The boundaries of right and wrong

Learning and the human brain

—by John N. Hatzopoulos

From among the many definitions of the term "global development," I interpret this to mean a phenomenon with two possible manifestations—how things are and how they should be. Running between these two manifestations of development are learning stages that may not be immediately obvious and whose outcomes may be difficult to predict. Recently, it's been Internet-based technology and learning that have helped redefine how we think and perform certain activities so as to avoid making mistakes.

Not all change is necessarily for the best. Serious problems may arise if we approach it the wrong way. Climate change, for instance, may indeed occur if we do not cap greenhouse emissions worldwide, Developing intensive beef ranching in the Amazon region may improve our diets but, at what cost to the world's climate if the region's rainforest is destroyed? Any action that's not well thought out can lead even the best laid out plans astray.

Behind everything we think and do is the human mind. A mind that cannot or will not learn is a sick mind, a destructive mind. A constructive mind is a healthy mind, an educated mind. The capacity and willingness to learn thus reach beyond the production and transfer of knowledge; combined, they create a healthy mind. Possessed of a healthy, educated mind, we develop clear boundaries of wrong and right in facing life's challenges.

Learning is a function of the human brain. Fresh neurons (brain cells) arise in the hippocampus, a structure involved in learning and memory, every day. New research suggests that the cells ultimately help with learning complex tasks and, that they may play a role in predicting the future based on past experience. In this article, I examine how these boundaries can be defined using the ancient Greeks' notion of learning in a three-dimensional space— the "correct space."

Aristotle's "midway of virtue"

Let's assume that a person walking on a flat ground is facing an obstacle on the way as shown in Figure 1. The person must lift a foot to get over the obstacle and continue walking. The trick is how high can the foot go without risking making a false step.

The perfect way to lift a foot would be to do so with minimum energy and minimum risk, but this perfection is rarely possible since neurons are not perfect, except by accident. There is, however, an upper and a lower bound around the perfect lift, a mid-space, if you will, where one can surmount an obstacle without a false step. Aristotle calls this mid-space the "midway of virtue" in his treatise entitled "*The Nikomachean Ethics*."

Lifting the foot below the lower bound will result in a false step—a human error caused by underestimation. If the foot is lifted beyond the upper bound, the resulting error is due to overestimation. The magnitude of the error ranges from temporary loss of balance and return to normal position to a fall causing serious injury.

Expressed numerically, these error states will range from zero to minus infinity and from zero to plus infinity. Computer simulation has shown that neuron-based structures can be trained to approach perfection at any desirable precision but never with zero error. Similarly, a child will likely make a false step the first time he or she tries to walk over an obstacle, but with continuing effort the neuron structures of the brain will become "*educated,*" and the child will become experienced in lifting the foot perfectly.

In the case I just described, the boundaries of wrong and right are clearly defined. Note also that within the "midway of virtue" shown in Figure 1 there is almost an infinite number of correct ways of lifting the foot and crossing over an obstacle. However, this diversity of correct choices exists only within the correct space, i.e., the midway of virtue. Any action outside this optimum for dealing with an obstacle could be assumed to result from lack of education [experience] or to be done on purpose, so as to harm oneself.

Thus, on both ends of Aristotle's midway we have the extreme positions of "badness" and in the mid-space is "virtue." Let's name these extremes as "cowardice" and "provocativeness." A coward could then be described as a person committing an error by underestimating virtue (marked with a negative sign). Provocative people may also find themselves committing an error, but they would be doing so by overestimating virtue, and the error will have a plus sign. Virtuous people are thus in the mid-space.

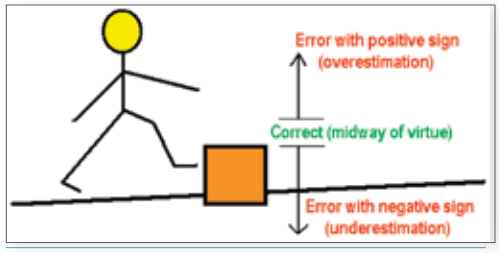

Figure 1. The boundaries of human error.

Aristotle further defines a person of virtue *as a person who makes a conscious* effort, through education, to maintain actions within the midway of virtue and, thus, minimize error. Anybody can aspire to acquiring education at any time and so "become a person of virtue" (it's *never too late!*).

The Aristotelian midway of virtue has universal validity. Let's use as an example the Earth's orbits around the Sun. The paths

of the Earth around the Sun are never exactly the same, but, in order for the Earth to maintain equilibrium, the orbits must occur in the midway. If the Earth gets too close to the inner bound of the midway, it could collide with the Sun; if the Earth gets closer to the outer bounds, it may "wander off" into the space.

From Figure 1 it can be deduced that human thought and actions can be sometimes correct and at other times erroneous, i.e. that the states of right and wrong coexist in anything we think and do, and that they are inversely proportional to each other. Mathematically expressed, if a human thought or action has an error of magnitude X, then the same thought or action is correct to a magnitude Y, so that:

$$Y = 1/X \qquad (1)$$

Which means that the more correct an action is, the less error is present in this action and conversely, the more erroneous an action is, the less correct this action is.

Another observation related to this analysis is that not all neurons of the human brain are susceptible to training. In particular, neurons controlling the actions of organs, such as stomach, heart, liver, etc. are untrainable because they have already been trained by nature.

The 3-D mind space

Human mind is a complex system occupying a space where logic, feelings, thought, imagination, desire, anger, joy, sorrow, and other states of the mind reside. It is apparent that most of these states depend on or are the result of other states of the mind. Sorrow, for example, occurs if the state of desire and joy is not reached.

In his book "*The Republic*," Plato describes logic, desire, and anger as the three basic states of the human mind which produce all other states. This categorization also helps to define the ideal state of the mind where an action is absolutely correct, i.e., it has zero error. According to Plato, this state of absolute correctness occurs when the logic state balances the other two states of desire and anger. Famously, Plato likens

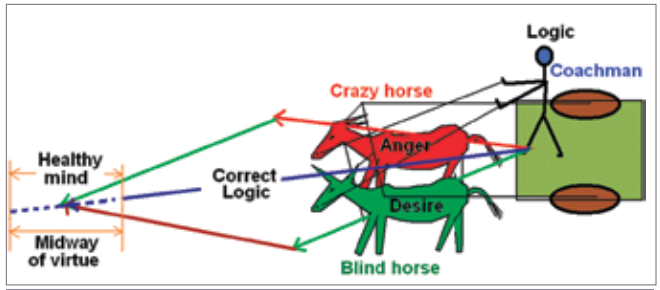

Figure 2. Plato's path to a healthy mind.

desire to a blind horse, anger to a crazy horse, and logic to the coachman urging the two horses to move the coach in the right direction (See Figure 2).

Plato's analogy leads us to a representation of the absolutely correct mind as an equilibrium between three forces: Logic (L), Desire (D), and Anger (A) (Figure 3). The key element in this equilibrium is logic. We distinguish between two types of logic—current logic (L) which drives our actions and ideal logic (L_B) which balances our desire and anger. Perfect logic is an ideal, absolutely correct state of the human mind expressed by the Pythagoras theorem:

$$L_B^2 = D^2 + A^2 \qquad (2)$$

It is interesting to notice that the difference of current logic L minus the balancing logic L_B defines the human error:

$$\text{Human error} = L - L_B \qquad (3)$$

If human error is an absolute value bellow a certain threshold limit, then the corresponding state of mind above this threshold is a healthy mind (see Figure 2), and the action taken by a healthy mind is thus the correct action. This finding is in agreement with the definition of "right" and "wrong" ["correct" and "erroneous"] action in relation to Aristotle's midway of virtue.

The three basic states of the human mind (D, A, L), when connected by lines form a three-dimensional system representing any mind state M_S(D,A,L) (Figure 3c). This 3-D system is quite similar to the 3-D geometric space used by surveyors to

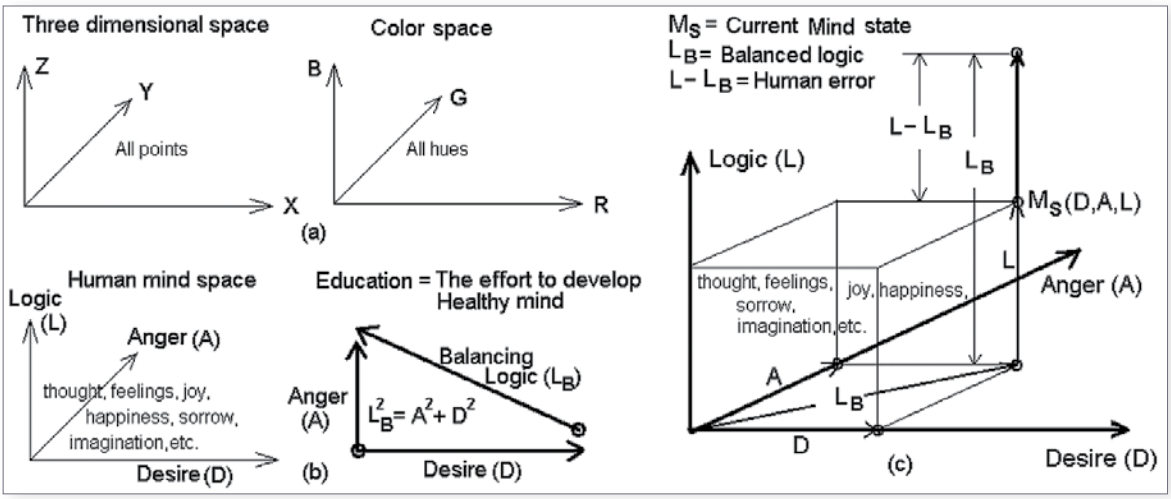

Figure 3. Three dimensional spaces: (a) Geometric and color space, (b) Human mind space, (c) Coordinates of human mind state.

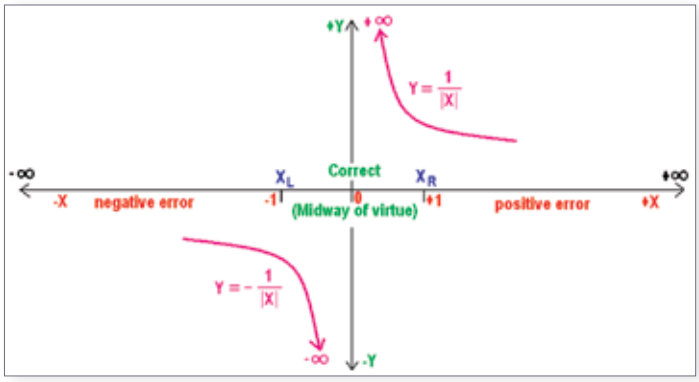

Figure 4. Graphical representation of wrong and right.

represent any point with three coordinates (X, Y, Z) (Figure 3a). It is also quite similar to the 3-D color space used to represent any color hue with three values of primary colors (R, G, B; Figure 3a).

Surveying the boundaries of wrong and right

Let us establish axis X to render human error from 0 to -∞ and from 0 to +∞. The correct location or midway of virtue is defined by the boundary points X_L and X_R which are located in the vicinity of zero error (see Figure 4).

If we apply a surveyor's logic to Equation (1), we will conclude that on a straight line between X and Y this particular function must give exactly the same value, i.e., it must be X=Y. This kind of thinking is commonly used to define the elevation along the common boundary of two adjacent cells in digital terrain models. Substituting in Equation (1) X=Y we obtain:

$$X = 1/X \rightarrow X^2 = 1, \text{ or, } X = \pm 1 \qquad (4)$$

Equation (4) defines mathematically the boundaries of wrong and right:

$$X_L = -1 \text{ and } X_R = +1 \qquad (5)$$

From Equation (1) and Figure 4, it is evident that:

$$\text{for } |X| \rightarrow 0 \quad \text{then} \quad Y \rightarrow \text{infinity} \qquad (6)$$

Equation (6) tells us that if there is a human being with zero error, its virtue ranges from -∞ to +∞, which means it is an absolutely perfect being. The symmetry of the curve also indicates an absolute harmony in such a being.

I've used Aristotle's definition of the midway of virtue to describe the "space of correct action by humans," but it is important to note that a similar process exists for determining the midway or mean values of natural objects.

For example, to locate the middle of a straight line segment, a surveyor will measure angles and distances, perform mathematical calculations and statistical treatment of measurements, and conclude: "the middle point of the straight line segment is here (marked with a nail or a stake), with 95% probability of having error less than one centimetre."

The process of locating the midway of virtue is not an easy task, because people may perceive the midway to occupy different space. When this space is "located" with as much consensus among people as possible, error and bias can be kept to a minimum.

Let us assume that individual voters cast their votes in the appropriate location on the X-axis, and the number of votes is shown on the Z-axis (Figure 5). We also assume that "all humans know their error." This may sounds strange, but it's true. Voters, for instance, have their positions clearly defined by their political parties, and, unless disillusionment sets in, they will vote on those positions believing that to do otherwise would be "erroneous." The sentence meted out to a criminal by the justice system is, ideally, in direct proportion to the gravity of error committed by the criminal—another variation of "knowing the error."

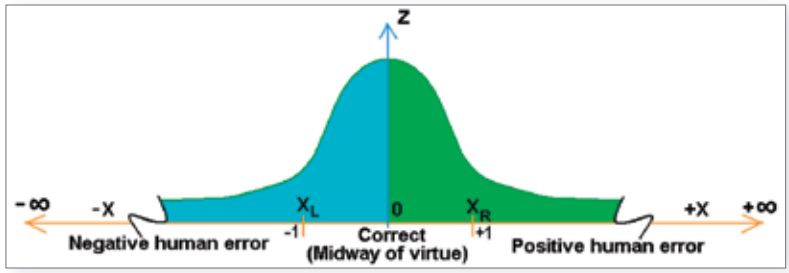

Figure 5. The midway of virtue for voting.

In situations with minimum bias, people's thoughts and actions occupy the space between -1 and +1. From Figure 5, and, assuming a normal distribution for voters, then, the function Z = f(X) is represented by the standard normal distribution of the Gauss curve. Note that this distribution has a mean of zero and a variance of one ($\mu = 0, \sigma = \pm 1$). Given these values and because the Gauss curve in the location $\sigma = \pm 1$ changes the radius of curvature, the correct or midway of virtue chosen by the voters can also be defined geometrically.

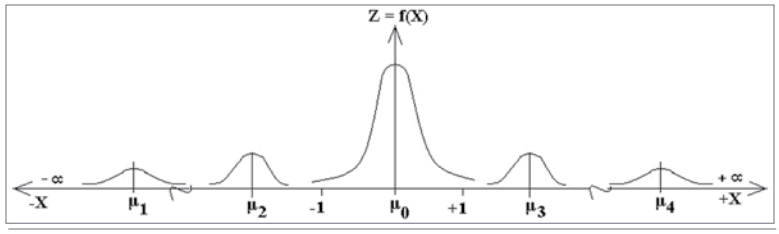

Figure 6. A society composed of groups with different biases $\mu_1, \mu_2, \ldots, \mu_n$.

If an ideal voting situation resembles the representation in Figure 5, what might real-life voting scenario look like? The answer to this question is in Figure 6 where, various groups of people characterized by their biases $\mu_1, \mu_2, \ldots, \mu_n$ are ordered along the X-axis in a symmetric order to maintain peace. This, of course, is a goal worthy of most human endeavor.

Born in Greece, **Professor John N. Hatzopoulos**, is involved in teaching, research, and consulting in geomatics engineering, geospatial information science and technology, and computer-related applications. In addition to contributing to scientific journals, Prof. Hatzopoulos authored two books—*Practical Philosophy of Thought and Virtue* (2004) and *Topographic Mapping* (2008). He will answer questions about this article at: <ihatz@aegean.gr>; URL: http://www.aegean.gr/environment/labs/Remote_sensing/EnglishBlock/Remote_sensing2.htm.