Nothing to Say

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Teaching

Since we mentioned knowing, learning, understanding, it is difficult not to think of how knowledge is transmitted. Teaching is one way that animals use in order to speed up the transfer of what they have learned and understood to a new generation. It is this sharing of knowledge that makes it last.

One can also learn without being taught. If not, we'd probably still huddle together as macaques mutually delousing one another, squatting on tree branches, picking vermins and other skin parasites. Knowledge would be barely limited to instinct.

Thus, teaching is transmitting knowledge.

But it also provides an efficient tool for controlling societies and the individuals that compose them. As such, the transferred knowledge is very often selective and the process of transferring it is also most often imposed to, rather than chosen by, who is subject to this teaching. At least this is true, in a more or less blatant manner, concerning school institutions. These teaching structures are erected according to strict patterns defining moulds into which it is compulsory for students to fit in order to "succeed." The key word in the foregoing is "*compulsory*."

And so, school teaching has been imposed violently using a great many aggravations and spankings that tan one's bottom hide. One must fit in, whether one likes or not. No choice. Or else, watch your butt! You'll be made to wear the dunce cap. Thus, the best students in this teaching system are the most easily influenced, or the most cowardly. They are rewarded with good grades and diplomas. They then join their spots in society, and occupy them, happy to please their masters. And, according to their degree of success, they then become the next masters, the "*élite*" of their society, who will maintain and define the teaching moulds they can profit from. Dunces, the "idiots," are in fact free spirits that refuse to be tamed. However, they are unfortunately exploited and mistreated by the "*élite*" that are the masters of their society. Be that as it may, there are occasionally some (rare) exceptions, fortunately, on either side. (I'll come back to this…)

This said, there exist other forms of teaching besides school teaching (whether secular or religious—same difference!). Indeed, religions (or rather religious people) have been at the inception of the school trick and its use since the dawn of humanity.

There are also teachings that we draw ourselves from our experience. Such are equally gratifying as—nay, more satisfying than—those taught in school. It is this kind of teachings that I would like to talk to you about: life lessons.

Among these teachings, some, the most precious, are transmitted to us by our mentors when we are lucky to have some. A mentor is not a school master. A mentor sets an example that we voluntarily decide to follow on our own. Such is a person whose words or writings, but also and especially whose behaviors, impress us by their generosity, their quality, their simplicity, or their elegance. Mentors do not teach: they *share*. They share the pleasure they feel to see their disciples understand what is offered to them, and even better when one refines it and conjugates it with one's own creativity, thus transcending it. It is the same kind of pleasure that a jazz improviser must feel: that triggered by a *resonance*, that of a *harmonic exchange*, that of a *communion*.

There is always a motivation to emulate — this is instinct.

"*Monkey see, monkey do!*"

However, in order to find a good mentor, it is not enough to want one.

As well, it is not enough to want *to be* a good mentor *to become* one.

> *Entre mentor et menteur*
> *Il n'y a qu'une différence*
> *De l'être …*[1]

A good mentor will not accept being turned into an ideal idol, and will always remain wary of vain compliments. Rather, a mentor will know how to share one's humanity, including being aware of one's intrinsic defects and limitations just as one's qualities. Humans often tend to idealize quickly. Respect devoted to someone, if taken to excess, becomes idolatry, and so is more the product of fantasy imagined by the admirer rather than actual qualities of the admired.

Excess of anything is harmful.

Even excess of quality.

Teaching must concern the transmitted knowledge, not the specific means via which it is transmitted. The message; not its transmission conduit.

One can better understand teaching, after having oneself first been a student, only once one has crossed over to the other side of the mirror, the side the teacher. Or, should I rather say, such was the case for me.

Nothing can replace the pleasure of explaining to someone else while sharing what we ourselves have understood.

This pleasure culminates whenever, among one's students, those who have learned the notions you taught them, and well understood their underlying principles, demonstrate it by refining them and sharing them in their turn.

But this takes time. And many an effort…

Not everyone is gifted to be a teacher.

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[1] Could be loosely rendered as:

> *Between a mentor and a mantis*
> *Is but a difference*
> *Of characters…*

Also, not everyone is interested in teaching; especially at the rate at which teachers are paid!

However, since I can only speak about what I personally know, I must admit that I owe a great part of what I have understood in life to specific teachers (be they official or not). I also owe a lot to my experience in the random circumstances through which my life has taken me.

Still, when I myself became a teacher, I felt more frustration than pleasure. Firstly, one does not necessarily teach *what* one wishes to teach. Secondly, one may not necessarily be allowed to teach *how* one wishes to teach. Lastly, one may not necessarily have a say about *whom* one wishes to teach.

Notwithstanding, the rare occasions when it happens that all the required conditions are fulfilled, the experience is always memorable.

Here is a little anecdote to illustrate what I mean.

In 1986, I happened to teach a graduate seminar at the University of Texas at Austin, in the USA. I had myself composed the course plan, which was rather ambitious yet interesting. I had proposed it to the Department of Computer Science expecting that nobody would register for it. So I was agreeably surprised to find out that there were about a dozen candidates, many of whom among the best grad students, and all seeming eager to be challenged by what I was proposing to share with them. Hence, this seminar took place as planned, despite the high amount of hard and demanding work I put them through all through the semester. Near the end of the term, I delivered a pernicious *coup de grâce* in the form of a particularly Machiavellian final project. They protested, but in order to cajole them into it, I promised to accept any challenge of theirs, at the condition that I be capable of doing it. Now, it happened that among my students, a quatuor were crazy acrobatic skydivers and worked as skydiving teachers in a local air club. They promptly accepted my deal and challenged me to perform a tandem skydive harnessed to one of them. They all declared that they would do my final project assignment as required if, but only if, I made that jump.

I was stuck!

I had no way to escape the deal…

So I accepted their challenge.

I did all in my power to complicate the project with particularly vicious specs, but they plowed through the whole bit. Those bastards were delighted sacrificing sleep for ten days and delivered a masterly realized project.

Therefore, I had to prepare myself to be thrown out of a craft above San Marcos, Texas, tied to one of them like a bag of dirty clothes.

Quite a memorable experience, indeed.

—*A LA MORISCAAAAAAAAAAAA ! …*[2]

[2] "Literally, *THE MOORISH WAY!…*"—What daredevil kids in Algeria yell when diving from high shore rocks into the sea hugging their folded legs.

Free Fall

What I felt through this experience was for me extraordinary! That was the most mind-blowing psychedelic "*trip*" of my life.

So we were at an air club near San Marcos, Texas, a charming town roughly half-way between Austin and San Antonio, heading southwest. It is a flat country to the south with hills to the north, and relatively green despite the texan climate thanks to the *San Marcos River*. The region is not so crowded as far as number of inhabitants, especially when compared with Austin or San Antonio. It is more of a country area with landscapes as far as the horizon—especially when seen from high in the sky.

Before making this famous jump (my first and only ever), my free-fall-crazy skydiving-nut students took me to their club's office, made me contract some sort of skydiving insurance and fill all sorts of legal forms. Then, then put me through a sort of *crash course*.[3] This described the details of what I was about to experience.

They explained to me that I was going to do a tandem jump harnessed to one of them. A tandem jump means that you share your parachute with a jump guide to whom you are linked with rather short belt straps. Your jump guide controls the jump and chute from behind you. He is strapped to you just like a mother carrying her child in a ventral pouch, the baby (*i.e.*, you) carried back on her belly, both facing the same direction. The idea, it was explained to me, was that we would soon all board a small one-engine plane that would take us up to an altitude of a few thousand feet; then they would open the plane's side door, and that we would… not jump right away. Because, being so harnessed to my jump guide, I would have to precede him and be the first to step out of the plane in mid-flight while firmly grabbing the side bar under the wing. All this in order to give one or two seconds to my guide (to whom I would of course be linked all through this delicate maneuver) to adjust himself and then make me let go.

They repeated several times all the details and made me rehearse all the moves while being harnessed, *etc.*, *ad nauseam*. At the fourth or fifth time, I protested telling them that I had had enough, that I had it figured out. But they smiled and ignored me, still insisting that I go again and again through the whole sequence of moves and the complete interaction protocol. Finally, seeing that I would not quit protesting, they explained to me the following thing.

The instant when I would let go, I would find myself in an entirely new situation with sensations my body will have never felt before. The survival reflex of the brain is instantaneous: it floods all its synapses with very potent endorphins, pleasure-inducing drugs that it secretes and uses massively when facing a life-threatening crisis in order to palliate any eventual end-of-life pain and focus on staying alive. These endorphins are hormonal derivatives, neuro-tranmitters such as ocytocin and vasopressin, which are very potent hallucinogens, substances that are close to morphin. Yet, they are produced

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[3] Unfortunate pun, don't you think?…

naturally by any living being's brain, and are used to make one feel pleasure in order to counteract pain—endure the worst by making it… pleasurable! It is in this way that a marathon runner achieves *Nirvana*, that a sportsperson of the extreme reaches a state of bliss, and they become addicted to it. They are not "morphin addicts" but "endorphin addicts." The quantity of these endorphins flooding the brain then is all the more important as the causing situation is extreme, urgent, and new. , However, how much and how satisfying this is tends to abate with habit. The addiction persists, though, always seeking extreme sensations.

In other words, before one's first free-fall jump, one has no idea about what one is about to experience.

We finally take off in a small rickety plane. As we gain altitude, we keep rehearshing the move sequence and acknowledgement gestures again and again. In all that, as I was concentrating on my instructions, I had completely forgotten that those were not the most important events that were to follow.

So we reach the intended altitude. My ears are buzzing due to pressure change. The roar of the engine is deafening. The pilot barks a couple of yells at us that I don't even parse, let alone understand. The four of us—myself, my guide, and two of my students, each of whom are supposed to jump right after we do and catch up with us in mid-air. All of a sudden, as the pilot yells "*Go!*" over his shoulder while waving a thumbs-up sign in our direction, one of our two jump teammates opens the craft's side door.

A terrible blow of wind slams into the cabin while the pilot struggles to keep his craft steady. All this makes an hellish racket. But I have no time to worry about it as my guide strapped to me from behind presses me forward (the same gestures I had been made to rehearse again and again dozens of times). Gosh! I then carefully lean into the air halfway out of the plane, firmly grabbing a metal handle under the wing in an apocalyptic wind and din, but reassured to feel that my guide is close behind firmly "holding" me with four straps hooks.

I hallucinate for a second that lasts forever, grabbing a handle off a plane's underwing, floating in mid-air over Texas, when all of a sudden, I feel my guide's hand pull my wrist off and make me let go.

And then…

Woooosh!

Undescribable. Enlightenment. My brain, and my body, exploding in myriads of sparkles. And for eternity.

Silence.

Immense.

All ceases instantaneously: the awful noise of the engine, of the wind against the plane's hull. Time itself stops. I am in heaven (literally!), in a new totally unknown dimension, on a hyper-psychedelic *trip*, in total silence. The San Marcos plain below, the *San Marcos River*, the shading off greens of the vegetation, the abutting hills in the north in Austin's direction, all of this is rushing toward me in the blinding light of the texan sun.

Yes indeed—since I am motionless. I am not moving. It is everything else that is rushing toward me. I then understand, through all the fibers in my body, and through all by brain's synapses, Einstein's epiphany—his "*Special*" Relativity Principle: mathematically, it makes no difference whether I am falling to Earth or whether I am at rest while Earth is rushing toward me at the same speed in the opposite direction.

That day I experienced 30 seconds of free fall.

It felt like eons.

When my guide eventually opened the chute, the whole thing became less fun for me. This is due to my being subject to seasickness and a chute is controlled by making sharp turns and one loses altitude by making tight descending spirals. In addition, the feeling of free fall ceases immediately, and one regains awareness of one's position and displacement in three dimensions. But surprisingly, a parachute (or rather the sort of rectangular flying wing composed of parallel tubes made of silky material whose shape can be modified by pulling two lateral straps) allows tight control so one can adjust the falling speed rather easily and even come to cancel it altogether if needed. One can thus almost land walking. (All in fair weather, of course, with negligible or no wind.)

Free fall is traditionally linked to the story of Newton's apple, the famous anecdote that is supposedly attributed to this English gentleman. In it, it is said that Isaac Newton understood his acclaimed law on universal gravitation when, as he was lost in his thoughts while sitting in the shade of an apple tree, an apple fell upon his head. Those, like me, who relished in reading Gotlib's comics,[4] will know what I am talking about… **B^D**[5]

His universal gravitational law is quite simple, in fact. It says that any solid body has a mass, and that this mass creates a "*gravitational field*" all around it which naturally attracts any other solid body within it. And thus, if two solids (one of mass m_1 and the other of mass m_2) are at distance d from one another,[6] each will be subject to a force of attraction f toward the other object whose intensity is proportional to the product of their masses divided by the square of the distance:

$$f = g \times \frac{m_1 \times m_2}{d^2}.$$

The letter "g" in this formula denotes a number known as the gravitational constant. It characterizes the acceleration that each objects will be subject to in the direction of the

[4] https://en.wikipedia.org/wiki/Gotlib

[5] http://media.topito.com/wp-content/uploads/2016/12/newton.aspx_.jpg

[6] Let us assume, in order to simplify, that this distance is measured between their geometrical centers idealizing such an object as a point is space.

other in empty space. When one of the objects (such as Earth) is much more massive than the other (such as an apple), this constant characterizes the gravitational power of the bigger one—in this case that of Earth, which averages to 9,81 m/s^2.[7] This means that when we fall toward Earth freely (*i.e.*, ignoring air resistance as if in empty space), our speed constantly increases every second by 9,81 meters/second, whatever our mass may be. In fact, this number is the value of this constant measure at Earth's surface: it gradually decreases as altitude increases. Therefore, the higher (*i.e.*, the farther from Earth's surface), the less we accelerate toward it. It also varies for other celestial bodies according to their masses. For the Moon, this constant is much smaller than Earth's (it is about 1,62 m/s^2). The same object (and so of constant mass) is therefore much lighter on the Moon than it is on Earth. This explains why a human can make giant leaps there. For Jupiter, this constant is 26 m/s^2. Much more "*crushing*." And for the Sun, it is 274 m/s^2—an altogether juice-produicing squeeze, notwithstanding the frying temperature as well: about 5,800°K.[8]

But then, why isn't the Moon falling toward Earth? And why are Earth and the other Solar System's planets not falling toward the Sun? Ah, but this is where Newton's genius is revealed. In fact, according to his law, all these celestial bodies are indeed free-falling toward one another! Earth is free-falling toward the Sun. But the speed of its fall is such, and when multiplied by its mass, its momentum (its thrust) is such, that Earth "*misses*" the Sun and is forced to go around it as if caught in an eddy that eventually will end up at its center: the Sun. But this will take time. It is going there but it will take very long before its momentum decreases sufficiently. The inverse effect (Sun falling toward Earth) is also applicable, but is negligible taking into accout its own momentum (mass times speed) in space—because it too gravitates around the center of its galaxy: the Milky Way. And so does the latter around the center of the universe, although at this scale, distances and masses are such that many parameters that could be neglected at smaller scales should probably no longer be ignored.

At any rate, understanding all this originated from an apple hitting the pome of a dozing English mathematician lost in thoughts.

Yet, even with the blatant proof of usefulness of Newton's Law for predicting the trajectories of celestial bodies by simplifying their computations, each time confirmed correct when so-predicted astronomical events are observed in the time and place derived from Newton's formula, there is still something essential missing in Newtonian Physics. Indeed, it does not *explain* the greatest of all mysteries related to these phenomena.

And this mystery is the so-called "*effect at a distance*" between celestial bodies all of which are surrounded by empty space (*i.e.*, *nothing*). It is this mystery that intrigued Albert Einstein's curiosity. And, to explain this mystery, he thought hard until he was able to give it a purely mathematical explanation that was theoretically coherent and observationally consistent. The mystery underlying this effect at a distance that needed to be elucidated

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[7] In meters per second squared.

[8] About 5,500°C.

was the following: *How can it be possible for a celestial body to "perceive" the presence (the gravitational field) of another celestial body somewhere in* <u>*empty*</u> *intersideral space?* Indeed, if there is *nothing* between them, what is it that makes them perceive one another's presence, and therefore attract one another?

This explanation, itself quite surprising, of universal gravitation that Einstein proposed, in his theory of General Relativity, is as simple as it is elegant. In fact, this explanation says that each celestial object is constantly free-falling at a constant speed following a straight line. Rather, it is the space in which this object moves that is itself *curved*. In a way, a mass creates a distortion in the space that surrounds it. This is difficult to picture in three dimensions, but there is a popular way one can do so more easily using only two dimensions. Imagine that space is an infinite plane of elastique texture (a kind of trampoline surface) upon which various spherical balls of various sizes and weights are sent rolling in a straight line. Each, according to its mass, will create a distortion in the texture of the trampoline's plane—the more massive a ball, the "deeper" the distortion. And so, as such a ball moves following a straight line on the plane, so does the distortion it creates move along the same path. As two balls approach one another, each on its straight line trajectory, the plane between them gets more and more distorted. This has for effect that each ball's path will bend in the direction of the other. Neither however changed its straight line trajectory; it is the space (in this case the plane of the trampoline) that was curved.

The simplicity of the idea, its elegance, and most of all the multiple consequences, first theoretical, then all verified experimentally in the observations made and measurements recorded. As, notably, the curvature of the path of light itself in the vicinity in a very high gravitational field (such, for example, as created by a black hole in the space surrounding it).

Pretty smart fellow, Einstein! But all he did, was to switch perspective. He resisted being conditioned by what had been considered obvious but that was suddenly no longer so since put in question!… This change of perspective (this *relativity*) can happen in any context. Just as when it was understood that it was Earth that gravitated around the Sun rather than the opposite as had always been believed. In mathematics, this is called an isomorphism: a two-way transformation between two algebraic structures where each point in the first universe corresponds to a a unique point in the other universe, and where any operation on points of one universe corresponds to an operation on these points's images in the other universe. This is simple—yet, one must be able to see such an isomorphism, to define it precisely, and verify that it functions as it should. Thus, as soon as such an isomorphism is at hand, we have a duality. And that's the whole trick!

Hard to believe, but this free-fall initiation I experienced over San Marcos made me understand Relativity's principle in my uncounscious. I had understood it in my consciousness long before. But I had not yet understood it in my unconscious. The effect was spectacular. I will let you be the judge.

We use programming languages. What for? Well, to "instruct" a machine to behave as we wished that it did. The model of the computer as conceived by this american genius called

John Von Neumann in the early 1940s (and which has since been called the "*Von Neumann Computer*") is based on an elementary principle. Indeed, such a machine can only be instructed to perform one of two actions: either turn on a light bulb, or turn it off. This allows distinguishing two elements of information: "*on*" or "*off*." In other words, *true* or *false*, 0 or 1. Each light bulb is therefore a binary digit—or, for short: a *bit*. When a machine can control a high number of these light bulbs (these bits), say 100,000,000 of them, it can therefore differentiate $2^{100,000,000}$ elements of information. This is quite a huge number of possibilities, trust me! Since those early days, the "light bulbs" have considerably shrunk in size (they now are literally microscopic). Their density in space is therefore extremely high, and always growing. And they can now be controlled at higher and higher clock rates (*i.e.*, frequency of possible binary signal switch), of the order of "*petaflops*" (10^{15} *Floating-point Operations per Second*).[9,10]

Be that as it may, these machines are still today what they have never ceased being: myriads of lamp bulbs lined up in rows of 0s and 1s (grouped into "binary words"). A gigantic organization of bipolar entities. That's all there is in there!

But these machines would be useless if we could not communicate with them. Indeed, how in the world could we ever tell such a machine to do anything at all, even if only with binary words?… Well, it is at this point that Von Neumann had his stroke of genius, when he finally understood what his mathematician colleague and friend Kurt Gödel had been desperately explaining to him: that any function that calculates a number (its result) given other numbers (its arguments) can be itself assimilated to a number. There is a mathematical isomorphism between the natural numbers (*i.e.*, data) and the set of functions on this set (*i.e.*, programs). In other words, any computer program can be represented and manipulated like a piece of data—*i.e.*, a sequence of binary words! This is how Von Neumann could make his universal machine work, thanks to what he called "*soft*ware" (soft, since it can be easily edited and transformed—simply switch some lamp bulbs on or off), as opposed to the more static "*hard*ware" denoting the actual electronic circuitry (the "lamp bulbs"). No need to build specific hardware for each program since one could re-program software *ad libitum*. Cool, isn't it? This is the key that has allowed us to conceive and build re-programmable computers that we use daily without having a clue of how nor why this works.

Math is useful after all, isn't it?

And so are creative math nerds, of course, even if their language is quite often difficult to understand!…

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9 $10^{15} = 1{,}000{,}000{,}000{,}000{,}000 = 10$ multiplied by itself 15 times.

10 A floating-point number is a fractional number; *i.e.*, what we usually call a "decimal number" such as 16.542 or 0.008876, whose value is not necessarily an exact integer. Operations on these numbers in binary form are the costliest in terms of time. So by convention, we use the cost per second of the time resources required by the Central Processing Unit (CPU) to perform one operation on two floating-point numbers as the unit of its computation performance.

Therefore, communicating with these multiply bipolar organisms may proceed according to the obsession and/or compulsion of an instruction-giving agent using a specific programming idiom; *i.e.*, a software programmer.

The first programming languages were therefore rather primitives as it was possible to communicate with a machine only with 0s and 1s. How? By making it “read” a “program” consisting in a sequence of “instructions” encoded as binary words following a specific convention (a vocabulary) suited to the organization of a given machine, “telling” the machine to perform the specified instructions and interpret the final outcome expressed in the same binary language. That was quite a daunting task, believe me! This was done first by entering each bit per word as a row of light switches on a console. Then, this was improved with the use of perforated paper tapes (one hole for a one, no hole for a zero).

Knowing how to program, then, was the privilege of a few geniuses! Indeed, one needed a big brain for it. So, as a result, knowledgeable programmers were scarce—not like today. The first “programming languages” were as difficult to learn and master as they were complicated and primitive. And one needed a plethora of elementary instructions to do even the simplest calculation. In addition, each machine “understood” only its own language, distinct from those of other machines. Hence, knowing how to program required very rare capacities and the indefectible brain investment of some obsessive-compulsive nerd.

Then, one had the following tought. “*What about encoding all the basic operations on any machine using the same intelligible names (i.e., strings of alphanumerical characters) that could be assembled once and for all into the specific binary words proper to each machine?*” This gave birth to programs called “assemblers” whose only purpose was to translate a given model of symbolic instructions more intelligible for humans into the corresponding binary bit sequences for each machine model. This immediately alleviated the pain of endured by programmers. It became easier to program a computer and the number of programmers increased drastically as a consequence.

However, it was still not child’s play. In particular, each machine had its own assembler, and therefore software written in assembly code that ran on one machine would not run on different hardware, not even on following versions of the same hardware.

It was then that a clever fellow named John Backus working at IBM had an idea that was as simple as it was genial: he proposed a single language, that he dubbed “ForTran” (for “Formula Translator”) that defined a unique vocabulary for expressing so-called “formulae” (*i.e.*, operations that could be computed by any machine, even using different binary word conventions) and a unique program per machine (a “ForTran Compiler”) whose job was to translate ForTran code into a machine’s specific assembly code.

And so, a program written in ForTran became “portable:” the same program did not need to be rewritten each time for a new machine as long as the latter had its ForTran compiler, itself written once and for all for each new model of computer hardware in the assemby language proper to a machine using this model. That was the genesis of a new discipline in Computer Science that has never ceased, and will certainly never cease, evolving. It is the field working at improving linguistic (syntactic and semantic) tools meant for communicating with decillions of lamp bulbs.

One of these families of languages among the most "evolved" today started in the 80's and its popularity has soared since (and still is mainstream) and is known under the denomination: "object-oriented" programming languages.

—*What the heck's this gobbledygook? Aren't you sick of boring me out of my skull with your pseudo-science that you vulgarize so much that it is close to being vulgar?*

I know that I have become [?] boring.

But be patient. Read on, you will understand.

All these boring digressions on how we learned how to program computers are to explain to you that it was my free-falling above San Marcos, Texas, that made me understand that the essence of "object-oriented" programming was a consequence of the same kind of mathematical isomorphism that the one used by Einstein in his Theory of Relativity.

I then understood, immobile at more than one kilometer above San Marcos, which was rushing toward me constantly increasing its speed by 9.81 m/s each second, how a trivial change of perspective, the dual vision, the isomorphism, enabled formalizing very simply object-oriented programming as a relativistic phenomenon. However, in order to understand this, one must first have an idea of what order-oriented programming actually is.

No, no, don't be afraid. I am aware that my techno-gibberish rantings above on bits and all that jazz have seriously bored you, and you wonder where in the universe I am now taking you with all that. I agree. However, again, be patient: you will soon understand that there is a spider web's thread in this labyrinth. I know that I constantly jump from branch to branch just like a spider monkey. But a spider knows how to weave a coherent whole even when hanging from branches that are seemingly unrelated to one another.[11] The complete web always emerges eventually as perfectly woven. Making all this entertaining to the reader is far from a sinecure; quite a challenge in fact, a bet, from both parties: the writer and the reader. The latter is curious to find out where all this leads. The art of the spider consists of anchoring itself in diverse points while building a welt, the corehence of which will emerge in the end. The threads of its work are not visible to flies. However, those seeing it from the appropriate perspective will appreciate its mathematical precision and pragmatic efficiency.

Talking about diverse threads woven in all directions, the simplest is to tell you a story. I promise that you will have no problem understanding.

[11] A spider—"*araignée*" in French—being represented in Greek mythology as weaving Arachne, whose name connotes that of Ariadne that gave Theseus the thread to guide him inside the maze of the Minotaur so he could slay the monster and escape from his labyrinth.

So here is an anecdote whose main character is Alan Kay, a famous american researcher in Computer Science to whom is attributed the discovery, the epiphany, of object-oriented programming, and why it enabled drastically simplifying how programming was done until then, as a set of instructions to be executed by a machine in precise circumstances.

He was then a young grad student at the University of Utah. As such, he had applied and was granted a summer internship at the famous *Stanford Artificial Intelligence Lab* (SAIL) at Stanford University, one of the best, if not *the* best, renowned in Artificial Intelligence research in the United States. This was in the late sixties. He was returning home in Utah at the end of his internship, and in the plane from California, was mulling over his experience there. His internship topic had been to program a robot so that it could move in a room cluttered with objects of various sizes and shapes and avoid all these potential obstacles.

Alan Kay was among the best computer programmers of his generation. Yet, he was coming back to Salt Lake City, Utah, utterly disappointed since he had miserably failed at the task that had been expected of him. The big complication had come from the fact that the obstacles on the robot's path were not necessarily static, and also that new objects of different sizes and shapes could appear after the robot had been programmed. Indeed, the task had been quasi-impossible even for a gifted genial coder such as Alan Kay.

But as he was snoozing in his return flight mulling over his frustration, he suddenly had an idea that could simplify everything!

Moreover, that idea was as simple as a child's play.

Instead of striving, but vainly, to program the robot by specifying how it was to avoid this or that obstacle of such size and shape, it would have been infinitely simpler to program each specific type of obstacle to *"modify" the curvature of space in its immediate vicinity*, sufficiently so that the robot, always going straight in this "curved" space, be actually oriented in such a way as never crossing the space being occupied by the obstacle in question.

This was simply a stroke of genius! This solved all the problems: programming the robot became trivial (always going in straight line). On the other hand, the space (the reference system) in which this trajectory was a straight line, was curved by the presence of an obstacle according to its specific geometry and its position. This curvature, each proper to each type of obstacle, could now be programmed with instructions to give to the obstacle, and no longer to the robot! And for each model of object, it was possible once and for all its curvature effect on the space around it. That boiled down to taking into account only its shape (that never changed) and only one parameter: its position—which information was also proper to each obstacle and available at all time.

Alan Kay verified that this indeed simplified considerably the task of programming the task of making the robot avoid the obstacles as well as the maintenance of the programs since each simpler for each kind of obstacle, being distributed since delegated to each object—including new object models. It was sufficient to specify for each class of object its own method of space curvature, with no need to touch anything else: neither the other obstacles already programmed, nor the robot itself. Thus, the latter was always moving straight in the space that was curved by the obstacles on its path without them beng “aware” of the robot’s whereabouts. The exact same “effect at a distance” between planets and astral bodies.

Since that epiphany, it was realized that indeed decentralizing the programming towards objects that react to a given context through methods of their own simplify prodigiously the task of programming and maintaining software of all kinds. Each class of objects can thus be given methods that are specific to this class, and that communicate with the rest of the world only through a fixed shared common context (the relativistic reference system). The internal details concerning how these objects behave can therefore be hidden, changed, improved, independently of enything else as long as this interface is respected.

What I understood that day free-falling in mid-air, was that the same isomorphism allowed just as well as relativity to explain mathematically object-oriented programming. It is nothing other than:

$$A \rightarrow (B \rightarrow C) \equiv B \rightarrow (A \rightarrow C)$$

which had been known for ages in Set Theory and also in Formal Logic. Indeed, if whenever A is true then B implies C, then whenever B is true it is necessarily true that A implies C.

—*As simple as “ABC!”*

We learn all the time: while dozing under an apple tree, and even jumping out of a plane above Texas to make a coconut shake with your brain cells. However, if I had to choose, I believe that I’d prefer a mere apple on my own pome… Unfortunately, not everybody can boast being a Newtonian genius—especially when “ABC” are one’s initials when your name is “*Ali Ben Couscous*.”

We can only pretend to be of genius that one can access, depending on whether something falls on your head or whether one is free-falling head first. All is relative…

Nothing to Say