Projective Processes and Neuroscience in Art and Design

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Chapter 14
Understanding How the Mind Works:
The Neuroscience of Perception, Behavior, and Creativity

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ABSTRACT

The understanding of the inner workings of the mind are relevant to enhance curriculum achievements, therefore optimizing the professional practice in general and of the arts and design in particular. The recent birth of neuroscience as a transdisciplinary field poses a challenge to the curriculum and is yet to be included as an integral part of its core. The lessons taught by #TheDress viral Internet phenomenon are here discussed with the intention of enlightening the urgency of a popularization of neuroscience knowledge, from daily life to the professional practice, as a tool to explain how context and experience influence our perception. Along the same lines, the section "The Roots of Human Behavior" addresses the fundamental concept of human behavior and how our emotions were built by our genes, helping us understand basic and complex human choices. Finally, the section "The Neuroscience of Creativity" discusses the neural basis of creativity and its relation to intelligence by dissecting what neuroscience already knows about the development of creativity and how the work environment could foster creativity. The discussion of these topics in this chapter aims to enlighten readers of the importance of neuroscience knowledge in the curriculum and how the arts and design practices can benefit society to become more tolerant.

INTRODUCTION

Although many leading concepts in modern neuroscience can be traced back to the speculation of ancient Greek philosophers (Crivellato & Ribatti, 2007), the neuroscience was not established as a unified discipline until 1971, date of the first meeting of the Society for Neuroscience. Neuroscience as a discipline is considered the rebirth of the mind study and one of the first truly transdisciplinary fields,

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giving researchers a large conceptual umbrella under which they could posit hypotheses about the neural basis of thinking at all levels (Tokuhama-Espinosa, 2010).

The first section of this chapter presents an event that catapulted neuroscience to stardom as a pop phenomenon, when on the 26th of February 2015 the photo known as #TheDress became a viral Internet Meme with over 10 million people from around the world astonishingly arguing over the dichotomy in color perception caused by its ambiguity: #whiteandgold or #blueandblack. This image taught the general public that color perception can be as relative as human perception in general. The brain is equipped with a mechanism called perceptual constancy, responsible for bringing some stability to our already troubled lives. In the specific case of color, this mechanism is constantly compensating for changes in lighting in order to aid the color appearance of objects to remain stable. Without the color constancy, we would perceive objects changing color constantly because the light emitted by them actually changes according to the change in lighting. The full understanding of the reasons behind people perceiving #TheDress as either white-and-gold or blue-and-black and what they have in common is still a scientific mystery to be solved, but the most important lesson from this viral phenomenon is that neuroscience principles can be easily grasped by the general public and that color perception can be as subjective as a political opinion or a purchase decision.

The second section presents humans as a congeries of genes. These genes are responsible for humans greatly appreciating their own well being, and greatly dealing with their own pain. They are also responsible for mutual assistance among relatives. The closer the relationship the more likely they are to help a family member: a mother is always willing to sacrifice more for her son than her nephew, and the nephew more than the son of a neighbor, and so on. What lies behind all of this is the selfish gene. Humans don't think and act on their own need to increase their chances of being replicated. The selfish gene is a replicator and an almost immortal replicator lasting millions of years. The mortal lasting only a few years is the human. The selfish gene is responsible for humans fighting so much and almost never helping a stranger. But the selfish gene doesn't control everything and humans might be the only animals on the planet who are aware of being the result of selfish genes as well as having the capacity to transcend the selfishness of this very gene. Only humans can change the rules of the game so that they can become real humans.

The third section discusses the neuroscience of creativity and the ability of thinking outside the box, that is; thinking differently from the norm. Creativity is a combination of genetics and environment. However, neuroscience studies still cannot explain how exactly these two factors are combined in order to enhance the development of creativity. The increase in size of the human brain happened during two different periods of our evolution and may have generated a sophistication in human memory that provided humans with a better mental understanding of the environment and with greater creativity on how to socially behave. This section also discusses the neural basis of creativity and its relation to intelligence and also tackles the importance of enhancing the working environment in order to foster creativity.

CONTEXT IS EVERYTHING: LESSONS FROM #THEDRESS

Color vision scientists around the world went to sleep just to wake up on Friday the 27th of February, 2015 with several emails and messages questioning them about the color of #TheDress. At first glance, most scientists concluded that they were all seeing the same picture on different screens and that different screens producing the emission of different lights in turn ended up influencing the perception of

the observer. However, the color difference was stark and even when people were looking at the same screen they were divided between gold-and-white and blue-and-black (Mahler, 2015; Rogers, 2015).

The general principle behind this dichotomy is "how we think we see". But to understand this sentence is necessary to understand at least some basic concepts of how the human mind works. Millions of people around the world were really passionate about the color of #TheDress and when someone perceived a different color it was like an affront, a threat to their own self-image (Rogers, 2016).

Color perception is as relative as human perception in general. A better way to understand this notion would be to use price as a measurement. For instance, the dress was priced at $77. Is this expensive or cheap? It depends. To a Hollywood celebrity is close to nothing but to a homeless person is quite a bit. So what is the relationship between price and color? The same way the notion of being expensive or cheap is related to a bank account, the color of the dress also depends on how each person's brain works. In the case of #TheDress, people are divided into two main categories, #whiteandgold or #blackandblue. The color of the original dress is black and blue (pictured below). Who is right? The answer is: everyone.

A brief testing was conducted by this author on February 27, 2015 with 24 observers using the same device: 12 individuals perceived gold-and-white and 12 others perceived blue-and-black. At the same time, across the town of Chicago, a student tested 29 co-workers: 11 perceived gold-and-white and 18 perceived blue-and-black. The conclusion pointed out the fact that the ratio of gold-and-white and blue-and-black could only be safely set after rigorously tested in a bigger sample. It also confirmed that the photo is actually controversial and people are divided between gold-and-white and blue-and-black. In general, color perception differences occur frequently but are so subtle that people usually don't pay much attention to them. However, #TheDress caused a stark color difference and that is why it turned viral.

The brain is equipped with a mechanism called perceptual constancy and that brings some stability to our already troubled lives. Among others, both the color constancy and the constancy of size or shape aim to ease the perceptual instability of our daily lives. In dealing with size, if a person is very close to you, their image projected onto your retina is different from the projected image when they are far away but your brain has no problem understanding that it is perceiving the same person with the same size, no more no less (Goldstein, 2011).

In the specific case of color, this mechanism is constantly compensating for changes in lighting in order to aid the color appearance of objects to remain stable. Without the color constancy, we would perceive objects changing color constantly because the light emitted by them actually changes according to the change in lighting - whether natural or artificial (Shevell, 2006).

The first known report on color constancy dates back to 1694 by Philippe De La Hire who addressed the fact that we don't realize that the colors are different under different lightings. Later on, a week before the French Revolution (1789) Gaspard Monge made a brilliant statement about color constancy, drawing attention to the phenomenon to the Royal Academy of Sciences in Paris. Clad in a red knit, he asked his colleagues to observe the clothing through red lenses. The result was an awestruck audience surprised that they had the feeling the mesh had a very whitish red tone - almost white (Feitosa-Santana et al., 2006; Mollon, 2006).

In the case of #TheDress, some brains assume that lighting is yellow and discount this lighting realizing the dress as blue-and-black while others assume that the lighting is blue, thus perceiving a gold-and-white dress.

Before the digital era, taking pictures required us to choose between Kodak and Fuji films – the former offering warmer tones and the latter cooler ones. Analog cameras were not equipped as our brain and were unable to discount the room lighting. So we had to do what we called white-balancing before

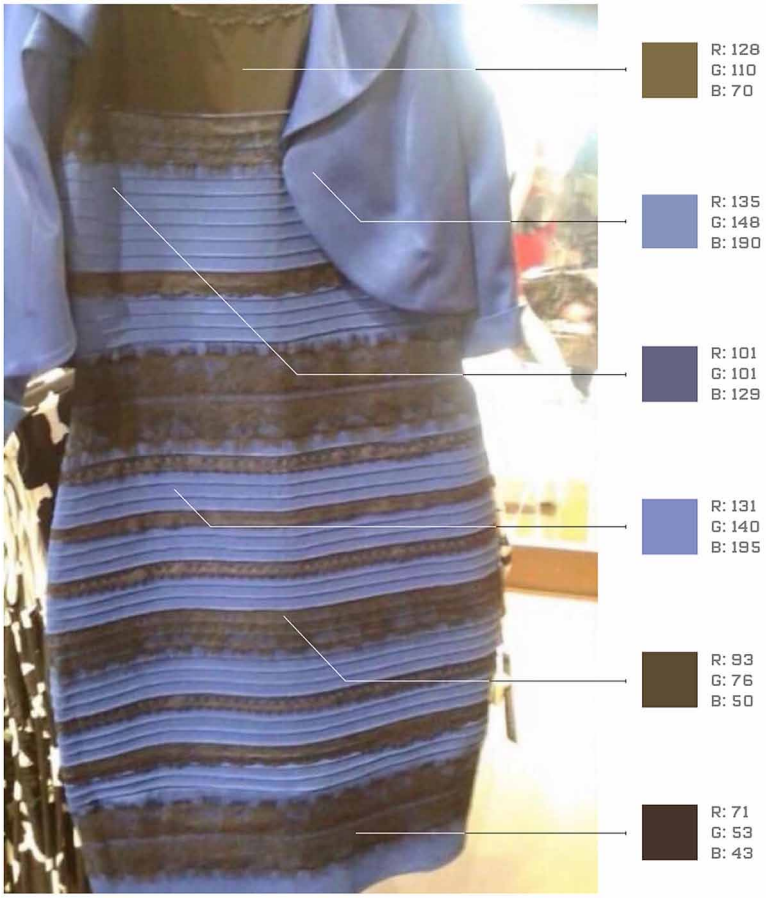
taking a picture which is similar to what our brain does with color constancy in order to stabilize our perception of the colors.

But if we were aware of this phenomenon for so long, why is that the world is only addressing this mechanism now? It so happens that the color difference caused by #TheDress is brutal and in order to realize why, we need to understand how we build relationships between colors (color space) within our brain.

Just over a hundred years ago, Ewald Hering proposed that the experience of color results from the analysis of colors in opposite pairs: green opposing red and blue opposing yellow. Thus explaining why we are unable to perceive greenish-red/reddish-green or bluish-yellow/yellowish-blue. He also used examples of afterimages that we realize after setting a straight stare for about 30 seconds on the same image (Feitosa-Santana et al., 2006).

As explained by Hering, our perception of color is based on two chromatic channels working in opposition: the blue-and-yellow and green-and-red. And what does that mean, exactly? Blue is opposite to yellow; they do not co-exist and so we cannot see a bluish-yellow or yellowish-blue (figure 1). The

Figure 1. #TheDress



same goes for green and red. It is important to stress that our vision is based on light-colors but not pigment-colors – the latter being easily understood by observing the process of mixing pigment-colors used by printers and painters (Feitosa-Santana et al., 2006).

The original dress emits lights that usually cause the color perception of blue-and-black. The dress-image, however, came out very differently. The photo analysis (picture above) tells us that the dress should be perceived as blue-and-gold but the image is unstable and itself full of lights - requiring an arduous task from the brain in order to decide in milliseconds which is the predominant color of the lighting, so that it can then discount and generate the color perception: in this particular picture either blue lighting or yellow lighting.

If it were the case that our brains had to decide between green or blue lighting, the dress most likely would have not become a viral phenomenon, since blue and green are not opponents and perceptual differences would have passed unnoticed. Blue lighting creates a perception predominantly yellow, and green lighting generates a perception dominantly red. Yellow and red are two different colors but between each other there is a plethora of colors such as yellowish-red, yellowish-orange, orangish-red and many other similar descriptions that we are very used to, so it would not cause any real controversy.

In the case of blue and yellow lighting, which are opponents, the result is completely different depending on which of the two the brain decides to perceive. The blue lighting creates a perception predominantly yellow and soon people identify the color as gold or yellow. Discounting yellow lighting generates a perception predominantly blue. Between the blue and yellow there is no chromatic intermediary, creating the stark difference in colors of #TheDress.

The study conducted by this author and colleagues (Feitosa-Santana et al., 2016) in a sample of 52 subjects indicated that the distribution of color perception of #TheDress was approximately of 30% perceiving as blue-and-black, 40% as white-and-gold and 30% as blue-and-gold. The study conducted by Lafer-Sousa et al. (2015) reported different proportions for their 53 subjects: approximately 50% reporting blue-and-black, 40% reporting white-and-gold, and 10% reporting blue-and-gold. The difference in the color perception distribution between these studies could be explained by the fact that most of the subjects in the study conducted by Feitosa-Santana and co-authors were art students very interested in the discussion about #TheDress and may be influenced by the knowledge that the colored stripes of the dress-image were actually blue (and not white) and gold (or orange, but not black) when evaluated by the Photoshop RGB system, not considering the color constancy mechanism in action.

Still, it is unclear the relationship between the brains of those perceiving white-and-gold and those perceiving blue-and-black besides the fact that the former attains its observation in shadows and the latter under daylight (Brainard & Hurlbert, 2015; Gegenfurtner et al., 2015; Winkler et al., 2015). Lafer-Sousa and colleagues (2015) suggest that it all depends on people's daily schedules: morning people would perceive the dress as white-and-gold and evening people would perceive the dress as blue-and-black. However, Feitosa-Santana and colleagues (2016) did not find a correlation between the chronotype (morning/evening schedule) and the color of #TheDress.

Feitosa-Santana and colleagues (2016) found that the perception of the color of #TheDress was associated to the white perception and to color preferences. White-and-gold observers added more blue than the other groups to determine a white patch as well as they preferred more light colors than blue-and-black as well as blue-and-gold observers. Moreover, this study found that the preference for light green can be used as a predictor to the perception of the color of #TheDress, meaning that #whiteandgold observers had higher preferences for light green than others, blue-and-black or blue-and-gold.

The fully understanding of what people perceiving #TheDress in the same colors (white-and-gold or blue-and-black) have in common is still a scientific mystery to be solved, but the most important lesson from this viral phenomenon is being grasped by the general public. Color perception can be as subjective as a political opinion or a purchase decision. If the brain is unable to perceive the world as it is, what exactly does it do? It creates a world that can be useful to us and, therefore, becomes our reality. What we see or what we think is just a point of view, sometimes shared by many but sometimes shared by few or none. As renowned Brazilian Poet Carlos Drummond de Andrade once said "Each one opted in accordance with their whim, illusion or myopia". According to Wallisch (2015), just because we see something in a certain way it doesn't mean that everyone else will see it in the same way. Having this statement in mind helps us to built better relationships as well as a more tolerant society.

THE ROOTS OF HUMAN BEHAVIOR

Whether a denied favor or a broken deal, the reality is that usually the benefited person of the equation is a relative and the harmed one is not. In most cases, the excuse given for denying a favor or breaking a deal is directly related to the personal need of someone or that of a relative. Behind this attitude lies the selfish gene setting a scale of priorities according to the percentage of genes that they have in common with their relatives. The more genes in common the greater the benefit. The lesser degree of relation, the smaller the possibility of a benefit. In the calculation that defines the grantee, the winner is the one with the highest percentage of genes in common. The logic: to benefit the one with more genes in common increases the chances of preserving its own gene (Pinker, 1997).

This is a simplified summary of how the selfish gene, the central unit of the theory of evolution accepted by most scientists today, which has its roots in the association between the natural selection of Charles R. Darwin (1809-1882) and the genetics of Gregor J. Mendel (1822-1882) and was synthesized nearly half a century after the death of both. Since then it has been extensively studied in almost every branch of science. The selfish gene shows that animals were not adapted to preserve their species, but to preserve their genes. As Darwin noted, natural selection favors genes that replicate better, the selfish ones. Examples of the selfish gene in action are found in both the animal and plant kingdom, and with very little effort, you can identify them in the human society. From a simple broken deal to the killing of a stepson, there are many examples of the selfish gene speaking louder in *Homo sapiens* (Coyne, 2009; Dawkins, 2006; Trivers, 1971).

The term selfish gene was coined by Richard Dawkins, and despite some criticism, it is still widely used in discussing the evolution of species. Some authors prefer to call it the immortal gene or selfish genetic element and Dawkins regrets the fact that he didn't chose the term 'immortal gene' as strongly advised by Tom Maschler (Ridley, 2016). Anyway, it is worth noting that all authors are unanimous in saying that, although termed as the selfish gene, these genes have no conscience and therefore just do what needs to be done for the gene to be replicated. All authors, including the author of this article, agree that when the gene is selfish or, for example, the creator of something – it does not imply motivation or moral connotation (Dawkins, 2006).

The selfish gene is the one that needs to replicate, and the more replicators it gets, the greater the chances of success. To understand what is the selfish gene, it is necessary to differentiate body from gene. In the case of human beings, we must distinguish the person from the genes that compose them.

See: Robert and Elisabeth had one son, Bobby, who is not a clone of the parents but a package of genes composed of genetic material from both sides – half from the father and half from the mother. So what Bobby has in common with Robert and Elisabeth are genes. In this gene package, Bobby has one in two chances of having genes in common with both his father and his mother. Robert and Elisabeth didn't want Bobby as an only child, and because they don't live in China they could increase their family. Therefore, Bobby now has a sister, Beth, and again he has a one in two chances of having genes in common with his sister because they are children of the same father and same mother. Bobby and Beth grew. He had a daughter and she had a son. So Bobby has a one in four chances of having genes in common with his nephew, and Beth also has a one in four chances of having genes in common with her niece. So, the nephew and niece are cousins and have one in eight chances of having genes in common with each other. This probability in the percentage of genes in common creates a kinship scale as the number of genes in common increases. In this genetic relatedness there is no novelty, no mystery, and it is difficult to find someone who does not have this knowledge.

What is not new, but many still do not know, is that the scale of relatedness is directly related to the predisposition to cooperate (Hamilton, 1964). The more genes in common, the greater the chances are of cooperation. The less genes in common, the lower the chances of cooperation. It is within the motivation scale to make the largest investment in the selfish gene, and there are few biologists who do not accept this theory: genes are selfish because they need to ensure their own replication. The bodies do not replicate and therefore should not be selfish. Thus the selfish genes need to create neural connections of pleasure and pain to regulate the actions of the animal and thus increase their chances of replication. That's why animals appreciate their own welfare and suffer horrors with their own pain. On the issue of welfare, humans never get tired of self-benefit: shopping, traveling or any other action with no apparent purpose but to benefit oneself. "Never is enough" is the best expression for it. Thus, selfish genes need to create circuits in which humans can appreciate and feel good around each other. The more genes you have in common with someone the better you feel – increasing the chances of cooperation, and therefore, creating greater chances of replicating the selfish gene. Remember, the selfish gene has no conscience (Dawkins, 2006; Ridley, 2016).

Natural selection is not synonymous with preservation of the species and to think this way is a mistake. Darwin knew this, but was and still is often misunderstood. If the overarching goal were the species, the blood ties would be irrelevant. And what we see in the animal kingdom, including mankind, is just the opposite. In practice, it is easy to see that every mother is always more willing to sacrifice herself for her children than for her nephews, and she is more willing to help her nephews than the nephews of her husband and is less willing to help the nephews of her neighbor and so on (Pinker, 1997).

The truth is not nice and animals do not care about what happens to the species or ecosystem. In the film *March of the Penguins,* the penguin whose baby did not survive, suffers from his loss while simultaneously not caring one bit about the puppy beside him being dragged by a sea lion. This same penguin is afraid to dive for food because he does not know if there is a sea lion ready to attack him. So, what does he do? He waits for a much hungrier penguin to dive or he even tries to push the penguin neighbor in order to check whether the local water is free of sea lions and, therefore, safe to get food. Penguins, as much as men, are not concerned about their species or the ecosystem. Think in terms of humans; how many people do you know that skip their vacation to donate the money of their planned travel to benefit a stranger? How many couples do you know who chose to be foster parents instead of biological parents? By contrast, it is very common to find people who do not like their stepchildren, or

worse, stepchildren who were obliged to leave home because they are victims of abuse by their stepparent. In general, animals behave in a selfish way depending on how the emotional circuits are designed, and selfish genes designed these circuits.

As stated earlier, it is necessary to separate the selfishness of the gene from the selfishness of the person, but because selfish genes built circuits in which people have more pleasure when they act in accordance to the wishes of the selfish gene, they end up being selfish too. Return to the exercise presented in the beginning of this paper. Most people are governed by their neural circuits, when in situations where they must choose between benefiting a relative or a non-relative. These neural circuits usually cause them to benefit the parent because of the well-being they feel from cooperating with the relative is much stronger when compared to the well-being they feel cooperating with a non-relative. For your friend, to benefit you at the expense of a relative would have much higher cost compared to the benefit given to a relative at your expense. The choice is often automatically and unconsciously based on cost-effectiveness (Hamilton, 1964; Pinker, 1997).

Now, imagine a change in scenery and your friend's dilemma is not to choose between his relative and you, but between his relative and his boss. If your friend benefits his relative, he runs the risk of being retaliated against by his boss. If your friend benefits his boss, he runs the risk of being retaliated against by the family. He probably will choose to benefit his boss and the chances of not being retaliated against by his family are enormous. In this dilemma, almost all human beings would benefit the boss. Why? When choosing a relative, the person is putting himself and his job in jeopardy, and he has more genes in common with himself than he has in common with a relative.

No one gets as sad about the pain of the neighbor as with his own pain. No one is as happy with the happiness of the neighbor as one's own happiness. But if that neighbor is a relative, the more genes in common, the more likely he is to have empathy and, therefore, the more likely he is to feel sadness or happiness for that family member with more intensity. And that is the essence of love, to feel pleasure with the pleasure of the other, and feel pain with the pain of the other. Today, knowing the selfish gene, it is possible to understand that cooperation between relatives or descendants of people with common genes is equivalent to helping themselves, and it is called kin selection. So if the love that exists between those who have genes in common is a mere reflection of kin selection, the question arises: love is nothing more than a neural circuit designed to work in favor of its creator, the gene selfish? Apparently, Yes!

But cooperation between people with common genes that corresponds to genes helping themselves is not the only type of cooperation in the animal kingdom, and especially in the human society. Cooperation between unrelated people exists, and friendship is an example (Trivers, 1971). The more you cooperate with your friend, the greater are your chances that they cooperate with you. This is mutual cooperation, also known as reciprocal altruism. From the point of view of the selfish gene, it may be good that you have the ability to cooperate with a non-relative. In practice, if you cooperate with your friend and your friend cooperates equally with you, you are even. But in the mathematics of friendship, no one wants to be abused and, therefore, you must be careful with the dodgers. The cheater is the one who wants to sell its cooperation for more than it's worth. Thus, he might be better benefited than those with whom he cooperates. A very clever dodger is one who can sell, successively, its cooperation for a little more than it is really worth. According to many evolutionists, cooperation between non-kin seems to have an important role in human evolution, and Robert Trivers (2011), in particular, suggests that humans are machines that have been adapted to cheat, to detect cheaters and avoid being seen as cheaters. In prac-

tice, it is easy to check, just look at the behavior of any child... It's no wonder that human society has its economy based on money, and also is full of laws, regulations, records, certificates, contracts, taxes, fines, etc. All examples that were made to prevent cheaters from having success.

Nobody wants to be cheated and there are impressive tactics developed through evolution to protect against a cheater. In much of the animal kingdom, females, unlike males, have much more certainty of having their genes in their offspring. Thus, males of several species have developed skills to ensure that they do not invest in offspring of other males and thus are not cheated. As an example, male mice secrete a chemical when a pregnant female smells him in order to check if he is indeed the father of the baby she is carrying. If she is not pregnant with him, the smell of the substance secreted causes abortion. Thus, it destroys their potential male stepson and the female is rendered to breed just for him. Think of the human race: the list of atrocities carried out by man to control the loyalty of "their" women is enormous. On the other hand, from the point of view of the female, most of them do not want a partner who is only interested in mating but do not want to collaborate in the creation of offspring. Therefore, in several species, the female requires a long courtship in order to check how much the male is really interested in investing in the future family. Recently, in modern society, another technique was developed to detect cheaters, man or woman, the DNA test.

In the eighties, the world followed a fairy tale that ended in tragedy. The story was a hoax, and many were the swindlers involved in it. Opinions are divided, and nearly all sided with Lady Di. According to the typical protocol, Prince Charles, who needed an heir to the English throne, could not marry Camilla and therefore sought the hand of his girlfriend, Diana, in marriage. Lady Di then discovered that she was not in a fairy tale and that her contribution to the marriage was only the "nobility" of her genes. Thus, she made no effort to hide from the world that she had been cheated. Human beings do not like cheaters. Lady Di was and still is admired by millions and millions of people worldwide. Recently, the couple's first child, William repeated the fairy tale and Kate was the chosen one. The royal family seems to have learned something and not encouraged, again, the realization of a marriage based only on genes. William and Kate were motivated to date for many years, trying to avoid another scandal that could, once again, upset the fans of the British royal family.

In the modern society, especially urban and virtual, there is a new type of cheating. Think of a friend who is a friend of all. They are the ones who please as many people as possible and rarely put themselves in conflict with others and they never take sides. They take sides only when they have no choice, and for sure their choice is based on who they see most likely to repay for their cooperation in the future. Whether consciously or unconsciously, their goal is always the same: self-benefit. Humans calculate the cost-benefit of any choice to cooperate in the future, always seeking chances to benefit from the cooperation of the chosen - short, medium or long term. Their motto: invest in their social network. You've just been introduced to one of the newest products of the selfish gene, the contemporary dodger. They are social chameleons, wearing the personality necessary to suit the environment, but you never really know who they are, much less what they think.

Genes have no morals, those who have morals are the animals - especially humans. Genes are not aware; those who are aware are people. The genes are potentially immortal while humans are not. Genes live for millions and millions and millions of years, people for just a few. Genes replicate, humans die. The gene does not learn, it just replicates. Humans learn, but take their knowledge to the grave. Not anymore. In oral society, humans lived an eternal cordless phone and knowledge could be lost easily.

But humans, unlike other animals, invented writing and have since avenged death. Therefore, with death avenged, the knowledge built by Darwin and Mendel is immortalized and enabled the development of the evolutionary theory presented here. Darwin descendants and some others have also contributed to the development of this theory. Mendel, in turn, had no children. His genes are gone, but his knowledge remained present. When his studies were rediscovered, many years after his death, they allowed the development of hundreds of studies that led to the understanding, treatment and often the cure of many genetic diseases (Heligman, 2009).

Humans are the only animals on earth that can break the totalitarianism of their genes. Genes created humans and they are the only ones that can turn against their creator. By rebelling, they can transcend their selfish nature and use free will to re-design the future of the human society in this planet.

THE NEUROSCIENCE OF CREATIVITY

Creativity is the ability to think differently from the norm, regardless of common sense. In other words, thinking "outside the box". What makes us creative? Like almost everything from personality traits to disease development, creativity is also a combination of genetic (nature/biology) and environment (nurture/culture), but the neuroscience studies still can not say how exactly these two factors are combined to the development of creativity.

Despite human lineage starting 6 million years ago, the first signs of human creativity are merely over 2 million years old – when *Homo habilis* was able to produce the first stone tools. Between *Homo habilis* and humans today, we have seen an increase in size of our brain that is associated with the improvement of our creativity, intellectual and technological productivity. The first increase in size of the head was noted in the *Homo erectus* (1.8 mi years ago) and coincides with the presence of creative thinking – the same that has adapted to climate differences, development of more sophisticated tools and long distance hunting abilities. The second significant increase in the brain has approximately 600 to 150 thousand years ago with a series of inventions like glue, protective mix of mosquitoes and fire, culminating in a giant leap of human creativity. Between 90 and 30 thousand years ago, it occurs the emergence of syntax in language along with the arts, sciences, and politics. Brain increase in these two moments may have generated a sophistication in human memory that enabled better mental representation (understanding) of the environment and greater skill in social behavior (Gabora & DiPaola, 2012).

Creative people in various fields like music, visual arts, poetry, etc. present creative processes with very similar standards such as the ease in creating metaphors. Besides the ease in creating metaphors, *Synesthetes* – people with synesthesia, also show 7 times more likelihood to pursue creative careers. Synesthesia is a consequence of cortical formation where 3 regions – temporal, parietal and occipital are not separated completely and the overlap of them is responsible for this perceptual phenomenon where two distinct senses are perceived simultaneously (such as seeing a color while at the same time listening to a certain musical note or tasting a flavor while at the same time feeling a certain texture of touch) (Ramachandram & Hubbard, 2003).

The study conducted by Jung and colleagues (2010) suggests that in neuroscience, creativity is correlated with increased cortical thickness in some regions of the brain and reduced cortical thickness in

other regions of the brain. These findings indicate that creativity is a complex activity that requires excitement in some regions of the brain as well as inhibition in others – e.g., the improvisation arts require synaptic inhibition in a certain region of the brain that is associated with a power giant concentration. Lhommée and colleagues (2014) showed how the dopaminergic circuits (dependent dopamine) are important for stimulating creativity.

Creativity and intelligence require distributed neural participation in a complex combination of brain activities, although both work with partially different circuits, and it is suggested that creativity is not merely the result of a high intelligence but a circuit that has evolved parallel to intelligence (Jung et al., 2013). Insights are more likely to happen after a good night's sleep: those who sleep well are more likely to have a light bulb moment (Eureka!) than those who are sleep deprived (Wagner et al., 2004).

Humans avenged death when they invented writing, making the transmission of knowledge after one's passing a reality. This revenge is the basic difference between human culture and the culture of other species as we tend to develop culture faster. Chimpanzees teach their children how to exterminate ants but can't refine this technique adding something else because they are unable to pass on improvements in this behavior for future generations as humans do.

So, what exactly is needed to develop one's creativity? For children, a good diet, many hours of sleep and diverse stimulation (motor, visual and intellectual) because the ability of our brain must create new neural connections and our neural plasticity is much stronger when we are young. The creative process involves many simultaneous connections between different brain regions. For adults, in addition to a good diet and good night's sleep (and the amount of time varies from person to person), time, attention and a physical activity that results in well-being. In this context, time translates into *quality* and attention into *concentration* and *focus*. Some studies show that the only way to enable creative solutions in a short period of time is through attention (dedication or exclusive concentration towards the solution of the problem). Too much time without quality or little time without attention are harmful ways to stimulate creativity. Two great examples of time in the creative process are Darwin and Einstein, both worked years and years to synthesize their theories.

How does the work environment foster creativity? Most workplaces do not encourage creativity. One needs a flexible work environment, respecting the employee's personality so that in turn this can exercise their creativity, since contrary to popular belief, stressful environments work against creativity.

CONCLUSION

The primary goal of neuroscience is to understand how the human mind works in its various capabilities. Its main barrier is finding ways to dialogue with the general public and in the classroom. #TheDress Meme gave neuroscience the opportunity to become pop culture material and took scientific material to the daily discussions of millions around the globe. Despite a nostalgia constantly evoking the past, there are plenty of scientific evidence (Pinker, 2011) proving that humanity has never been better, and that we live in a much safer and compassionated society than our ancestors. Our biology may be still the same for thousands of years but our cultural changes are responsible for all this present positive change. Humans are the only animals on earth that can break the totalitarianism of their genes. And we hope to keep on going until we are done with that job.

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KEY TERMS AND DEFINITIONS

#TheDress: A photo that became a viral meme on 26 February 2015 also associated with the hashtags #whiteandgold and #blackandblue.

Color Constancy: One type of perceptual constancy in which our brain compensates for changes in lighting in order to aid the color appearance of objects to remain stable.

Color Perception: A perceptual phenomenon determined by neural processes in the brain.

Context: The frame of reference, circumstances, factors or conditions involved in a scenario or event, background.

Creativity: The ability to think differently from the norm, regardless of common sense. In other words, thinking "outside the box".

Illusion: The deception of the senses, changing the actual appearance for a fake one.

Selfish Gene: The immortal gene that is the core view of evolution theory.