Opinion and Perspectives

Autism and the Interplay of Deterministic and Quantum Information Processing in the Act of Creation

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Abstract

Autistics' preference for invariant knowledge and their rejection of change led the author to hypothesize that the ability to preserve known schemes is a necessary but insufficient element for developing the human capacity to solve problems, uncover new truths, and re-create the world. This proposition can be falsified by examining two derivatives. The first one is that autistics' ability to pass recognition tests arises from an undivided attention and intention that value the truths one recognizes and reject what contradicts that information—similar to the deterministic stance of classical computational logic. The second derivative is that autistics fail false-belief tests because they lack the divided attention and intention that value simultaneously what one knows and what contradicts that knowledge—which is analogous to the ambiguity that surrounds quantum phenomena. Research on autism may lead to an understanding of the interplay of deterministic and quantum information processing in the act of creation.

Key Words: autism, deterministic information processing, quantum information processing, creativity

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Introduction

Autism, Early Philosophy, Quantum Physics, and Neural Quantum Computing

In 1996, the author (Cassella, 1997) proved that our attachment to repetitive knowledge (within deterministic neural computing) is spared in autism. At the same time, he corroborated that our attraction to ambiguous propositions (within flexible neural computing) is impaired in that syndrome (Baron-Cohen *et al.,* 1985). The experiment with autistic subjects discussed in this article suggests that sustained research on autism may lead to an understanding of the play of deterministic and flexible information processing in the act of creation.

Twenty-five hundred years ago, the Ionian philosopher Heraclitus suggested that the tension generated by embracing opposite interpretations of a sign (for example, truth and falsity, *being and nonbeing*, or 1 and 0 within quantum computational logic) re-creates reality (Cappelletti, 1969). His view implies that the gate to creativity lies in the crossroads of diametrical worlds. That crossroads agrees with the ghostly act of *sharing the same space with something else at the same time*, as well as with the fantastic act of seeking the new by *walking along divergent paths simultaneously*, which entails an infinite "speed." Understandably, the Italian Parmenides criticized Heraclitus's seemingly absurd thought by contending that knowledge of reality "is" only about

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what remains unchanged. His *being, as opposed to nonbeing,* agrees with the perfect order and repetition sought by the autistic side of our minds, the rejection of novelty, and the pedestrian perception that *two objects cannot share the same space at the same time* and that *one object cannot lie simultaneously in separate places*. Within quantum physics, the confrontation between being and nonbeing (or 1 and 0) may be linked to the dislike of massive, polarized particles—for example, electrons—to share the same stochastic orbital (a consequence of *Pauli exclusion principle*). And yet the embrace of an electron and a positron behind a photon and the interference of a photon with itself along the split components of a beam of light indicate that non-locality is more than a metaphor.

Autistics cannot take the place of someone else while they remain in their place or enjoy the eerie clash of yes and no in the word "maybe." As with Parmenides, they dislike doubt because their isolated, deterministic neural computing network compels them to view ambiguity as if it were madness. Eventually, sustained research on their difficulty in dealing with novelty will lead us all to a better view of the play of permanence and change in nature and the mind.

From Autism to Neural Distributed Hierarchy

According to DSM-IV-TR (APA, 2000), poor eye contact, idiosyncratic language, repetitive behavior, an abnormal interest in restricted patterns, and a lack of spontaneous make-believe play are the key traits that reveal the presence of autism in a child. The adopted working rate of the prevalence of autism in the world is 10/10,000 (Fombonne, 2006). Prenatal brain damage in autistics hurls postnatal neural organization into a deviant plan of development (Bauman and Kemper, 2006). An intact capacity for imitation (Baron-Cohen, 1993), an undivided attention and intention, and the penchant for shared order allow autistics to respond to behavior-modification techniques that help them acquire shared and unchanging schemes so that they can navigate the world. Nevertheless, clashing meanings, mishaps, and unpredictable changes frequently disrupt the implementation of the familiar sequences that autistics are fond of. When that happens, their inability to display a divided attention and intention leads to deep disappointments, tantrums, and self-aggressive behavior. Consequently, working with autistics is extremely demanding. And yet, an understanding of the psychological nature of autism may allow us to uncover the genetic blueprint that compels autistics and the autistic side of our minds to preserve known patterns and the blueprint that invites us, but not autistics, to find new patterns. A step in that direction may come if we consider a central hypothesis:

The mental ability to preserve known schemes is a necessary but insufficient element for developing the human capacity to solve problems, uncover new truths, and recreate the world.

Keeping in mind this hypothesis when examining the implications of autistics' successes and failures in neuropsychological texts leads to the four propositions of a hypothetical distributed hierarchy (Logos, or Λ) at the source of creative intelligence:

1. Sequence—a deterministic, classical-like mode of neural computing—allows us to conserve, recognize, and use familiar information;
2. simultaneity—a flexible, quantum-like mode—helps us integrate competing views when gathering new information.
3. the two networks complement each other within natural development and social progress;
4. natural and social systems fall apart when deterministic and quantum-like information processing become disjointed.

Logos's propositions will be developed in the remaining sections.

Background

Autism and the Act of Creation

Kanner (1943), the psychiatrist who first described the strange behavior of autistics, suggested that their predicament arises from inadequate nurturing; Asperger (1944) proposed that autistics' dysfunctions have an organic origin; and Rimland (1964) proved that autism is unrelated to modes of parenting. Studies of identical twins and of siblings of autistic children, the finding of a

sex ratio of 4 to 1 (male to female) in autism, and evidence of abnormal fetal development picked up in the autopsy of the brains of 20 autistics (Bauman and Kemper, 2006) validate Asperger's pioneering view.

Autism imprisons its victims in a structure of restricted repetitive behaviors and a diminished ability to uncover or accept new truths, interact socially, and communicate flexibly. (For example, most autistics become confused when they are faced with new arrangements of furniture, strangers, and crossed interpretations of the same sign—as given in humor and irony.)

According to the theory of weak central coherence, the diminished creativity in autistics is connected to their inability to integrate information from disconnected sources (Happé and Frith, 2006). And according to the theory-of-mind theory, autistics' diminished social interaction is due to their difficulty in seeing the mental states of others (Baron-Cohen, 1993, 1995; Baron-Cohen *et al.*, 1985). Tager-Flusberg and Anderson (1991) emphasized that autistics' limitations in communicating flexibly stem from their blindness to nuances of meaning, and Happé (1994) attributed this to their inability to discern contextual clues, metaphors, and puns.

The common denominator of most theories on autism is autistics' inability to deal with ambiguity, which accords with their partiality for order and their horror of errors. To autistics and the autistic side of our minds, errors belong to intolerable chaos. However, dealing with doubt means valuing chaos, which autistics cannot do. Thus, uncovering the reasons behind their mental blindness will lead to an understanding of the absurd and creative ways of our artistic side.

Shakespearean plays are a good example of the ambiguous world in which we listen simultaneously to the voice of common knowledge and the voice of chaotic madness. Hamlet's words "to be or not to be" suggest that his readiness to deal with doubt will help him uncover hidden truths. If the Prince of Denmark were schizophrenic, after listening to the testimony of his father's ghost, he would kill the former king's assassin—his uncle Claudius. Conversely, if he were autistic (the opposite of schizophrenic), he would never suspect that the seemingly honest mien of Claudius hid a murderer, and he would then marry Ophelia. Hamlet is neither schizophrenic nor autistic, and yet in the process of pondering the dilemma of the guilt or innocence of Claudius, he is both schizophrenic and autistic. Hamlet's attraction to both wild fantasy and a shared reality opens the gates to the exciting and terrifying path to knowledge through which he finds out the truth about his father's death.

The Search for Nature's Nature in Ancient Philosophy

Two millennia before Shakespeare, philosophers in Ionia, Southern Italy, and China wondered about the true nature of what we all see or believe in.

In the fifth century BC, the Ephesian Heraclitus suggested that the invisible tension that simultaneously joins and separates opposite tenets—within *being-and-nonbeing*—generates worlds caught up in permanent change. In his very words:

> They do not apprehend how being split it is rejoined with itself: there is a front-to-back stretching, as in the bow and the lyre. (Cappelletti, 1969, p. 61)

From the Italian city of Elea, Parmenides retorted that change and multiplicity are illusory. In his view, beyond unchanging *being* lies only worthless *nonbeing*. Hence, knowledge is conserved when we pit the way of being (the real, mathematical truths, certainty, perfection, shared order, or the known) against the way of nonbeing (the unreal, falsity, uncertainty, imperfection, chaos, or the unknowable) (Figure 1).

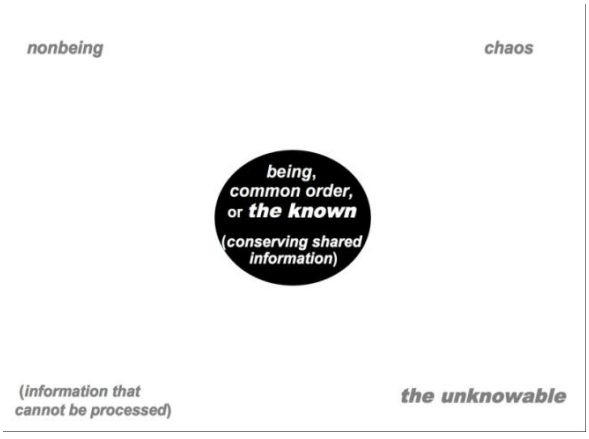

Figure 1. The confrontation between order and chaos

These beliefs led Parmenides to criticize Heraclitus with heated words (Cerri, 1999, p. 151):

> People with two heads, . . . blind . . . and foolish, who think that being and nonbeing are and are not the same thing

Due to his bias toward the perfect control that conserves unchanging being, Parmenides did not recognize that in finding new knowledge, we obtain help from the less-than-perfect control that supports being-and-nonbeing, which is framed between the perfect control attached to being and the absolute lack of control intrinsic to nonbeing (Figure 2).

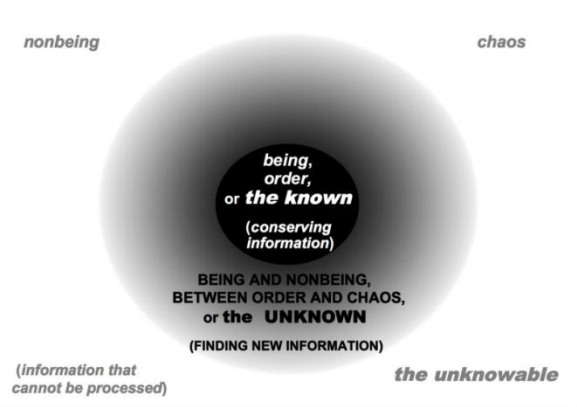

Figure 2. The interplay between order and chaos.

In the fourth century BC, Aristotle praised the path of being—as opposed to nonbeing—opened up by the Eleatic school and based classical logic and physics on a rejection of ambiguity. That's why, echoing the words of Parmenides, he wrote (*Metaphysics*, 4 3:1005 b23):

> For it is impossible that somebody comes to believe that the same thing is and is not simultaneously, as some think that Heraclitus says.

Aristotle never noticed that the reality of being-and-nonbeing was masterfully proved by Plato in his dialogue *Parmenides*. In it, a fictitious Parmenides offers Socrates a chain of reasoning that reaches the unavoidable conclusion that the parts of any natural system are and are not at the same time. The logical and simultaneously absurd views of Plato/Parmenides imply that the development of any natural system is driven by the distributed hierarchy created by the dance of being-as-opposed-to-nonbeing (or deterministic computing) and being-and-nonbeing (or flexible computing).

Heraclitus's vision can be paired with Lao Tzu's emphasis on the search for novelty in the unknown reality that lies between known order and unknowable chaos (Figure 2.); and Parmenides' eagerness for choosing order over chaos (Figure 1.) can be paired with Confucius's praise of tradition, rites, and obedience to central authority.

The views of Heraclitus and Lao Tzu remain obscure to the present day. By contrast, the alleged clarity preached by Parmenides and Confucius has furthered ways of controlling nonhuman species through classical science and other human beings through empowered authority. However, quantum physicists stress that ambiguous less-than-perfection is as real as deterministic perfection.

The implication is that an understanding of the nature of autism might prove or disprove the hypothesis that perfection and less-than-perfection are complementary in nature and in humane societies. That possibility is implied in Rappaport's (1997) recognition of the difference between a deterministic and an ambiguous mode of learning. In Rappaport's words:

> The mind may follow at times more deterministic paths, based, for example, on learned strategies or well defined problem-solving techniques, while at other times it follows less predictable avenues based on the presence of contextual information. (P. 326).

The deterministic path is exemplified by the success of autistics in recognition tests and the perfect reliability sought in classical physics and computing. The existence of less-than-perfect paths is exemplified by autistics' failure in false-belief tests (Baron-Cohen, 1993; Baron-Cohen *et al.,* 1985) and the ambiguous embrace of mutually exclusive tenets in quantum information processing.

The next subsection reviews key aspects of quantum information processing; and the following subsection, of key neuropsychological tests in which autistics fail and tests in which they succeed.

A Brief Review of Quantum Information Processing

Lloyd (2006) stressed that processing information through the quantum bits—or qubits—that arise from an embrace of opposite states (for example, 1 and 0) would accomplish calculations that would be impossible to achieve by processing information through digital bits, which rest on the need to choose 1 over 0, or vice versa.

Computer scientists theorize that the superior performance of a quantum computer over a classical computer would rest on the non-locality of entanglement (an instantaneous "correlation" between two particles, whatever the distance that separates them) and superposition (the "existence" of the same particle in different places at once).[2-3] The difficulty of controlling decoherence (or the process by which qubits exit the non-locality of a quantum state and collapse into the locality of a classical state) and the erosion of our common sense have hampered the manufacture of an effective quantum computer.

At this point in time we cannot fathom the relationship between entanglement, superposition, Pauli exclusion principle (*electrons with the same quantum state are averse to sharing the same subatomic orbital*), a theoretical anti-exclusion principle (*an electron and a positron may meet behind a photon*), and Heisenberg indeterminacy principle (*we cannot measure simultaneously the momentum and the position of an electron*). The phenomenon by which electrons change into photons by rotating 180 degrees in an extra dimension (Icke, 1995) and experiments in which an electron or a photon may pass through two slits simultaneously (Lloyd, 2006) add to the challenge of explaining the interplay between the certainty found in observable locality and the ambiguity that arises in unfathomable quantum non-locality.

Exploring the odd performance of autistics in neuropsychological tests—in particular, the findings that they fail false-belief tasks (Baron-Cohen, 1993; Baron-Cohen *et al.,* 1985), pass other-recognition tests (Perner, 1991), and pass self-recognition tests (Cassella, 1997)—may explain the strange relationship between the certainty sought through classical computational logic and the ambiguity that opens the gates to quantum information processing in creative thought.

The Odd Performance of Autistics in False-Belief and in Self-Recognition Tests

The neuropsychological literature labels as theory of mind (Wimmer and Perner, 1983) the aspect of intelligence impaired in autism (Baron-Cohen *et al.,* 1985)—one that allows nonautistic probands to pass false-belief tests (Dennett, 1978).

Here is one of the two false-belief scenarios the author used in 1996 in one of his experiments with autistics:[4] Experimental subjects were asked to look at two dolls—a boy called Bob and Bob's dad—who were playing a game. The subjects were then shown that Bob placed the game in the closet before leaving the room momentarily. They also saw that Dad moved the game to a toy box while Bob was out. At this point, a researcher asked an experimental subject where would Bob (who was about to enter the room) look for the game. Normal children, as a rule, would answer that Bob would look in the closet, where he left it. By contrast, autistics would say—as the author's autistic experimental subjects did—that he would search for it in the box, where the game was located.

Autistics' failure in false-belief tests has been confirmed in numerous experiments. A coherent theory on the reasons for that failure has yet to be found. But a coherent theory might emerge if we understood why in passing Zaitchik's Photo Task (Zaitchik, 1990) autistics surpass normal subjects by two to one (Perner, 1991).

Normal children pass Zaitchik's Photo Task (a test on the ability to recognize the existence of the other over time) around

[2]In this article quantum superposition is circumscribed to being in several places at the same time.

[3]The affirmation that photons may coexist in the same state simultaneously—as in a laser beam—reflects a mode of existence attached to locality and not the virtual reality inherent in non-locality.

[4]The results are given in "Experimental Section."

the age of four to five years—the same age at which they pass false belief. This finding indicated to Perner that the two tasks are of the same complexity. In brief, both tasks call for linking one representation with another (or metarepresentation). In Zaitchik's Photo Task, Ernie, a *Sesame Street* character, takes a picture of his friend Bert lying on a mat. Bert leaves, and Big Bird takes Bert's place on the mat. Pointing at the developed picture without showing its content, an experimenter asks the subject, "In the picture, who lies on the mat?" Acting in a way seemingly opposite to their behavior in false-belief tests, autistics answer Bert although they see Big Bird lying on the mat.

Another task that calls for the capacity to metarepresent is Proper Self (Povinelli *et al.,* 1996). Its protocol allows researchers to measure the capacity to recognize the self over time. In the task, the leading experimenter stands beside a seated subject. A helper takes a picture of the subject and the experimenter while the latter is on the verge of surreptitiously placing a sticker on the subject's head. In a second picture, the sticker resting on the top of the unsuspecting person's head is clearly visible. The experimental subject passes the test if he or she takes the sticker off upon seeing one or both pictures.

The next section reinterprets the author's experiment with autistics in order to examine the central hypothesis in this article.

Experimental Section

In 1996, the author compared the predicted performance of autistics in false-belief tests with their unknown behavior in Proper Self under the protocols described in the previous subsection. Table 1 shows the data and the results.

Table 1. Measurements of dichotomic and continuous variables. N = 18. Legend: (A) IN: Subjects' identification number; (1) CA: Chronological age—years-months; (2) PS: Proper Self—P (Pass) or F (Fail); (3) FB: False Belief—P or F; (4) V-IQ: K-BIT (Kaufman Brief Intelligence Test) verbal IQ—%; (5) P-IQ: K-BIT Performance IQ—%; (6) C-IQ: K-BIT Composite IQ—%; (7) PPVT-S: PPVT (Peabody Picture Vocabulary Test)-Standard—%; (8) PPVT-MA: PPVT Mental Age—years-months; (9) CELF: Clinical Evaluation of Language Fundamentals—a measure of the capacity to metarepresent—20 points maximum.[5] Out of 16 subjects tested for Proper Self, nine passed it (seven high-functioning autistics and the two nonautistic subjects). Another key result is that the two nonautistic subjects (IN 4 and 14) who passed false belief also passed Proper Self.

(A) IN	(1) CA	(2) PS	(3) FB	(4) V-IQ	(5) P-IQ	(6) C-IQ	(7) PPVT-S	(8) PPVT-MA	(9) CELF
06	20;3	P	F	43	46	40	0	5;10	8
03	15;1	P	F	40	40	40	40	2;10	4
12	21;1	P	F	40	43	40	40	4;1	5
07	20;8	P	F	42	65	49	40	5;6	9
04	17;10	P	P	130	113	124	108	25;3	20
08	15;09	P	F	40	40	40	40	4;7	8
09	17;10	F	F	floor	floor	floor	40	2;7	floor
02	14;01	F	F	floor	floor	floor	40	floor	floor
11	17;10	F	F	40	40	40	40	4;2	9
05	14;06	F	F	40	40	40	40	3;10	4
10	17;01	F	F	floor	floor	floor	40	2;10	3
01	14;08	F	F	40	40	40	40	3;1	9
14	17;10	P	P	113	96	105	113	10;1	20
15	12;07	P	F	68	88	76	46	5;10	10
17	11;11	F	F	54	40	42	46	5;9	NA
13	13;11	P	F	74	65	66	40	5;8	11
16	16;00	Invalid	F	40	40	40	40	3;09	3
18	10;04	Invalid	F	40	40	40	40	2;09	9

[5]The team that measured the nine variables was headed by Dr. Helen Tager-Flusberg (University of Massachusetts) and by the author (Harvard University).

The results detailed in Table 1 corroborate the prediction that autistic subjects will fail false belief. Further, the fact that autistic subjects in the author's sample passed Proper Self proves that the underlying neural network is different from the network detected by false belief. This view is strengthened by arranging the nine variables (among them Proper Self, false belief, performance IQ, and verbal IQ) in a matrix of point-biserial correlations (Table 2).

Table 2. Bivariate correlation matrix of the nine variables considered. N = 18, two-tailed statistical analysis based on point-biserial correlations. *Confidence interval of (1-0.05) x 100%. **Confidence interval of (1-0.01) x 100%. NC means not computable.

	(1) CA	(2) PS	(3) FB	(4) V- IQ	(5) P-IQ	(6) C-IQ	(7) PPVT-S	(8) PPVT-MA	(9) CELF
(1) CA	1.00	.15	.19	.28	.16	.23	.26	.05	.22
(2) PS	.15	1.00	.33	.41	.54*	.46	.32	.36	.50
(3) FB	.19	.33	1.00	.92**	NC	.91**	.99**	.84**	.85**
(4) V-IQ	.28	.41	.92**	1.00	.93**	.98**	.93**	.88**	.87**
(5) P-IQ	.16	.54*	NC	.93**	1.00	.97**	.83**	.82**	.86**
(6) C-IQ	.23	.46	.91**	.98**	.97**	1.00	.91**	.88**	.89**
(7) PPVT-S	.26	.32	.99**	.93**	.83**	.91**	1.00	.82**	.84**
(8) PPVT-MA	.05	.36	.84*	.88**	.82**	.88**	.82**	1.00	.76**
(9) CELF	.22	.50	.85**	.87**	.86**	.89**	.84**	.76**	1.00

The matrix shows that Proper Self and false belief do not correlate with each other and that Proper Self correlates only with performance IQ.

In 1991, Perner concluded that passing Zaitchik's Photo Task is a necessary but insufficient condition for passing false belief. Similarly, the author (Cassella, 1997) concluded that passing Proper Self is also a necessary and insufficient condition for passing false belief. The falsifiability of Perner's and the author's conclusions is given by the prediction that autistics will succeed in tasks based on the capacity for performance IQ (for example, Proper Self and Zaitchik's Photo Task) and fail in tasks that lean on verbal IQ (for instance, false belief). At present, they also support the following array of falsifiable assumptions:

- Proper Self and Zaitchik's Photo Task tap a primary and deterministic neural computing network;
- autistics' success in Proper Self and Zaitchik's Photo Task reflects their reliance on our deterministic approach to acquiring, conserving, and using familiar information;
- false belief taps a secondary and flexible neural computing network;
- autistics' failure in false belief suggests damage to that network;
- the development of our primary mode of neural computing constitutes a necessary yet insufficient condition for developing the secondary mode;
- our flexible network piggybacks on the deterministic one in an effort to uncover new information and adapt to unpredictable change.

This array sustains the central hypothesis that *the ability to preserve known schemes is a necessary but insufficient element for developing the human capacity to solve problems, uncover new truths, and recreate the world*.

In the next section, the author deals with the fundamentals of our primary neural computing network (the first proposition of Logos), of our secondary network (the second proposition), and of their potential complementarity (the third proposition).

Discussion

Weighing up a classical and a quantum derivative of the central hypothesis may help us uncover the psychological roots of autistics' success in recognition tests and their failure in false-belief tasks.

The classical derivative theorizes that autistics' ability to pass recognition tests arises from the undivided attention and intention that value what one knows (being, or 1) and reject what contradicts that knowledge (nonbeing, or 0)—which resembles the deterministic stance of classical computational logic; and the quantum derivative, that autistics fail false-belief tests because they lack the divided attention and intention that value simultaneously what one knows and what contradicts that knowledge (or 1 and 0)—which evokes the ambiguity that feeds quantum information processing in the subatomic world.

The exploration of autistics' restricted repetitive behavior and interests opens the discussion.

The Psychological Roots of the Neural Computing Network That Is Intact in Autism

Keeping in mind the classical derivative allows us to approach the possible grounds for autistics' success in recognition tests: (a) Non-retarded autistics perform exceedingly well in Zaitchik's Photo Task because they remember, with a dogged certainty, that Bert and Big Bird sat on the mat one after the other, or in a sequence; non retarded autistics remember exactly what happened to Bert, Big Bird, and the mat because they are free from the interference caused by our normal bent for ambiguity and because neural equivalents of Pauli and an implied anti-superposition principle (*the same elementary particle cannot exist in two or more places at the same time*) lead them to believe that objects and concepts exist only if they are found in one piece and one place at a time; (b) in Zaitchik, normal subjects fall behind autistics because, upon being asked about who lies on the mat in the picture, a penchant for valuing competing answers to a question (within quantum non-locality) invites them to see Bert and Big Bird sharing the same place simultaneously on the mat—in a manner that evokes the anti-exclusion principle; and (c) the author's seven autistic subjects and two nonautistic subjects succeeded in Proper Self and removed the sticker from the top of their heads because their primary adherence to neural equivalents of Pauli and anti-superposition allowed them to stop a schizophrenic attempt to disrupt the prototypical representation of the conscious self.

The success of high-functioning autistics in Zaitchik's Photo Task and Proper Self suggests that they are like normal individuals in linking prototypical conceptual schemes so as to produce unequivocal cause-effect schemes within a metarepresentational mode of undivided attention and intention that eludes nonhuman animals. In general, all autistics are compelled to choose what they consider true (being, or "1") over what they deem untrue (nonbeing, or "0") by neural rules that match the rigidity of classical computational logic, Pauli exclusion principle—or Pauli—and the anti-superposition principle.

In the observable world, Pauli and anti-superposition guard the separation of objects through space and time. In the same fashion, in the frame of knowledge guarded by the autistic side of the mind, neural notions that call to mind Pauli and anti-superposition protect the invariance of true prototypical schemes and of anything perceived through our senses from the onslaughts of false interpretations.

By contrast, our nonautistic side shows a propensity for embracing truth and falsity (being and nonbeing, or 1 and 0) and all sorts of crossed interpretations when we are asked a question; and that explains why nonautistic subjects trail autistics in dealing with unambiguous situation—as in Zaitchik's Photo Task. As the next subsection shows, however, when nonautistics face false-belief tasks, the wild call of ambiguity becomes the cornerstone of their success.

The Psychological Roots of the Neural Computing Network That Is Impaired in Autism

The quantum derivative allows the hypothesis that in false-belief tasks, normal subjects find the truth spontaneously—in

agreement with Rappaport's view of an indirect path to knowledge. For example, the two nonautistic subjects who passed the specific false-belief task set up by the author in his 1996 experiment saw the game in the toy box with their own eyes; and, simultaneously, they "saw" it in the closet through the "eyes" of Bob. In a metaphorical way, they "moved" into the body of Bob, although the never left their body, which seems unreal. And yet, a hidden three-act trick underlies non autistics' real, magical feat: (1) After crossing a coherence bridge, which leads from a deterministic to a quantum neural computing network, nonautistic subjects embraced simultaneously an expendable mental copy of what they were seeing in reality and a competing piece of information—a copy of what Bob was "seeing" in his mind; (2) because they "were" Bob, they saw the true answer to the question they were asked; and (3) because they also were themselves, they brought back home the true answer by crossing the decoherence bridge, which goes from quantum-like neural non-locality back to classical-like neural locality.

Further reflection suggests that normal subjects succeed in false belief because they can cohere into being in two places simultaneously (act 1), lie in the same place with another individual at the same time (act 2), and decohere into neural locality with the solution to a problem (act 3). Their feat evokes quantum superposition and the anti-exclusion principle.

Our capacity for embracing virtual copies of competing prototypical stimuli or representations is innate and matures around the fifth year of human development. At the age of four months, nonautistic children may integrate copies of their own emotions and their mother's; toddlers may tease us by playing with copies of mutually exclusive actions; two-year-olds may play pretend by linking the copy of a sensation with the copy of an unrelated representation; and at the age of four to five years, the metarepresentational ability to link copies of diametrical representations simultaneously allows most preschoolers to pass false belief.

The author posits that non retarded autistics fail false belief because they cannot link copies of discordant representations. The lack of neural parallels of anti-exclusion and superposition prevents them from seeking non-locality at any stage of development. In fact, experiments (Courchesne *et al.,* 1994) on multimodal attention shifts allow the prediction that adult, non retarded autistics will not match the covert attention act displayed by a baby girl when she shifts her attention between opposite visual stimuli (Johnson, 1995).

It is a truism that *no one can perceive two objects in the same space at the same time* or *the same object in two or more places simultaneously*—a consequence of Pauli, the rigidity of atomic nuclei, and the law of conservation of mass-energy (the first law of thermodynamics). The same can be said about the prototypical interpretations of reality stored in our cerebral cortex by our classical mode of neural computing, which is constrained by a rigid neural hierarchy that brings to mind Pauli, the concentration of mass at the center of the atom, and the principle of anti-superposition. Our deterministic mode of neural computing keeps prototypical memories centered in one place at a time. However, the fact that memories may survive massive brain damage and the superior copycat ability of autistics lead to the conjecture that our autistic side can make perfect copies of prototypical beliefs and of anything we perceive. That possibility opens the door to another wild thought: In the unconscious "back" of the creative mind (hypothetically, in the neocerebellar cortex), our deceitful quantum mode of neural computing may link discordant copies of known prototypical concepts or witnessed events in new ways.

In more detail, creative individuals may merge mental copies of separate sensations or representations by virtue of an anti-exclusion-like, neural principle—which is impaired in autism. For example, within simultaneous metarepresentation, a copy of the prototypical representation of a serpent and a copy of the prototypical representation of an eagle may merge in the fantastic creation of a winged dragon.

Neural quantum magic allows us to integrate two familiar schemes into a new scheme (as did the forgotten ancestor who built the first bow and arrow with two sticks and a liana); deal with the ambiguity that

characterizes the confrontation of opposite alternatives (as in understanding others' free will when they answer a pressing request with the word "maybe"); choose the right context after dividing our attention among crossing contexts (as in passing false belief); or recreate our minds by playing with disparate interpretations at the same time (as Agatha Christie did in her novel *Murder on the Orient Express*).

Continuing the discussion of the first two propositions of Logos, the next subsection runs through key elements of the deterministic neural computing network by which we use the world we recognize and elements of the quantum computing network that helps us enrich the known world with new patterns.

Key Cognitive Elements Spared and Impaired in Autism

Our primary attention and intention system—which the author calls sequence—is spared in autism. Sequence centers on the perfect recognition attached to choosing being (or 1) over nonbeing (or 0). In particular, our undivided first attention agrees with learned strategies, well-defined problem-solving techniques, a classical mode of neural computing, and the deterministic approach to interpreting reality, as exalted by Confucius and Parmenides; and our undivided first intention—or autistic executive function—pursues what we first perceive through the first attention (for example, by first recognizing and then buying a particular snack when we are hungry).

Our secondary attention and intention system—which the author calls simultaneity—is impaired in autism. Simultaneity relishes the anguish and euphoria that accompany choosing being and nonbeing (or 1 and 0) simultaneously. In more detail, because it values disparate stimuli or interpretations at the same time, our divided second attention agrees with a quantum mode of neural computing and the exploratory mindset envisioned by Lao Tzu and Heraclitus; and our divided second intention—or artistic executive function—feeds on the insight offered by our second attention.

The last implication leans on the fact that, in addition to failing false belief, non retarded autistics fail Tower-of-Hanoi (TOH) and the Wisconsin-card-sorting test (WCST) (Ozonoff *et al.,* 1991). Both the stacking of disks from largest to smallest on a goal peg in TOH and the sorting of cards by changing criteria in WCST require the act of imagining moves that run countercurrent with perceptual or habitual contextual cues. Consequently, autistics' failure in double-intending tasks can be attributed to an impaired second attention. Still, the fact that many autistics are hesitant even when they know what they want or need to do sustains the impression that their primary intention is hampered by pervasive confusion, insecurity, anxiety, and fear.

In the next subsection the author reviews the rules of sequence, and in the subsection following it, the rules of simultaneity.

The Rules and Doings of Sequence in Space-Time

Within Logos, sequence (or classical-like neural computing) assumes the existence of a set of down-to-earth rules (Cassella, 2000). For example, by virtue of the rule of no divergence (*the same entity cannot be found in separate places at the same time,* or a neural version of anti-superposition), a judge will release a defendant who has an alibi—that is, who proves that he was far away from the particular place and time in which a crime was committed. Furthermore, by obeying the rule of no convergence (*separate entities cannot be found in the same place simultaneously*—akin to Pauli), the first attention and intention of a salesperson, in the belief that the man in front of her owns the particular credit card he is handing her, will not suspect that she is dealing with an impostor.

The certainty that the rules of sequence impose on us is both essential and insufficient. For example, when simultaneity (or neural quantum computing) is dormant, our autistic-like belief that each sign has an invariant meaning and that laws and familiar knowledge are here to stay makes us vulnerable to other people's hidden agendas. Because autistics lack simultaneity, they operate solely with our sequential bent for

doing—that is, for repeating a known scheme and for doing one thing at a time. The autistic-like belief that a concept and an object can be found unchanged in a unique location at a specific time (the consequence of the rules of no-convergence/no-divergence and Pauli/anti-superposition respectively) defines our recognition of a shared, familiar reality in space-time and our belief that unfamiliar others share no knowledge and ways of being with the familiar self.

Within the doings of sequence in space-time, the author includes our adherence to names; our habits; the invariant meanings guarded in our long-term memory; the familiar road to home, school, or work; the unalterable sequence of past events and the belief that the future will bring more of the same; the literal meaning of what we have read; the rules of grammar (syntax); the prototypical interpretation (semantics) and correct pronunciation of known words; the certainty offered by tradition, authority, perception, logical deduction, observation, measurements, classical science, and the concept of 100% probability of existence; our know-how; the laws of our country and their rigid enforcement; the delineation of borders with neighboring countries and the loyalty of an army that must guard those borders from an illegitimate incursion; the synchronic behavior of marching soldiers and of ants and bees; any ideology; the uniform contraction of cells in a muscle; photons' obedience to the same frequency in a laser beam; uniformity in Bose-Einstein condensate; the autoimmune system that protects our bodies from hostile bacteria; the survival of the fittest in natural selection; the enmity between the two teams that arrive at the final match in the World Cup; and so on.

Without the perfect order, repetition, and control (represented, for example, by the number 1) that sequence seeks, the world would seem disjointed to us. That is why, under the command of sequence, the autistic side of our minds will reject chaos (represented by 0), or the diametrical opposite of order. Chaos may be seen as sheer randomness, absolute freedom, dire imperfection, 0% probability of existence, the impossibility of repeating a measurement, the other who robs us of our place in the sun, obstacles we find along the way, anything we cannot recognize, our opponent in a match or in battle, anarchists in collision with central authority, and so on.

Within sequence, what is order to one side is chaos to the opposite side, which means that sequence is either winning or losing, order or chaos. Similarly, within classical computational logic, at the end of the road we must choose either 1 or 0. In the view of sequence, anything that does not belong to order becomes intolerable chaos. Autistics reject change because they confuse it with chaos. Clearly, autistics show that sequence is blind to the magical feats, the delightful grace, or the vicious malevolence generated by simultaneity—the cognitive endowment examined in the next subsection.

The Rules and the Not-Doings of Simultaneity in Hyperspace

Simultaneity follows a set of bizarre rules (Cassella, 2000), which deny the matter-of-fact rules of sequence. For example, according to the rule of divergence, *the same entity can lie in separate places simultaneously*; and according to the rule of convergence, *separate entities can lie in the same place at the same time*.[6] Neural divergence evokes quantum superposition; and neural convergence, quantum anti-exclusion. By default, autistics show that simultaneity may enrich non autistic minds with social empathy (as it did with Mahatma Gandhi, Martin Luther King Jr., and Mother Teresa) or amplify the visceral drive to deceive others in order to use them.

Autistics and the autistic side of our minds cannot fathom deceit. Let us return to identity theft. An unsuspecting salesperson will see an honest, unique customer in the crook who is handing her an apparently legitimate—but in reality fake—credit card. Left to itself, her autistic side cannot see that she is dealing with a two-faced criminal who "exists" in two worlds simultaneously (the rule of divergence, or a neural equivalent of superposition)—his own and the one

[6]In the book *The Act of Creation*, Arthur Koestler (1964) suggests that bisociation—the process by which we embrace opposite stimuli simultaneously—stands at the root of creativity. In his view, bisociation rests on co-incidence (the principle of convergence in Logos) and ubiquity (the principle of divergence in Logos).

belonging to the victim; or that two identities (again, the actor-villain's and the credit-card owner's) lodge in the same body at the same time (the rule of convergence, or a neural match of the anti-exclusion principle).

Because they lack the eerie rules of simultaneity, autistics cannot understand deceit, humor, make-believe play, metaphor, and the fitting use of pronouns. Within spontaneous discourse, the pragmatics displayed through simultaneity—for example, in our use of the subjunctive, metaphor, irony, and puns—leans on the invariant semantics and syntax guarded by sequence.

But the weird rules followed by the eerie spirit that moves the creative, graceful, or devious mind are more evident in fantastic dreams in which we "move" instantaneously between disconnected worlds and experience new harmonies. As Freud suggested, dreams reflect the infinite power of the unconscious self—which, in his view, escapes the rationality and perfect control sought by the conscious self.

Because of its flexibility, the domain of simultaneity in nonlocal hyperspace—beyond local space-time—eludes measurement and the understanding of "Muggles," Rowling's (1997) term for individuals who cannot fathom magic; it is also a metaphor for the rigid consciousness guarded by the autistic side of our minds. Similarly, autistics cannot fathom the magic displayed by Harry Potter, and there is a reason for it: autistics lack the capacity for make-believe; that is, Heraclitus's arch, our quantum neural computing system, or simultaneity. For example, in the movie *Harry Potter and the Prisoner of Azkaban* (Rowling, 1999), Harry and his friend Hermione violate the irreversibility of time inherent in the second law of thermodynamics when they help their past selves free a hippogryph (a cross between a horse and a griffin) unjustly put to death. Many times during the episode, spectators see Harry and Hermione in the present and Harry and Hermione in the past simultaneously—which is equivalent to saying that *Harry and Hermione are in two places at the same time* (a hint of the rules of divergence and superposition). Further, whenever Harry goes through a brick wall on platform 9¾ in London's King's Cross Station, *the "matter" in his body and the "matter" in the wall share the same space at the same time* (the rule of convergence, the anti-exclusion principle, and a violation of the rule of no-convergence and Pauli). And yet, the autistic-like electrons of Harry Potter's body never violate the laws of thermodynamics and the principles of physical and mental locality. The reason is that Harry's artistic body and the brick wall are composed of fake electrons: photons. Clearly, in making fun of Pauli exclusion/anti-superposition, artistic-like photons allow us to see on the screen of a theater the magic J. K. Rowling first saw in her imagination.

Autistics are blind to the magic of quantum-like neural computing. Because they are ruled by sequential doing, they see concepts in their minds as perfectly as they recognize known objects in reality. Having no fantasy life, their minds cannot see the enchantment—or the malice—of the not-doings allowed by photons. By contrast, non autistic persons may "not do," or deny, something in their minds without denying it in reality.

Among key not-doings—that is, imaginary violations of the known world in hyperspace—we may include the ability to understand and make puns; the ambiguity that enlivens a masterpiece; the capacity for displaying figures of speech within discourse pragmatics; the fitting use of personal pronouns; the modulation of movements in dance; the teasing by toddlers when they offer us a toy and simultaneously withdraw it before we can grab it; the make-believe of a child who pretends that a banana is a telephone; the paradoxical plots that drive intriguing detective stories; our "moves" through walls (the principle of convergence and the anti-exclusion principle) and our quantum-like jumps between separate places (the principle of divergence and quantum superposition) while dreaming; the falsifiability of a scientific theory; the patience with which we listen attentively to divergent opinions; the hope that feeds our patience; the compassion emphasized in sacred texts; the symbiosis between distinct biological organisms; the balance between need and chance in evolution; the arbitration

of an impartial referee in a soccer match; the exchange of virtual photons between orbiting electrons and the atomic nucleus; the magic of virtual photons in moving beyond the speed of light; the variety of virtual couplings between photons and electrons; and the ghostly meeting of an electron and a positron behind a photon.

The not-doings of quantum-like neural computing may strengthen humane development and social progress when they are used to recreate the world with others. In line with that thought, the next subsection deals with the reciprocal empowerment of sequence and simultaneity in nature and sustainable social groups—the third proposition of Logos.

The Complementarity of Sequence and Simultaneity in Humane Affairs

Without a modicum of respect for shared order and central authority, no social group can survive. That is why rigid-minded leaders and their acolytes enforce the prejudices that compel them to destroy anything they cannot understand or control to perfection. However, the bent for order may be lethal to a society if the accompanying hatred of chaos is left unchecked. In other words, forgetting that chaos is as necessary as order is a tragic mistake. Without chaos, confrontations between opposite tenets would wane; and in a system without confrontations, the infinite "speed" attached to the capacity for viewing competing stimuli simultaneously would vanish. Spontaneous creativity would also vanish. Similarly, rigid regimes' Parmenidean imposition of perfect control in an effort to pursue the eradication of chaos explains why they suffocate in their inability to respond creatively to unpredictable change.

Without simultaneity, we would learn solely through deterministic methods, faithful imitation, or trial and error—the way of autistics. With that approach to knowledge, uncreative individuals sooner rather than later will fall prey to their own misreadings of a context (the kind of blunder comedians exploit with gusto) or to the malicious stratagems of tyrants who seek total control. By contrast, through simultaneity we may discover the habits of a prey we are after and hide our own routines in order to avoid becoming prey; smile when we see the double meaning inherent in humor; uncover the lies and the ill-conceived machinations of power seekers; understand the divergent views and needs of others; listen to the call of compassion; and enrich the pool of shared knowledge by picking up new schemes near the edge of chaos.

Although our artistic side is very valuable, our autistic side is blind to the magical gifts of its dancing partner—to the point that rigid-minded individuals will confuse the less-than-perfection produced by being-and-nonbeing with the imperfection intrinsic to nonbeing. Hence, we must trick our autistic side by handing it new schemes that have an appealing use.

An example of the complementarity of sequence and simultaneity in the act of creation is offered in Walt Disney's movie *Ratatouille*. In it, a clumsy garbage boy named Linguini (a metaphor for an approach to learning by trial and error), in the kitchen of a Paris restaurant, defeats a malevolent head cook (a metaphor for the inhumane use of our quantum-like neural computing network, which in this case tries to control and use others). He is helped by an experienced colleague (a metaphor for the skills we acquire through increased repetition, the know-how guarded by classical science, and the memories protected by our classical-like neural computing network). He also allies with a rat called Ratatouille (a brilliant chef and a metaphor for the mysterious ally who may teach us the artistic deployment of our quantum-like neural computing system). Ratatouille, who hides inside Linguini's hat (a metaphor for the hideout of our quantum adviser in the neocerebellum), guides him in preparing new dishes that customers find exquisite.

Finally, a last example may help the reader appreciate the interplay of classical and quantum computational logic in the act of creation. In a fair judicial system, sequential finiteness operates within the opposition between the defense lawyer (or stance 1), for whom the defendant is innocent, and the district attorney (or stance 0), for whom the defendant is not innocent. If, in a trial, we removed the defense lawyer

or the district attorney, then infinity (1 and 0 at once, or the equanimity of the judge and the jury, for whom during the trial the defendant is and is not innocent simultaneously) would become meaningless. Likewise, any trial would become chaotic if we took away the judge and the jury (1 and 0 simultaneously) after setting up the defense lawyer (or 1) against the district attorney (or 0).

This discussion intended to show why the impairment of simultaneity—the quandary of autism—leads to severe incapacitation. As Rimland (1964) demonstrated, modes of parenting have no influence on the prevalence of autism. And yet the emergence of a humane complementarity between the deterministic and the ambiguous neural network in normal children can be blocked by either harsh or laissez-faire modes of parenting, social deprivation, pervasive prejudice, and the use of simultaneity to control others.

The last section recapitulates key findings on autism and examines the fourth proposition of Logos, namely that natural and social systems fall apart when our quantum-like neural computing and our classical-like neural computing become disjointed.

Conclusion and Outlook

The performance of autistics in neuropsychological tests and the examples reviewed so far strengthen four propositions: (1) The infinite speed of simultaneity sustains both our ability to deal creatively with ambiguity—which is impaired in autism—and the stochastic behavior of elementary particles in subatomic phenomena; (2) the uncertainty that permeates neural or sub-atomic hyperspace will eventually decohere into the alleged certainty and repetition attached to observable space-time; (3) in balanced minds, quantum information processing will start from and return to the finiteness, locality, perfection, and determinacy supported by classical-like information processing; and (4) classical-like and quantum-like neural computing hide behind and complement each other.

More specifically, the quandary of autistics sustains the following cascade of hypotheses:

- *A confrontation between opposite beliefs within the classical-like neural computing network that conserves known schemes (sequence) is a necessary and insufficient condition for developing the capacity to solve problems, uncover new truths, and recreate the world through quantum-like neural computing (simultaneity);*
- *instead of leading to mutual destruction, the confrontation of opposite beliefs unleashed by no-convergence and no-divergence may foster the creation of a new scheme by the infinite "speed" inherent in divergence and convergence;*
- *being-and-nonbeing (or choosing 1 and 0 at the same time), within quantum-like neural computing, is as essential as being-opposed-to-nonbeing (or the need to choose 1 over 0, or vice versa), within classical-like neural computing; and*
- *classical-like computing anchors quantum-like computing in neural networks as anti-superposition and Pauli anchor superposition and anti-exclusion in the subatomic world.*

Entanglement, in particular, points at the complementarity between anti-exclusion and Pauli. For example, the phenomenon in which a Bell-state quantum eraser converts a photon from a laser beam into a pair of entangled photons with linear polarizations that are orthogonal to each other shows that entangled photons lie simultaneously inside a photon, which in turn lies in a unique place at a time. Entanglement, then, strengthens the view that infinite speed is not the product of fantasy but the mother of fantasy.

An infinite speed sustains the virtual couplings between fermions and bosons; and an infinite speed drives the creation of infinite discourses out of a finite number of prototypical concepts and grammar rules. The complementarity of sequence and simultaneity, which agrees with the mathematics of complex numbers, endorses the hypotheses that quantum-like neural computing (within the unknown, and the

unconscious) hides behind classical-like neural computing (within the known and the conscious); that avatars of elementary particles (for example, virtual photons) pave both the coherence bridge that leads from local space-time embedded in no-divergence/anti-superposition to nonlocal hyperspace within divergence/superposition and the decoherence bridge that connects the spontaneous insight generated by convergence/anti-exclusion with a renovated familiar world conserved through no-convergence/Pauli. And yet, divergence and convergence remain active in fantasies, dreams, and the spontaneous smile that accompanies an understanding of the double meaning of a pun.

Moreover, the research of Bauman and Kemper (2006) and Ito (2008) implies that the neurocircuitry that leads from the cerebral to the cerebellar cortex supports the coherence bridge and that the neurocircuitry that leads from the cerebellar to the cerebral cortex sustains the decoherence bridge. It appears that autistics cannot cross the bridge of neural coherence, which leads from classical-like to quantum-like neural computing. By contrast, schizophrenics cannot return to the familiar world by entering the bridges of neural decoherence. The fact that allegedly balanced people go from and come back to the familiar world (or cohere and decohere) when they deal with a problem, value the divergent opinions of others, and evaluate competing courses of action, implies that they follow Hamlet in courting autism and schizophrenia simultaneously.

Computer scientists theorize that a quantum computer could perform calculations that are impossible to do with a digital computer. Perhaps quantum power will be harnessed to manufacture a deterministic supercomputer. (Financial institutions worry about the possibility, introduced by Shor's algorithm [Shor, 1999], that a quantum computer could factor the prime numbers used in the encryption of codes that protect bank accounts from unauthorized intrusions.) The promise of harnessing quantum computing, however, centers on devising creative (or simultaneously autistic and schizophrenic) artificial extensions of the human mind. It would seem that before making that dream come true, we should uncover the secrets hidden in autism and use them to deepen our understanding of literature and sacred texts, develop a balance between our two neural computing networks, and aim for more than a long, affluent, and healthy life at the expense of the wellbeing of free species.

The idea that creative thought relies on the complementarity between two systems of cognition—one rigid and the other fluid—is old. For example, the clash of warriors in Homer's *Iliad* is a metaphor of the workings of our deterministic mode of neural computing by which two opposites (the Trojans and the Mycenaean Greeks) will fight each other in their quest for absolute control of the same place (Troy, which held a strategic location between Europe and Asia). And the quest of Ulysses in Homer's *Odyssey* is a metaphor of the call—by our quantum mode of neural computing—to leave behind the familiar world, explore the unknown, and then return home. Ulysses' traveling companions are first transformed into pigs and then die on their way back because of their reckless use of the power of simultaneity. The cautious, humane, and frugal old warrior returns unscathed, but he courts annihilation in an effort to free his home from parasitic guests—a metaphor of the risky path in which we seek the power to control the power of simultaneity by freeing the self from the assault of unilateral ways of being.

The certainty of a chaotic end to unilateral control is implied in the most sacred texts. An example is Zechariah's vision of the consequence of the loss of grace (simultaneity, or neural quantum-like computing) and, subsequently, of union (sequence, or deterministic neural computing) in natural systems:

> I took for myself two staffs; one I called grace (noam) and the other union (chabal, or jovlim) . . .
>
> And I took my staff grace and cut it in two to revoke the alliance that I had celebrated with all the tribes . . .
>
> Later, I cut in two my other staff, union, in order to break the brotherhood between Judah and Israel . . .

> Wake up my sword against my shepherd and against the man nearer to Me, says the Eternal . . .
>
> Hurt the shepherd, and the sheep will scatter, and I will turn my hand on the young.
>
> Two parts of all Earth will die, but the third one will last (Zechariah [XI-XIII]).

This prophecy accords with the fact that at present the young of nonhuman species seem to have no future. In the distant past, biodiversity experienced a definitive growth because a circle of predation (by which each link becomes hunter and prey simultaneously) prevented domination by a generalist species (Leakey and Lewin, 1995). The emergence in Homo sapiens of the ability to use other species and avoid being used by them did not cause a significant change in the background extinction rate[7] until the second half of the 19th century. In the last 150 years, however, the background extinction has increased considerably because of the simultaneous growth of population and affluence. Before the end of this century, two-thirds of higher-order animals and plants will become extinct. At the same time, the release of carbon dioxide from an unabated use of fossil fuels will cause an increase of 3 degrees Celsius in the average surface temperature of the Earth—the threshold of a global ecological landslide. In that eventuality, the catastrophic change that Zechariah viewed twenty-five hundred years ago would endanger also the young—or the future—of Homo sapiens.

And yet, research on autism and creative intelligence suggests that surrendering our world to cockroaches is not inevitable. Ironically, behind the potential tragedy we read about in the book of Zechariah hides the opposite interpretation: Instead of weakening each other, classical-like and quantum-like neural computing may empower each other in the mind of whoever realizes—either through early education or later life experience—that the only control worth keeping is shared control.

[7] About ten species per year.

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