead.

At a developmental scale, which operates throughout the life span of individuals, when they perform a more hierarchically complex task, this new stage will act as an attractor. The attraction is exerted because the individual obtains more reinforcement with the present solution: this new task action earns it, which is in opposition to what happened at the previous stage, at which there was failure or random responding on the (now solved) task. Attraction means that from a higher stage on, individuals will perceive the surroundings with a certain increased degree of hierarchical complexity and respond likewise. Furthermore, attraction of the degree of complexity is usually, but not necessarily, spread to all domains of life. If no trauma or injury occurs, we predict that the developmental movement will not regress to lower stages, but only move forward to higher stages, as far as biology, or genes, allows (Commons, Miller, & Giri, 2014).

The changes in stage we are about to discuss in more detail take place in cultural evolutionary time, not personal time, not historical time. So, if we take this sequential movement of increasing stage along life span onto an evolutionary scale, the emergence of higher stage performing individuals will provide that yet unsolved societal problems will be solved. The solutions will be more hierarchically complex and adaptive. These new solutions created by an innovative individual will optimize cultural success of a community and society, because they are wider solutions that transcend previous ones. Often, they increase productivity.

Memes are the equivalent to genes; they exist at a social scale. Genes compose the DNA of an individual, determining a great part of how the individual *is* and behaves; memes compose the structure, the driving force, of a society, determining the behaviors that culturally characterize it. A new meme is the cultural unit of cultural information. It is represented by one new action never performed before. A drive gives the reinforcing value to a consequence derived from applying the new meme. Following higher rates of reinforcement, whenever a new solution that increases cultural success is discovered, new *memes* are introduced in the society. A change in culture, therefore, can be seen as a change in the memes that are reinforced. Each change is driven by increases in reinforcement, the same principle that rules at a developmental scale passed onto an evolutionary scale. These changes do not take place suddenly, but by averaging over trials or people, appearing to have an *s*-shaped curve. The changes define new roles, each better than the previous. Hence, parallel to a developmental scale, we also predict that future memes will be more complex, not less. Also in accordance to the developmental scale, the new memes redirect the canvas upon which problems and perspectives are considered in many cultural domains. For example, at the beginning of the 20th century, cross-paradigms started to emerge in many domains: Picasso in the artistic domain, Einstein in scientific domain of physics, and Turing in the computer science domain.

Before we proceed, we illustrate how memes act as attractors of a society taken the scientific domain as an example. Copernicus (Koyré (1973) coordinated geometry of ellipses that represented the geometric paradigm and the sun-centered perspectives. This coordination formed the new field of celestial mechanics and led to what some call true empirical science with its mathematical exposition. That helped Isaac Newton (1687) to coordinate mathematics and physics, forming the new field of classic mathematical physics. The field was formed out of the new mathematical paradigm of the calculus and the paradigm of physics. Rene Descartes (Madjarof, 2011) created the paradigm of analysis and used it to coordinate the paradigms of geometry, proof theory, algebra, and teleology, resulting in the field of analytical geometry and analytic proofs. Charles Darwin (1909) coordinated geology, biology, and ecology to form the field of evolution, later paving the way for chaos theory, evolutionary biology, and evolutionary psychology. Albert Einstein (Mehra & Rechenberg, 1982) gave rise to modern cosmology when he coordinated the paradigm of non-Euclidean geometry with the paradigm of classical physics to form the field of relativity. He coinvented quantum mechanics. Max Planck (Mehra & Rechenberg, 1982) coordinated the paradigm of wave theory (physics of energy) notions from probability (mathematics), forming the field of quantum mechanics, which led to particle physics. Godel (Charlesworth, 1980) coordinated epistemology and mathematics into the field of limits on knowing.

Cultural Evolution

At an evolutionary scale, we can trace this mechanism of hierarchical complexity back to the Neanderthals. This is done to illustrate both the cultural success of innovations and how they pave way for evolution. For example, Neanderthals' innovations first required formal "stagers" to save fire. Forthcoming innovations required systematic "stagers" to start fire, beyond saving it, as well as to create compound spears. A great innovation was a spear-thrower or atlatl. A spear-thrower is a long-range weapon and can readily impart to a projectile speed of over 150 km/h (93 mph); wooden darts were known at least since the Middle Paleolithic (McClellan & Dorn, 2006). While the spear-thrower is capable of casting a dart well over one hundred meters, it is most accurately used at distances of 20 m or less (Garrod, 1955). This allowed the killing of very large animals from a much safer distance, reducing the risk and increasing the chance for survival. These are examples that show why more hierarchically complex solutions generally imply cultural success and adaptation.

We will now go briefly through the sequence of types of societies that progressively established, from hunter-gatherers until nowadays, the information age, showing how the main societal change introduced was relevant for population increase.

Hunter-Gatherers

Hunter-Gathering was the only mode of subsistence until the end of the Mesolithic period, some 10,000 years ago. Hunter-gatherers were organized in small societies (Hamilton, Milne, Walker, Burger, & Brown, 2007). These small societies were pioneering in the sexual division of labor. This division was assumed to be a major incentive that flew into the beginnings of agricultural societies. Actually, the transition into the subsequent Neolithic period is chiefly defined by the unprecedented development of nascent agricultural practices. During this predecessor period, hunting required empirical evidenced-based decisions on tool use and group organization. These included how to organize a hunt and how to kill animals with spears that could be thrown. Hunting bands were organized with people filling different roles: chasing the animals, throwing spears, processing the animals. Gathering required formal Stage 11 action. Consider basket making as a way to foraging make easier and affective over longer distances. Also consider the problem of knowing when to collect certain food stuff seasonally and not just randomly. The average stage of the population has not changed since humans evolved. It is half below formal Stage 11 and half above.

Agriculture

Agriculture originated and spread in several different areas including the Middle East, Asia, Mesoamerica, and the Andes beginning as early as 12,000 years ago. With agricultural societies, the usefulness of labor increased. This came along with slavery. However, people lived longer and, in evolutionary terms, it was possible to increase the resources and subsistence. The number of people per unit area of land dramatically increased. The life span of men went up. The rate of innovation also increased greatly. Innovations requiring systematic and metasystematic stage bounded. Consider the invention of astronomy to guide planting, the keeping of money and financial records to produce an economy not just based on barter. All of this dramatically increased the size of the population. By the first dynasties of Egypt, population had grown possibly between 1 and 2 million inhabitants. However, Egyptologists tend to dodge the issue of population numbers, as there are no statistics available and all such numbers are based on more or less educated guesswork. For instance, Edward S. Ellis put the New Kingdom population at 5 million. The author of the Royal Ontario Museum website gives an estimate of between 1.5 and 5 million Egyptians during the Pyramid Age, a rather noncommitting number for a nicely vague and long time period.[1]

Crafts

The more stratified organization of agricultural societies and the progressive spatial establishment of people's lives paved the way for the emergence of craftwork. People became specialized in producing certain products. This increased even more the societal organization. Craft people worked in specialized areas that evolved into shops. Started with a single person, shops evolved into having additional crafts people and apprentices. Craftsmen were in charge, making the deals, doing all manner of work by hand and later powered tools, teaching apprentices and being helped by them. There was no standardization. Everything was custom made. Craftwork was a solution for improving the cultural success of local societies, but, still, the one off nature made products expensive and profits very low. Originally coined to the medieval era, craftwork societies established approximately 800 years ago.

Industry

In the industrial age, standardization was the solution for increasing production and profits. The organization was top down. There was not much difference among the workers as to their education and smarts, as they were required to perform repetitive actions, extremely uniformly and quickly. Their roles were tightly controlled. Besides the lower level workers in the organizations, leaders tended to need people at the systematic Stage 12, who would work on sales and marketing. Because profits increased dramatically, monetary circulation also increased, which in turn improved the quality of life of the workers in terms of what was considered basic needs: food, warmth, hygiene.

Information Age

Nowadays, information became a usual way or organizing and carrying out work much more cheaply. Productivity and profit are still up, but this information age allowed that this was coordinated with customized solutions that do not rely on standardized work. Also, people can afford to create their own jobs and have a way higher range of choice for carrying out their lives. The metasystematic Stage 13 performing people stopped working for organizations, become consultants, contractors, small entrepreneurs. For others, the work that they do becomes more subsidized by the government. Increasingly businesses contract for work. Government will increasingly subsidize by paying for it. This has been leading to an increased mobility, less bureaucracy, and lower number of administrative layers. We can predict that long term attractors are likely to be an increased efficiency, profitability and income. As information support becomes universal, smarts became more and more dominant.

At a coarse grain analysis, we call attention for the fact that each change or each new meme allows for productivity increases and population

[1] http://www.rom.on.ca/en#/gallery/recent

growth. As total gross national product went up, individual income and access increased as well. The kinds of goods and services expand. The rights of people increased. Their control of their own work increased. There is an enormous shift from dying in the preagricultural times when conquered to working for food, to receiving recognition and social reinforcements. All these facts underlie population growth over times, especially since agricultural practices were introduced and progressively dominated.

However, it is not only that new memes drive cultural behavior to a higher stage. Also, innovators and those who follow them will be selected, in Darwinist terms. Hence, positive reinforced memes drive evolution along with the naturally selected higher staged individuals that are able to follow up with those new memes. This leads to a selection of the highest behavioral stage performing individuals and reinstates why the emergence of innovative individuals is so important for cultural evolution and for species evolution, which is the object of study of the present work.

Rarity Drives Evolution

It has been defined elsewhere that to innovate "means genuinely transcending existing knowledge and assumptions, and originating understandings previously not known, not conceived, not assumed, and/ or simply not used" and that it implies that the innovator "has novel insights into complex challenges of some kind" (Commons, Ross, & Bresette, 2011, p. 287). This highlights the intriguing fact that innovative individuals cannot be taught to innovate. These individuals are an innovation in themselves because they *emerge*; otherwise, someone else earlier would have done their innovation.

This introduces the notion that innovation is necessarily top–down. The innovators, we repeat, cannot be taught; opposite to this, in order for memes to be introduced, the innovative individuals must be "found" and followers must learn about their inventions and teach others. The followers and learners necessarily perform at a lower stage than the innovator; otherwise, they would be innovators, as well.

The fact that true innovations are rare is exactly because innovators are also rare. They are necessarily rare, once they begin to be the *only one* (or one among very few candidates) figuring out a solution. So, the result of a simple syllogism is that rarity will drive evolution. In probabilistic terms, the rarity is going drive the fact that the rate of innovation is proportional to the size of the society. Bigger is better, which is the premise of the present work.

We do not dismiss the fact that inventions are necessarily built up on previous ones, this being reported since ancient civilizations. Even *truly* disrupting knowledge had its seeds in the scientific and political environment of its era (Farrington, 1944). Hence, along this line, we do not either dismiss that societal organization have always had a tremendous impact on the access to education and to previous knowledge, which has been, as well, documented since early ages. For example, in Greek societies, it was a given fact that only socially high positioned individuals would have access to knowledge and learning and the possibility to engage with their culture's higher systems of thought, whereas the remaining elements of the society were deterministically assigned the only role of executing upon updated scientific strict directions. Nowadays, we still face the consequences of societal organization in terms of access to education and knowledge resources, although we have entered an information era that tends to decrease this gap.

Despite being aware of the multifaceted nature of evolution, as has been initially reported, we will restrict our modeling to available data and to variables that are "operationalizable" and quantifiable. We definitely assume the above issues as worth of discussion, but hold to a probabilistic evolutionary perspective.

Method

The analysis here conducted is based on recent estimates of the average stage of development of nowadays humans. Hence, before proceeding, we will provide some relevant information about the limitations attached to the estimation procedure.

Estimates

First, available estimates of average stage are not based on random or representative samples, which would be the most accurate sampling method. Data were collected mainly through convenience sampling, as surveys were distributed online, and analyzed following a cross-sectional design. Furthermore, the strength of this bias and the direction in which it influenced the results cannot be ascertained. This method can either have led to overestimation or underestimation of average stage.

One the one hand, convenience sampling may have led to an overestimation average stage because the samples were tested through online material. This means that we were collecting data from people with technological access, likely to be more highly educated and also likely to be younger. On the other hand, a cross-sectional data analysis design may have led to an underestimation of average stage because we measured "functional" stage. This means that stage was measured only once, with no support provided and no reinforcement of performance. It has been customary to use the "functional" stage as the "true" stage; however, in line with previous reference to the role of reinforcement, measured stage (in an educated sample) can go up by one stage is support is provided. If, with support, an individual performs a stage above, they might at least be considered transitional to the next stage (Adhikari, 2016; Fischer, Hand, & Russell, 1984).

Despite these limitations, the data collected across previous studies point in the direction of robust estimates. This means that although we cannot assume external reliability, we can ensure internal validity. Recent evidence using data from performance on the laundry test shows that behavioral developmental stage is normally distributed, with each higher stage deviating from the immediately previous by 1 *SD*, and with the average stage shown to be 10.5 which is between the abstract Stage 10 and the formal Stage 11 (Commons et al., 2014). Another study points toward the same direction. It was conducted with senior counseling students, whether bachelor and master beholders, using two different assessment methods (narrative coding and helper person problem). The average stage was shown to be 10.76 ($SD = 0.27$), also between abstract Stage 10 and formal Stage 11. A second version of this study conducted with graduate counseling students showed that the average stage was 10.5 ($SD = 1.67$), again a midpoint between abstract and formal (Miller & Crone-Todd, 2016).

Rationale

Recent evidence from the model of hierarchical complexity shows that stages of development, represented by scalars, are normally distributed in the population, are equally spaced and cannot be skipped (Commons et al., 2014).

Based on this evidence, we reversed the statistical reasoning and calculated the minimum number of individuals that are necessary for a higher staged individual to emerge. In other words, a probability is a value below one, unless it is 100%: so, how many elements are necessary such that, multiplied by the value of the probability (below one), the result is, minimum, the integer one? This result of *one* is the same as saying that, among a certain amount of cases, there will be at least one that falls into the category under probabilistic modeling. Hence, we want to know how many cases are necessary to find at least one that falls within each category of stage.

We know a priori, from a normal distribution, that the probability decreases with the rise in stage. Then, we also know that the amount of individuals necessary to find a higher staged individual will necessarily increase. Once we reverse the calculation and get the number of minimum cases necessary to find one case of each higher stage, we can model the increase in population that is required for the emergence of a higher staged individual (from the average on). This modeling was only performed from the average stage to the highest stage currently known (metacross-paradigmatic Stage 16).

Procedure

First, we transformed the standard deviations into the correspondent one-tailed percentages (*) that correspond to the area under the Gaussian curve which includes the cases in question. Second, we calculated the inverse of this percentage, which indicates the minimum number of elements/events that are required to find one of the cases in question (**). Third, we conducted a regression analysis to estimate the curve that best modeled the rise in stage as a function of the population growth.

Results

In line with some of the limitations of the estimation procedure and to minimize ungrounded generalization of the obtained data, we will zoom in the results to the U.S. population, which is estimated to be composed of 324,180,726 individuals (Worldometers.info, 2016).

The following table (see Table 1) illustrates the steps described above. The sixth column presents the minimum number of elements that is required for a certain staged person to emerge. The seventh column presents the estimates of how many people performing at each stage there are in the United States.

The table shows that higher stage requires an increase in population. In larger populations, the emergence of one person performing at the metasystematic Stage 13 is possible with an increase of the population from 2 to 161 units ($SD = 2.5$ above the mean); at the paradigmatic Stage 14 is possible with an increase to 4,291 ($SD = 3.5$); and at the cross-paradigmatic Stage 15 is possible with an increase to 289,855 ($SD = 4.5$) units.

The regression analysis of the table data showed that the rise in stage, at an evolutionary scale, is strongly and linearly predicted by the natural logarithm of population growth, with $r(3) = .974$ and adjusted $r^2 = .931$, $\rho < .005$. Equation 1 represents the relationship between both variables:

$$\text{Stage} = 10.774 * 0.361 \, [\ln(\text{population size})] \tag{1}$$

This curve fitting model suggests that there was a period in history where population growth saw the highest acceleration, after which it the acceleration of growth started to progressively decrease. It is important to mention that we obviously only have data until nowadays, which limits the reach of our modeling. This fact, in itself, explains why the acceleration is currently null (given no *posterior* data is available, current population size is assumed as a constant).

Discussion

As has been delineated throughout this work, cultural success and rise in stage can be seen as positive feedback loops, where higher Staged solutions increase cultural success and adaptation through the introduction of new memes, which act as attractors. An examination of the cultural memes introduced since *hunter-gatherers* until nowadays *information-age* societies opened up the way for suggesting that cultural adaptation provided for population to increase in number and longevity. Adopting a probabilistic approach, we hypothesized that population growth could be taken as an independent variable to model the rise in stage at an evolutionary scale. We based our assumption on the fact that more individuals mean more variability, which is a requirement for a higher staged individual to *emerge*. We acknowledge that higher staged individuals are historically shown to have received support and reinforcement from the system of thought of their era and to pertain to high sociopolitical status (Farrington, 1944). Nonetheless, higher staged individuals, usually identified as innovators, are *not* taught their inventions. They were *alone* the inventors that brought about a new cohesion among previously segregated knowledge.

Based on a normal distribution of stage of development in nowadays estimates, we obtained a strong correlation, with population growth explaining 93% of rise in stage. Stage grows linearly with the logarithm of population size. The main deduction we can draw from the results is that what matters for explaining evolution through a probabilistic lens is not the amount of elements that compose a group, but a measure of the increase in the number of ele-

Table 1
Stage of Development Distribution Based on The Estimates of Average Stage Among Humans

Order	Stage	*SD*	% population (*)	Inverse of %	Minimum (**)	People in the United States
10.5	Abstract/Formal	0	50%	1/.5	2	162,090,363
12	Systematic	1.5	6.6807%	1/.066807	14.97	21,65,7541
13	Metasystematic	2.5	.621%	1/.00621	161.03	2,013.162
14	Paradigmatic	3.5	.0233%	1/.000233	4,291.46	75,534
15	Cross-paradigmatic	4.5	.000345%	1/.00000345	289,855,07	1,118

ments, or acceleration. This deduction also accounts for explaining why other species, which count with a higher number of elements than the human species, are not seen the same increase in behavior complexity as is seen in humans.

In regards to the variability in the highest stage attained in adulthood, although we do not have data to directly address and measure it across species, we find it a matter of interest to discuss. We assume that variability in the highest stage attained is possibly a monotonous increasing function of the average stage of that population. If modeled across species (or populations), we further add that variability in the highest stage attained possibly takes the natural log of the average stage as the predictor. This speculation based on two facts. One is the obtained curve fitting falling into the category of logarithmic models; the other is the fact that, to our knowledge, chimpanzees are the species that achieve the highest stage after humans, primary Stage 8 or concrete Stage 9 and they are also the only species that shows a variability of one stage in the highest stage attained (Miller et al., 2016). Species that attain lower average stages do not show any variability, at least in studies conducted to date.

Assuming, then, the principal role of acceleration of population growth as a requisite for evolutionary rise in stage, we suggest that the Neolithic Revolution was the fundamental period in history for liberating human's reasoning abilities. The Neolithic Revolution is considered the transition period between the organized societies of hunter-gatherers, who already divided the work to increase the accumulation of resources, to agricultural societies, who became able to apply the most diverse techniques rendering them the ability to control the environment and increase sustainability (Farrington, 1944).

Still highlighting the role of acceleration, we have shown that agricultural practices required the coordination of systems; thus, innovations were bounded by the systematic and metasystematic stages. Nowadays, after 12,500 years and three societies that were established in the meanwhile, innovations are bounded by the paradigmatic and the cross-paradigmatic stages, which correspond to a gap of one to two stages only, when compared to early agricultural societies.

We are aware that the methodology here employed might be considered cyclical or vicious, as we are reversing the reasoning that is substrate for current estimates. Nonetheless, because natural processes are likely to be fractal, we assume as well that what is modeled at one level of analysis might inform upper or lower levels of analysis, as is the case between development and evolution. At a developmental scale, stage of development is shown to increase across life span as a function of the logarithm of age; at an evolutionary scale, developmental stage of one society is shown to increase as a function of the logarithm of population growth, which occurs over time (and time is a linear scale).

Finally, although our results are robust, we do not dismiss the multivariate nature of evolution. It is historically well documented that the sociopolitical environment of individuals, as well as their adaptation needs, dictate not only the content of inventions, but also the access to information (Farrington, 1944). There are studies in the field of individual differences that highlight and, to some extent, explain, the differential content and the differential capacity of problem-solving across countries. Based on socio-politic-economic predictors, the idea of "intelligence of nations" has been put forward (Lynn & Vanhanen, 2002). It is also well documented the role of support and reinforcement at a behavioral level, leading individuals to reveal optimal intellectual capabilities in the face of an optimal reinforcement environment (Adhikari, 2016; Fischer et al., 1984). Thus, if an educational system in one country is more efficient in this regard and more accessible, it is a direct product of it to create a higher staged population.

Conclusion

Given the limitations inherent to our estimates, we are cautious about the generalizing conclusions to the world population. We restrict the concluding remarks to U.S. population, who meets the conditions of data collection to a greater extent (Commons et al., 2014).

In regards to the current era, the United States is where the most diversity exists and where the best universities are concentrated. Consider being a student admitted to the "best" schools as an indicator of high developmental stage. The most successful startup founders include: Bill Gates, Edwin Land, and Mark Zuckerberg, Harvard students; Larry Page and Sergey Brim, Stanford students; Jeff Bezos, Princeton student; Steve Jobs, Reed student. It is estimated they performed at the paradigmatic or above, in line with the order of complexity of current innovations. Following this probabilistic trend, we can expect India to witness the next innovative solutions, as middle class is growing bigger than the United States and Europe together.

It is worth to note here that people who introduce new memes are most likely to be only a subset of these cross-paradigmatic performers. One of the Dare versions of the Holland Scale, these people are likely to be high in the investigative or artistic domains, as well as low on the conventional category. There is probably a tendency for extremely high stage people, that is, cross-paradigmatic Stage 15, to have high interest in investigative, thus, being mostly represented among the scientific community. The Dare version of the Holland Scale is obtainable from Commons@tiac.net.

In terms of future work, in line with the biological probabilistic approach we here employed, it will be interesting to collect data on how the population of different species might have grown in size, so as to compare the correspondent curve fitting models with human's population growth; this comparison will be relevant to corroborate or reject our speculation on the role of acceleration. Also, in line with the multivariate nature of evolution, it will be interesting and important to collect data from a representative sample, if possible, of a rich country, of an in-development country and of an underdeveloped country, so as to compare the average stage of each population. Although this comparison is only possible in a cross-sectional design, it might provide a socioeconomic-political vector upon which to further understand the differential evolution in stage of subpopulations.

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Received August 3, 2016
Revision received September 13, 2016
Accepted September 13, 2016 ■