Faculty of Interactive Media Design
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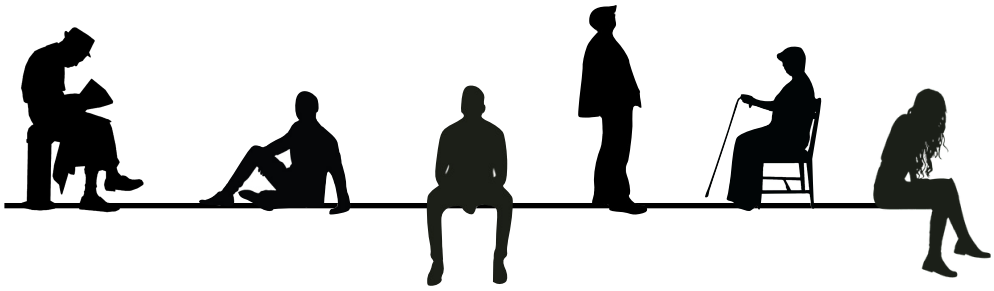

REALITY IS IN THE EYE OF THE BEHOLDER

A study of cognitive perception and its implication for UX design.

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“LIFE IS NOT A PROBLEM TO BE SOLVED, BUT A REALITY TO BE EXPERIENCED”

Soren Kierkegaard

Abstract

Reality is something we are all aware of. We are attached to everyday things, and day by day, we create ourselves based on the reality we grow up into.

From a designer point of view, I analyzed the way reality is perceived by us humans. I focused my attention on a scientific research of the mechanism our brain processes information coming from the world to create our perception of it.

My research explores how the perception of the reality differs from person to person and analyzes how many factors are involved for the creation of a very unique experience, and a well-defined opinion, that every human has, about what 'belongs to reality', and what does not.

The findings show that during the process of the brain in perceiving the reality, the flow of information coming from the outside is far less than the one already present on the inside. By exposing interviews and experiments on how reality is perceived, and how easily our brains daily trick us, the aim of this paper, is to raise awareness on the vital role our brain plays, in the perception of our world and life, allowing us to think, feel, perceive and produce interactions.

Finally, the importance of "minding the gap" between reality and perception, will be analyzed and discussed, for the suggestion of a new perspective, and design approach, for the development of future user experience projects.

Research question: Can a deeper understanding of how the human brain constructs and perceives reality guide designers towards a new approach in the development of user experiences?

Keywords: Reality, Perception, User Experience Design, Parallel Processing, Perceptual Prediction, Neuroscience, Cognitive Process.

Contents

Abbreviations & Acronyms

2nd ed. = second edition

APA = American Psychological Association

CBS = Charles Bonnet Syndrome (see Glossary)

Ed. = edition

Ed. / Eds. = editor(s)

e.g. = example

Km = kilometers

n.d. = no date

No. = number

p. / pp. = page(s)

UX = User Experience

Vol. / vols. = volume(s)

Explanation of the Citation Method

Literature Sources

The citation is according to the guidelines of the American Psychological Association (APA). Each source will, therefore, cited both in the text and the reference list. The sources have all been examined, in order to provide accurate and trustful information. APA style does not make use of footnotes or endnotes, to direct the reader to a source in the reference list at the end.

The paper's quotes are either indirectly or directly. In the paper, the quotations used are shown in round brackets with the last name of the author, the year and, if necessary, the Indirect page's number.

In-Text Citation with a Paraphrase or Summary

For indirect quotations, the contents read are captured together with their own words. The source is quoted with the author's surname and the year.

e.g: (Norman, 2004).

In-Text Citation with a Quote

If directly quoted - i.e. parts of text literally come from the source, together with the author's last name and the year, it will, as well, indicate the page on which the cited text passage is located.

e.g: (Norman, 2004, p. 200).

Or e.g: (Norman, 2014, pp. 195-203).

In-Text Citation with Multiple Authors

e.g: (Knapp, Zeratsky & Kowitz, 2016).

References

In the reference list, the bibliography is finally arranged, divided per sections and paragraphs, in an alphabetic order.

e.g:

Section 1

Norman, Donald Arthur. (2004). *Emotional Design.* (1st edition). Basic Books.

References - Book

AuthorSurname, FirstInitial. (Year). *BookTitle* (Edition). City, Country/State: Publisher.

References - Journal Article

AuthorSurname, FirstInitial., & AuthorSurname, FirstInitial. (Year). Article title. J*ournal title, Volume number*(Issue number), page numbers. https://doi.org/number

References - Article on the Internet

AuthorSurname, FirstInitial. (Year, Month Day). ArticleTitle [PossiblyTypeOfInternetsource]. Retrieved on, Month Day, Year, from http://URL

References - Interview in a Article Online

Author name, first initial. (year, day month). Article title. Name of publication (page number, if available). Retrieved from: URL

Citation of Figures

The figure's sources are located directly below each image in connection with a short description. Illustrations without source's notes were originated from the author.

In-Text Citation

e.g: (Figure 1) / (Table 1)

Under Each Figure or Table

A number and a title with a caption will be displayed.

e.g: *Figure 1.* How to create figures in APA style. This figure illustrates effective elements in APA style figures.

e.g: *Table 1*. Comparison of Median Income of Adopted Children

References

The List of Figures is also alphabetically arranged in the Reference List at the end, according to their number and chronological appearance in the paper.

e.g:

Section 3

Figure 4. Population of Grand Rapids, MI by race (1980)

Table 5. ANOVA Table (1990)

Introduction

Reality and Illusion.
Human beings are caught in between.

Introduction

Reality and illusion; human beings are caught in between.

Our mind and consciousness dwell in the subjective, and personal world of inner thoughts, ideas, and personal opinions; at the same time, we physically exist in a world of concrete objects and objective reality.

The truth is that the world is often perceived in different ways even among colleagues, friends, or families, and when that happens, it may come as a shocking event. More often than not, human beings fall victim of the belief that what each of us sees doesn't differ from what others might perceive. As Douglas Adams puts it: "Everything you see or hear or perceive in a way at all is specific to you. You create a universe by perceiving it, so everything in the universe you perceive is specific to you" (Adams, 1992, chapter 9, p. 71).

It is paramount to stress that perception and reality are not the same thing; what we perceive as reality does not always match objective reality. The world is full of examples where our mind is tricked into seeing, hearing, believing or even wanting something that under more rational and conscious circumstances we wouldn't consider to be real. It is the case of magicians, but also of advertisement and marketing. Artists do the same and so do VR and AR glasses. When the trick does not bring us to unconsciously respond in a way we would not want to, we experiment how our brain works and are drawn to admire the artist for understanding that before us. Julian Beever (Figure 1 & 2) is one of the examples for pavement drawings and for how to trick the brain into seeing things one could not possibly believe to be there.

Figure 1. Julian Beever. "Dancing butterflies in Rome"

Figure 2. Julian Beever setting the scene in Argentina

Human beings cannot win the fight against all misperceptions of reality. Most of the time, our brains run on “default setting” and decides for us what we should see, hear or perceive, selecting for us what matters in that precise moment (Hallet & Kamp, 2011).

Reality changes from everyone's perspective. The sound of a barking dog does may provoke different experiences for different people. In the same way, if a group of people were to stare at a landscape, they would have no guarantee that everyone would “see” the same things, nor store the same information for future memories.

From the very first moment when we meet someone, our brain starts storing an enormous amount of perceptual hints, like a giant calculator piecing together bits of information such as the proportions of a face, the body structure of that person, her character, clothes, attitude, behavior, and so on. Neuro processing then begins scanning previous information for comparison, in a default-setting attempt to take mental shortcuts and find patterns. We rely on a sort of proprietary databank of previously known visual hints to look for similarities, for instance linking them to people that it had saved as “familiar”, “nice”, “clever”, “trustworthy”, or the complete opposite. What this means, whether we like it or not, is that we are bound to develop opinions about that person before any following rational information can be processed, hence falling victim of prejudice, despite our best intentions. What we “select” and associate to positive and negative perception of faces relates to feelings. That explains, for instance, how we are able to recognize someone with whom we have experienced strong feelings, even after many years. As a matter of facts, there is virtually consensual agreement among neuroscientists that the strongest the feelings and emotions felt, the most effortlessly our memory will be preserved.

What needs to be kept in mind is that reality does not look the same to everybody. For autistic people, a face is “scanned” with just the same amount of importance as an object like a chair would. Those who suffer from autism have, in fact, a clinical separation from emotions, also known as “emotion’s blindness”.

Yet we don’t need to wander that far to find other instances of the tricks perception plays on us. Examples like 'magic' cards games, where cards seem to disappear, or like the famous "experiment of the gorilla”, where people too focused on a different task fail to notice a gorilla walking by, all go to show that when the brain is narrowly focused or overwhelmed by too much information to process, our information receptors go in overload and cause us to miss the 'whole picture'. Because our attention focus is elsewhere, we turn parts of the world off, we shut them down to ensure survival of mental processing from a tsunami of overwhelming information.

“So much of what we do is unconscious”

Allan Snyder, from the Centre for the Mind Sydney (Hallet & Kamp, 2011).

Sight gives another good example of this. If we put our thumb in front of us and stare at it, we will notice that all we can really focus on is our finger. The background information ceases to be detailed, everything else seems to become out of focused and confused.

Neuroscientists Dr. Macknik and Dr. Martinez-Conde from the Barrow Neurological Institute, Phoenix gives an explanation for this phenomenon, arguing that if we were able to see and focus on everything at the same time, way too much information will simultaneously come to us, and our brain would need to be 500 times bigger than its current size. Our eyes would likely need to be redesigned from the ground up, and even then, our attention might still be projected on only one piece of information at a time (Hallet & Kamp, 2011).

But why is it important to acknowledge differences in perspective and take note of how our brains process reality? The power that ultimately lies behind the consciousness of others' experiences is the power of empathy towards each other's perspective. By understanding how our brains analyze and elaborate the same kind of experience in so many wildly different ways, we have a chance to move away from the de-humanization of our times and re-humanize our human interactions and, consequently, also the technologies we design for it.

Definitions

Reality

Normally intended to be the world where we live in, made of objects, other living beings, sounds, landscapes and everything that constructs our life.

“Reality”

Will be referred to the reality each living been produced and lives in their own brain.

Natural

The immediate and smooth integration of a particular task, activity or behavior.

Real Experiences

Full-body involvements and exposure to events or situation, that provide “empirical knowledge” and a full emotion reaction.

Scope of Work

This research paper focuses on the scientific processes undertaken by the human brain when assembling pieces of information and inputs from the world. The human senses were researched deeply, together with examples of correlation between senses, and the scientific explanation behind them. This includes the processes of “Cross-Referencing” and “Parallel Processing”. Synesthesia was also researched, but only to the extent that it would yield an understanding of its essence and its implications for those affected by it.

A quick overview of how our memories are stored was useful to understand the principle of “perceptual prediction” and the reason behind our capability to rewrite our own reality in our brain.

In addition to that, some forms of visual and auditive hallucinations were also analyzed, but not inso far as to hone in on all kinds of hallucinations or syndromes like the “Charles Bonnet Syndrome”.

The research did not take into consideration modern theories about consciousness and their techniques like meditation or others, because not pertinent to the final target of the study.

It did also not take into consideration the social aspect of being conscious and the ability to be empathetic towards other people and the society to avoid the risk of moving into a psychological and philosophical arena and thus too subjective for the results to be projected and proven true for most people.

In addition to that, the paper is not meant to give a detailed scientific explanation of the brain and its function, to avoid diverging from the scope of the research. For the sake of understanding the concept of “perception of reality", much of the scientific jargon and anatomic details have been left out, and only some anatomy cues and processes explanations were given, in an attempt to provide the reader with an overview of the functions, without the need to overindulge in scientific knowledge.

Methodology

This research relies on a socio-scientific framework to analyze the complete process that human beings internally and externally go through while perceiving and experimenting the "reality".

It all started with some discovers regarding sounds and images that were perceived in completely opposite ways. This was the beginning of the interest in knowing more and getting deep in the field, allowing myself to understand the process or find out possible patterns or correlations.

In order to do so, I decided to carry out two experiments regarding the perception of "reality" through the process of "hearing" and "seeing".

For the first experiment, twenty-one participants were invited to listen to the given track: "Laurel & Yanny" and try reproducing the sound themselves.
I investigated the participant's results and observed their subjective reactions to the experiment. What I could find out was:

- People would split into two groups: some were only hearing a sound similar to "laurel", while the other group, could only hear something similar to "yanny" or "jelly".
- That the differences in perception were not related to age, gender or genes (my family and I were also split into two groups).
- That for all the participants (and myself at first) it was a great shock to discover, that the reality could be perceived in such different ways.

In the second experiment, the (viral) photo of a dress was shown to an equal amount of participants. Those were asked to have a look at the photo, either from a smartphone's screen or a computer's one, and tell what color did they see. My discoveries here were:

- The differences in perceiving the colors were not "small", as it might be in some cases where people see blue colors and some others green. The colors that were perceived had a great contrast. The participants would mostly see blue and black or white and gold. A small part also mentioned seeing blue and gold.
- The colors perceived were relatively always referring to the same piece of texture, of the dress. That means, that one part of the dress could be perceived either as blue or white and the other part of the dress could be perceived either as black or gold.

After some desk research both examining professional opinions about the two experiments, that went viral on the web for the past three years (Mitchell, 2015), and studying deeply the

process of how a human brain analyzes the information collected from the outside world through our senses, I developed the following hypothesis:

Experiment 1 - Sound "Lauren & Yanny"

- The different perception of the sound might rely on the way the human brain perceives frequencies.
- In that short amount of time, our brain decides which frequencies should be predominant, or which one carries the most "important" information for us and literally "cancels" the other frequency, that we are then not able to hear at all.
- The device could be a factor, that influences the way frequencies are delivered, therefore the way people hear and perceive sounds.
- Sounds, that are being recorded more times form the same record, lose a part of their intrinsic information and leads to misperceptions and confusion.

Experiment 2 - Image "Blue & Black / White & Gold dress"

- When taking pictures, the luminosity of the room might have an impact on the perception of colors for the human eye.
- Once again, according to the device, the way pixels are delivered changes. Participants would sometime see different colors, in a second attempt, by changing the screen where the dress was displayed.
- There is an automatic correlation, the human brain does, when looking at a photo, between the colors of the objects and the amount of light perceived in the background of the photo (Udland, 2016).
  In the experiment, the participants who perceived the dress to be white and gold, actually saw the room quite highlighted, and the dress therefore in a shadow (dark white and gold). For the other group of the participants, who perceived the dress to be blue and black or blue and gold, the room seemed to be pretty dark and the dress, therefore, highlighted (light black, blue, gold).
- In the live interview, conducted by Ellen DeGeneres (2015, March 30) during her show, with the owner of the dress, Cecilia Bleasdale, nobody had any contradiction in recognizing the colors anymore. That means, that those kinds of "hallucinations" our brain produces, happen mostly in "recreated reality", like photos, sketches or paintings.

The goal of this analysis was to assess the extent to which the results of my experiments could reveal something “hidden” about the way we perceive the reality, every day.

The implications for this are that, if we accept the hypothesis that the brain analyses reality in entirely different ways, and thus we agree that the way reality is perceived (and therefore the experience of it) changes greatly from one person to another, then user experience design should consider a new approach and design process. With this in mind, I have attempted the creation of a new design process that would reflect the perception hypothesis and might improve user experience processes in the future.

Body

Reality is lastly, whatever your brain tells you it is.

Body

Literature Review

Reality Is in Our Brains

Every living being perceives the world through their senses.

As humans, we don't come into the world with a trained and pre-instructed brain. Our genetic "hard-wiring" lets us know how to breath, cry, suck, it makes us interested in faces and objects in order to learn from the world around us (Eagleman, 2015). Nature provides each species with different kind of senses, "default-settings" if we may, that determine which senses should be more relevant – and thus prevalent – than others. Senses, therefore, are dictated by biology, as "each creature perceives what it has evolved to perceive".

Dogs for example sense molecules that we humans won't. Their smell experience, by comparison, is as rich as the one for our sight. Ticks are blind and deaf. To them, important signals are temperature and body odours. Bats, on the other hand, eco-locate through sounds, in the form of air compression, which plays a key role in this process. Finally, snakes and fishes don't have ears like we do, so their body sensors allow them to "hear" their surroundings by perceiving sound waves.

The way we perceive the world is very different, and that is true not only in our comparison to animals, whose body-composition is often biologically very different than ours. The perception through human senses differs from person to person, because in the cognitive process, the interaction with our brain "databank" and its complexity makes for a very subjective end result.

Some scientists argue that there is actually no color, smell, nor sound in the world; they claim that all we perceive is a cognitive elaboration, a subjective construction that takes place inside our brain. Together with a long and complex process, the inputs we get from the world and the information stored in our memory seek to bind cues and bits of information to create, shape and sustain a very subjective reality in our head – one that is ours and ours only.

Although it might feel like the experience of reality takes place directly through our senses, led by the belief that we can reach out for the physical world, the sensory experience is by no means direct. We may think that we touch with our hands or smell through our nose or taste with our mouth, but the truth is, none of those sensory feelings would happen if the computational material of our brain wasn't there to process them.

Reality, therefore, could be defined as “the brain’s ultimate construction”, as it bases its truths on all the streams of information coming from our senses, and consequently constructs, shapes and sustains subjective perception.

We start to create a personal “reality” from the very first moment we are born. Our eyes play a key role in this process, for each time we look at something, they are engaged in a non-stop practice of collecting missing pieces of information and storing them to make increasingly more sense of our surroundings.

The brain will scan for new information and will add it to the internal databank of already existing information, linking it to that particular visual and perceptual cue that is already present in our head. Neuroscience teaches us that every time we look at something, we miss parts of the puzzle. Unconsciously and automatically, our brain calculates on our behalf what piece of information we “want” or “need” to look at, in a fraction of a second or for extended periods of time.

What the brain does is selecting and processing while look, in an aim to catch, as quickly as possible, the most important piece of information it needs. And the carousel doesn’t stop: every time we look at something there is going to be things we don’t notice or register. For every piece of information we can focus on, there is going to be something else we are not aware of.

A good example of this is how our eyes see. If we were to take a video of us looking at a city (from the perception of our eyes), we would feel sick for how quickly the eyes move in order to collect as many information as possible in a limited amount of time, as quick as possible. The eyes catch just the “missing pieces” of the subject we look at, to complete and update the “databank of information”, that our brain already has secured in our previous encounters and experiences.

The Brain Is the Universe Ultimate Storyteller

The human brain creates the reality we need to live in, right inside our head. That reality, we mostly take for granted, requires intensive training across a whole life, as it will adjust and adapt, according to the environment we live in or the experiences we make, that finally define our lives and who we are.

"All the experiences in your life - from single conversations to your broader culture - shape the microscopic details of your brain. Neurally speaking, who you are, depends on where you've been." (Eagleman, 2015, p. 7). The experiences we make will be eventually stored in our

memories and will have a great impact on the perception we have in all future experiences of our life. The brain will, in fact, constantly re-write its own circuitry, basing itself on the unique experiences the human does, and because of their impact on human life, the personal identity becomes a moving target and so will our perception of reality, with no endpoint.

Memories are stored in our head like pieces of “truth”. We will therefore always give more credit to what is in our head, then to what “the outside world” would tell us. To understand that it is necessary to analyze the processes that happen in our brain in details when perceiving the reality.

The human brain is constantly bombarded by stimuli from the world "out there" (even though we are only aware of what our senses can pick up), but the "gap" between the reality and what we experience, finds its answer in the way those stimuli are being received from the brain, and transformed in pieces of meaningful information.

The brain interprets information from the outside world and embodies the essence of the mind and soul. It governs intelligence, creativity, emotion, and memory. Whenever our senses are active, they send inputs to the brain in form of electrochemical signals (Mayfield Brain & Spine, 2018). It almost feels like sights and sounds could almost “stream” inside our brain, but there is actually no way for those information to directly reach the brain. The brain sits in silence and complete isolation, protected by the skull, but even if the brain itself never sees or hears the outside world, it is able to experience it (Eagleman, 2015. [documentary]).

Photons of light and air compression waves become here converted into electrochemical signals. These signals travel inside dense networks of brain cells called neurons. There are hundred billions of neurons in the human brain, that are constantly communicating between each other (Eagleman, 2015. [documentary]).

All this activity produces our sense of “reality”.

As a confirmation, that the reality is lastly, whatever your brain tells you it is.

Human Senses: Our Portals to the Outside World

There is only a way, to bring information to the brain to be analyzed and used, and that is through our sensory organs. Those "portals to the outside world" (Eagleman, 2015, p. 156) act as interpreters by detecting information sources like photos, air compression waves, molecular concentrations, pressure, texture, temperature and so on, and translating them into electrochemical signals.

These electrochemical signals hit networks of neurons, that will bring signals to the brain. Every second of our life, a hundred billion neurons send hundreds of electrical pulses to each other. From the never-ending stream of upcoming data, the brain will sift it all, looking for patterns, which will then be assembled into our perceived reality. It is an operation, which is the product of millions of years of evolution. It is so powerful and efficient, that its work seems effortless and instantaneous (Eagleman, 2015).

Taking as an example, vision, our most dominant sense, it will be demonstrated, that to see clearly, many different systems need to be operating in concert.

For blind people like Mike May, a man interviewed by the neuroscientist David Eagleman, in his book *The Brain* (2015, pp. 41-43) , who lost its sight when he was three and a half years old as a result of a chemical explosion, the world in his mind has not been created based on his vision. What Eagleman found out, was that, after Mike undertook the surgery (a decision he took in his late forties), the moment when the bandages came off as was for Mike as a "whoosh of light and bombarding of images on to my eye. All of a sudden you turn on this flood of visual information. it's overwhelming" (Eagleman, 2015, p. 41).

His brain did not learn how to correlate the information coming through the vision, with parameters of space or perspective and has no connection in its internal databank of pre-existing patterns to create a meaningful reality. Once he got home to meet his sons, he saw them for the very first time, but their faces had no real meaning for Mike, as they were not related to any memory he had, he says: "I had no face-recognition whatsoever, none" (Eagleman, 2015, p. 43). For the same reason, he was not able to recognize facial expressions.

The example of the interview with Mike gives us a glimpse of all the elements that have to be in place, for the brain to construct a visual reality.

Many regions of the brain are specialized in vision. They all specialize in different aspects such as motion, edges, colors, face recognition. The brain unifies all this into what we experience as an image. For Mike, after decades of blindness, these regions have instead been occupied with different tasks, like hearing and touch.

A good way to understand how the brain operates is often to make the experience of having specific operations getting disrupted. In an experiment conducted by Alyssa Brewer from the University of California, Irvine, a test-person was invited to wear a special pair of glasses or goggles, that would flip the images coming from the right eye, with the ones coming from the left eye (Eagleman, 2015, p. 45). Target of the experiment was to see how long the test-person would take to rehabilitate his brain to the "new reality" perceived. It turned out, that after a

week, all new visual inputs are being converted into meaning. What Alyssa Brewer found out was that “it takes about a week to start behaving normally. They start being able to figure out how to interact with the world, and constructing a new reality around them a new way of dealing with these incoming perceptions. They say that initially, they can tell that there is a new left and an old left, a new right and an old right” (Dr. Alyssa Brewer - University of California, Irvine, 2017, interview). So after a week, the participants of the experiment Dr. Brewer conducted, seemed to have lost the concept of right and left directions, like the whole cognitive, spacial map of the brain is being newly trained. “By two weeks in, they would write well, read without a problem, do all our walking tasks and reaching tasks, and then when they remove the googles, it actually takes a good amount of days to go back to normal behavior” (Dr. Brewer, 2017).

Seeing seems natural and effortless, although the process happening inside the brain is so long and complex, that it will take half a second each time, in order to elaborate a respond from the body. It means we kind of live in the past, reacting for inputs we received, with half a second delay each time, and that seems to be the unbridgeable gap. We can see that, for example, on a tracing race. By looking at the racers in slow motion, it is possible to notice, that there is a real gap between the shot of the pistol and the actual body respond from the racers.

That is why many different parts of the brain elaborate the information we get from our senses and each type of sensory information takes a different amount of time to be processed. For vision, for example, 1/3 of the brain is involved, and it is a much more complex process.

But the brain hides all this, giving us the impression that we move, think and act synchronized and immediate.

The research paper is not aiming to explain the brain in every detail but just to give some useful information to understand the process it goes through while perceiving reality.

The Thalamus, for example, plays a key role with the analysis of the inputs coming from our sensory system, as it is one of the brain's biggest junctions and most information is collected here, before moving to the Cerebral Cortex, our "council's mind” (Eagleman, 2015). So, the data collected from the eyes stoops here before being elaborated by the cortex. There is a constant exchange of information, between the Thalamus and the Visual Cortex. Interesting here is that the flow of information coming from the visual cortex to the thalamus is actually far bigger than the other way around. That means, that much more information is produced from the brain itself, than from the information collected directly from our senses. When we look at a familiar place, we don't really see anything, because those images are already present in our mind.

It’s like the visual cortex is sending optical expectations to the Thalamus the whole time.

"Remove the world and the show still goes on", because the world already lives inside our brain! (Eagleman, 2015, pp. 49-54)

Memories like this, for example, are processed in a part of the brain called Amygdala. In a critical situation, through the Amygdala, the brain is able to bring up memories with a lot more details than normal circumstances, for us to remember particular details of a moment in our past.

Through our senses, the brain assembles a huge amount of data, in order to create reality.

Human ears, never stop working. This is why, if someone is watching TV in the same room as we sleep, we might have some distortions in our dreams, because that information coming from the movie or tv-show, will be sent from our ears directly to the non-stopping brain to be processed inside our unconscious dream-activity. A professor of music's history, Dr. Sabetta (2006) explained once, how he and his wife liked to listen to classical music, while she was pregnant with their daughter, and how that same music would help the baby to sleep and calm down, once she was born. In her brain, that information was unconsciously stored, by being linked to strong emotions, that later on, in her life, allowed her to recall the same feeling and, therefore, the same result of falling asleep and calm down.

The nose too, at any time, will catch up information from the world and send it to the brain, influencing the perception, mood or feeling about situations and moment. The use of essential oils for medicine or personal care have a big impact on the perception of our personal state.

Cross-Referencing

Sensing requires more than the sensing organs themselves. Babies tend to reach out for everything to touch, smell and perhaps event taste to get a "feeling" of it. This happens actually as a way for them to see the object better (Eagleman, 2015, p. 44). By experiencing the texture and shape in their hands, the visual memory of the object will imprint in a more clear way. Learning how to see is a complete body experience. This junction of different senses starts a process called “cross-referencing” (Eagleman, 2015, p. 45); a process that will continue to grow throughout our whole life, there is, in fact, always something new to learn.

This process is so relevant, that the data collected through our senses, will only mean something to us if we are able to cross-reference it to other information from our inside databank, and match patterns.

Our senses depend on each other and are influenced by one another. For example, by only smelling the food we start processing in our brain an image of what it may look like. When we then look at it, the sight and smell alone will already give me a sensation of how it might taste, and finally, reach the decision of wanting to try it or not.

Our reality is built by comparing these streams of data coming from our sensory system. When they are moving together, we get the perception of a specific moment. We saw, that what we touch influences what we see and that taste is affected by our sense of smell, but also our sight informs us how we hear.

Sensation and Perception

Sensing and perception are one connected experience. From the figure 3 ,we can see how sensation is a bottom-up process by which our senses like vision, hearing, and smell, receive and relay outside stimuli. While perception is the top-down process where our brain organizes and interprets that information and then put it into context.

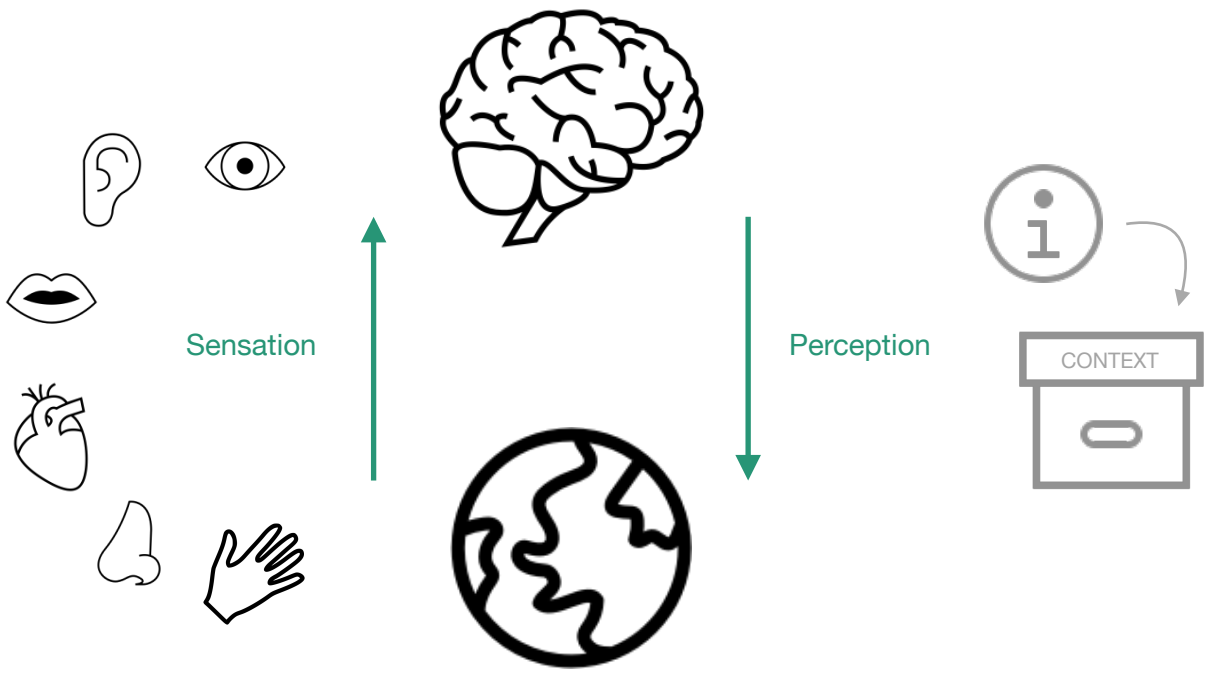

Figure 3. Sensation and perception's process explained

When we experience holograms, our brain calculates what we are supposed to see. Basing itself on previous -already stored- information regarding a similar object to the one appearing in the hologram, it tells us it's a real object. Unfortunately, as soon as we try to touch it, we get confused because the reality is suddenly not as we expected it to be. Our brain is confused because it cannot find patterns between contradictory inputs.

Another interesting fact is our ability to become sensory adapted. By experimenting with constant stimulation one same input, like living next to the train station, hearing trains coming and going at every hour of the day, within some time, the senses will eventually adjust and then just stop perceiving those inputs, consciously.

A theory developed between the 50' and the 60', which evolved from the development of communications and radar equipment, explains why people perceive stimuli in different ways according to the situation. This is the Signal Detection Theory (Heeger, 1997), a model for predicting how and when a person will detect weak stimuli, partly based on context. This has something to do with the person's psychological state, that defines the alertness or expectations at the moment (Heeger, 1997).

Parents, for example, who hear their baby crying, exclude for a moment the inputs of the world surrounding, because the brain focuses on what it's most important for us in that situation.

How Do We Experience Reality

From the moment we entered this world, our experiences have been surrounded by an explosion of senses. The reality is where our life is lived every day, where we are immersed, and without whom, we wouldn't have evolved properly. We experience reality as it is presented by our senses.

Somehow everything we collect from our senses, every electrochemical signal, results in the experience of being us.

But because experiences always require explanations, billions of neurons in the brain work together to generate a conscious experience and to try to give a meaning to everything concerning it.

Through a process called "Parallel Processing" (Green, H. & Green J., 2014) our brain tries to give meaning to our vision simultaneously processing the given information in the current situation. Color, motion, form, and depth are all perceived together. Just as we have seen in

the example of the baby, when we learn how to see, we parallel link different information to a specific thing, that then becomes an intrinsic part of it.

But sometimes it is not possible to give meaning to what we experience. One case is the one of Synesthesia. Synesthesia is the results of cross-thoughts between sensory areas of the brain. Synesthetic people have a special ability to connect senses, without being able to explain why.

There are many different types of Synesthesia, among them the Lexical-Gustatory Synesthesia, the ability to see words while perceiving their taste, like “tasting words”. Another interesting kind is the Chromesthesia, an ability that many musicians claim to possess, to see music in colorful experiences, some others will hear colors. People with Mirror-Touch Synesthesia would literally feel the same percussion the person in front of them is doing themselves. Sometimes words can evoke experiences, for those people with Grapheme-Color Synesthesia, reading and seeing words is a very colorful whole experience, as specific letters, numbers or words, like the days of the week, are associated with colors. Always, as a permanent link.

We Predict Ourselves into Existence

Every one of us has this internal-generated reality, a world that exists inside our brain. The experiences we do are not as much linked to what is out there, but rather to what is predicted from our brain. Our brain renders us a beautiful simulation, making use of our internal models.

Internal models vital for our ability to function (Eagleman, 2015). In our databank of information or memories, we have been built internal or mental models over a lifetime of experiences. We created mindsets of all that became familiar to us and started to look out to the world in these mindsets. An explanatory example is to be found in the works of arts of the Italian artist Gianluca Gimini who in 2009 asked random people to draw for him a man's bicycle from memory.

He finally decided to give life to their sketches by actually constructing them (Figure 4).

Those are the reason why we recognize well-known objects like cars or houses or other daily objects, within a glimpse; our brain has already built an internal model for that and will recognize any other similar object as one of the same "family". And when we experience

something, we already have an internal model for, my brain let me see only what I expect to

see. That means, we mostly just see what we already expect to see!

Figure 4. Gianluca Gemini. Velocipedia 8 & 11

In some cases, we even consciously experience this process at work. It is the case of visual and auditive illusions, like the ones of my initial experiments. We predict an outgoing result for a specific experience and then our brain is shuttered by a totally different version of it.

On May, 17th 2018, Ellen DeGeneres played a track of a totally unrecognizable sound. After some seconds of confusion, she played the speaking voice of a woman, saying "The juice of lemons makes five punch". Finally, she played the first track again, but this time, everyone in the audience could clearly understand the same "hidden" spoken message. Our brain saves and collects information continuously, updating internal models already created, to finally predict ourselves into existence.

> “It’s easy for the brain to make an estimation of the world to make us exist, instead of trying to achieve a precise perception of what’s out there”
>
> (Stephen Macknik, Das authomatische Gehirn, 2011)

Our brain knows more than we do. Its prediction is supported by all the knowledge, that we have been 'feeding' it, in our life, and basing itself on that knowledge, it is always calculating and forecasting what will be happening next. The 'motivation department' in our brain, releases dopamine for anticipating all the good things in our life, and when we get ready for a race, our heart starts pulsing faster and the whole body prepares itself for the big moment.

This is actually called “perceptual prediction", our ability to imagine and overwrite what is really out there or what it is going to happen and perceive instead what we think, that we should perceive.

“MIND THE GAP, BETWEEN REALITY AND PERCEPTION”

Discussion

We need the reality to evolve ourselves,
to collect that information that feeds our brain,
and become the essence of who we are.

Discussion

Why Is Reality so Important for Humans?

Our brain is constantly working to construct a reality for us. Though our personal perceptions create different ones in each other's head. Internal models help us to make sense of the things we see and experience. Reality is important for living beings for a better interaction with the world. And that's even if what we consciously see pends on the brain's best guess of what's out there.

Does it not affect us, that we continuously miss part of the reality?

We know that people like magicians would exploit just this "missing parts" we do not record, to trick our perception and so do marketers with advertisement campaigns do.

Knowledge is very important for humans because knowledge is power. That is why, every time we do not understand something like visual or audio illusions, first thing first, we want (and feel the need) to know why and understand its explanation. But the reality is, that our brain serves us up a story and we all believe it all. We believe the dream we happen to be trapped in. We believe the sight of colors, the hearing of sounds and music, the taste of food, all this simulation that our mind produces for us. And the reason is, that we need the reality to evolve ourselves, to collect that information and feed our brain, and to become the essence of who we are.

My Conscious, Unconscious and Myself

> "The emerging understanding of the brain profoundly changes our view of ourselves, shifting us from an intuitive sense that we are at the center of the operations to a more sophisticated, illuminating, and wondrous view of the situation"
> (Eagleman, 2011, p. 10)

So who is in control here? Are we "paddling our own canoe" (Baden-Powel, 1939), or is there some kind of external force, always guiding my actions and thoughts? If the brain is taking control of all what we think and see or hear or feel, where is our free will? Do not we need to be conscious while deciding how we act?

Most people tend to think that being conscious all the time might be the only way to accomplish things in a proper way, but instead, our brain is able to accomplish a lot of things unconsciously while we are busy doing other tasks. A famous line of Saunders (1957) says: "Life is what happens to you when you're busy making other plans".

Sometimes, when we walk down a street and someone we have not heard in a long time, calls us, we start walking around, completely caught in the conversation, that we do not really pay any attention to where we are going or why. Sometimes it happens, that at the end of our conversation we do reach our destination, but not really knowing why. Some other time, instead, we might end up in an area we did not consciously plan to go, and here we start asking ourselves why and most importantly, how did we get here without being conscious? On our legs? How did we manage to go past cars on the streets or people walking around us, how did we calculate everything in order to be still alive and safe, in the place our unconscious brought us? After many years of scouting, I learned how a good conversation with other people could bring me to walk twenty-five km per day, up and down the mountains without previous training. This may mean, that we should probably give our unconscious brain a chance, to accomplish tasks or guide our body towards goals, we would not consciously bring ourselves to do, or we would not have the chance to be focused on.

There is a difference between having a body and being a body. The brain makes its best to experiment what is, and what it is not part of its body, and as the next experiment will show, this perception could be easily tricked.

About ten years ago, some psychologists in Pennsylvania discovered the amazing illusion of the now known as "rubber hand illusion”. The target of the experiment was to understand how sight, touch and "proprioception" (the sense of body position) would, combined, create the feeling of body ownership (Botvinick, B. & Cohen, J. 1998).

The experiment required each of the ten participants to lay both arms on a table. One of the arms, though, was placed behind a standing screen to hide it from the view of the participant. A life-sized rubber hand and arm was placed perpendicular to the participant's shoulder to simulate the "missing arm". The participant had to stare at the rubber hand, while a paintbrush was synchronic stroking both the rubber hand and the participant's real (hidden) one.

After the participants completed a questionnaire, describing the experienced experiment, it was hypothesized, that the distortions of the position-sense, have an impact on the visual and tactile inputs. The participants stated that after a while, it really felt like the rubber hand had become part of them as their own.

A similar experiment of "Body Transfer Illusion" was accomplished by taking a rubber life-size doll and placing it standing in front of a participant. The neuroscientists demonstrated the same illusion as the rubber hand one, by being both the participant and the doll touched on the same body parts at the same time. After some time of synchronizing touching, to allow the illusion to take place, the scientist would take a knife and make the gestures of cutting the doll's stomach, the reaction of the patient, fearing for their stomach, reveals that the knife was felt from the patient like cutting their own stomach (Hallet, T. & Kamp, T., 2011).

We experience cases of body transfer illusion also in the Virtual Reality world. Playing inside a virtual world, we will eventually fall for the reality that is being presented to us, because of the interaction we experience inside it. Even if we know that what we see is not real, the interactions and the stimuli will bring our brain to believe all the inputs and information coming from the new world, forgetting about having googles on, or being physically somewhere else. The web is full of videos of VR-players falling down on the floor while virtually experiencing to fall down inside the game. And that appears to work also with games where there is not a body to relate to. This confirms, that the experiences of our body come from inside the brain.

What Do Hallucinations Reveal About Our Minds?

“Hallucinations are like movies with no sound”
Anil S. (TedX, 18 July, 2017).

The brain hallucinates our conscious reality. And each time we experience a visual or auditive hallucination, our brain would take time to process the incoming information, and in that time, we get an insight into how our brain works.

Taking as an example my first experiment, the "Yanny-Lauren" sound, as analyzed at the Speech Lab at Virginia Tech, it turned out to have been a poor recorded “Lauren” speech recording of the vocabulary.com website, that brought people to hear either one sound or the other. With the second experiment of the picture of the dress also, it came out that our perception of "twilight vision" makes us distinguish colors in a very personal way. Some people calculate more the blue parts from the visual light (white-gold dress) when interpreting shadow and twilight, others calculate more the red parts (black-blue), explains the American expert Bevil Conway (2015).

And all that teaches us how the psychological effect of priming plays a very important part in the perception of our world through our brain.

Conclusions

With a greater sense of understanding,
comes a greater sense of wonder
and a greater sense of realization that we are a
part of and not apart from the rest of nature.

Conclusions

We experience the world as it is presented by our senses after our brain has elaborated that information for us. For a fruitful experience of the world, we need to be immersed in it, and interact as much as possible with it, discovering different kinds of inputs and strengthen in the process our senses. Reality is the perceived result of this long and complicated process, happening between the senses, and the elaborated information inside our brain. In other words, reality is whatever the brain tells us, that it is. And this is because every living being experiences the world, according to the instruments, they were given by nature.

This process of sensation through our senses would have no meaning if the brain would not perceive and put into context the elaborated information through the process of perception.

Through the process of cross-referencing, humans are able to correlate new information with already stored information inside their mind. In their brain, humans will create, and continuously update, unique models of the world and the environment where they live. We, therefore, experience the reality through internal models of the things and the living beings, that surround us. This cognitive process has a strong connection to the emotions, that humans develop while building relationships with the components in the story of their life.

Internal models are the base for the brain to predict the reality and perception of future events and prepare our body consequently.

We have pretty much no choice than believing to the simulation of the reality created in our mind, but sometimes, by experiencing visual or auditive hallucinations, we get the opportunity, to consciously watch ourselves perceiving the world and struggling to decide what we just perceived, or what to believe.

Findings

Designing Real Interactions, Means Living Real Experiences

There is a need for design to implement all this knowledge in its process. By designing sensory user experiences, as it is happening right now in the world of technology and design, there is a great need for exploring the possibility of a junction between design and neuroscience. A healthy and safe relationship between the two could mutually bring benefits for future progress, new discoveries, and achievements.

What if we could design a way to augment our senses to experience the world in a more complete and unconscious, intuitive way? Sensory substitution might be the answer for circumventing broken sensory systems, like ictus, blindness, people who can't walk or babies who are past the time where they're supposed to be talking and yet don't.

Can the brain be also augmented to modify how we perceive and reach out to the world?

One interesting example is the one of Jan Scheuermann (Eagleman, 2015, p. 156), who lost the ability to move her arm on her own. Her mind is now connected through wires to a mechanic arm, and she just has to think about getting her arm up or grabbing a glass of water, to move the mechanic arm and do it.

How we sense the world is only half of the story because the real experience comes with the interaction with it. It is impossible to predict how many kinds of signals could our brain learn, in the future, to incorporate. Maybe one day, we will be sitting home enjoying time with our family, while our brain is working in the office, taking care of tasks, by communicating to some kind of external machine.

In the future of designing experiences, designers should take into consideration, how the brain works, to make the product and or service work. In order to create a more human-related and human-centred experience, their interactions should not appear to be unintelligible and complex, but rather smooth, hidden between the lines of thinking, feeling and perceiving. Designing products and services for people could probably go past their physical body, and concentrate on the expanding of 'the sense of being human' through design concepts for the brain.

Designers need therefore to get involved in psychology and neuroscience, in order to truly understand the cognitive process of all the involved users.

Knowledge of cognitive processing can guide designers understand how people experience sound, taste, smell, colors, patterns, movement and spatial location, as well as provide them with an understanding of how these are tied to emotions – which is what ultimately shapes the experience itself.

The understanding of humans and their behavior is absolutely vital for a user experience designer. In order not to fall in the temptation of guessing or arbitrary decide what could be best for the user, UX designers need to get to know the participants and watch them being active in the process, they are designing for them, letting themselves be included in the activity as well, in order to completely experience it with their whole body.

> "Pay attention to what users do, not what they say."
>
> Jakob Nielsen (2001)

According to some of the design principles of Don Norman, UX designers should always start designing from the human, and by saying that, he means all the humans and component that will take part of the interaction with the product or service. Designers should also always try to solve real problems, those to be found at the root, not just the symptom because by solving the root problem, we might eliminate all possible symptom. The last thing he suggests is to think about everything as a system, and designing the interconnections between its component because, through interactions, we will reach the final goal and purpose of the design project once for all (Norman, 2018). And that gives already a good connection to the neuroscience analyzed so far.

> "People ignore design that ignores people."
>
> Frank Chimero (Curtis, 2012)

Everybody Loves a Good Story

Jonathan Gottschall, in his book “The Storytelling Animal” (2012) reports that humans spend around 1900 hours per day involved in stories. That corresponds to around 5 hours per day. We use stories to explain things, compare experiences or topics in our conversations with friends and families. We cannot think about anything that is not involved in a story. As the research paper could here demonstrate, the human life is full of complete experiences, where we take part with our whole body and mind and are immersed in a world made of sensations, perceptions, and emotions. This is the best way to develop our skills and grow our consciousness.

For example, my life has taught me, that the best way to achieve fluency in the speaking of a foreign language is getting yourselves a full-immersion, not only regarding the language, but more letting yourselves be immersed in the culture and experiences, exchanging thoughts and living stories together with the natives, in their native land.

By reading this paper, we learned, as well, that for the process of seeing, our strongest sense, it is vital for the human to have a whole body experience. Designing products and services should mean designing experiences that do not limit themselves in being concerned in one specific 'department' of the brain or involving one sense at a time because humans are the result of the combination of all the senses, elaborated in the brain via cross-referencing and parallel processing.

Experiences are strongly linked to emotions. Think about personal experiences like traveling around the world. Every travel, for different reasons, brings us on a whole body-journey, where we are involved completely and let ourselves be open to discoveries and curiosity.

We change to adapt to our environment, and traveling the world seems to teach us about it in the best way. Our mind opens and perspectives change.

With this principles, I learned how to travel, experience and discover the world and myself at the same time. Those experiences will always be with me, stuck in my memory and myself, because I not only took a holiday, I became part of the journey and the journey became a piece of whom I became today. Those are the experiences that are worth living and that designers could make available for everyone. And this is the power, designers should discover to achieve the ultimate approach with the user.

Reality is something in our mind and everything we don't perceive as real is left, somehow, outside our brain and life. Through our brain, we cannot accept the "un-reality" as something interesting or useful to us and therefore we will never be able to interact and enjoy it fully.

So designers need to design products and services that feel real to humans. Real experiences will have an imprint on human mind that will stick forever, changing and supporting their life for real. It is fundamental, for designers to understand, that they possess the power, to redesign reality because reality can be overwritten in our brains and newly represented back to the users.

I, therefore, developed some principles from my research, to implement for future UX design processes, in order to design real experiences:

THE BASE OF EVERYTHING

UNDERS TANDING

understanding the real problem at the root;

understanding the primarily as well all the secondary users involved in the experience;

understanding the role of the human senses that govern the human throughout the experience;

THE KEY TO SUCCESS

EXPERI MENTING

Experimenting the correlations between different senses, to analyze the human behavior and their perception of the experience;

Experimenting with the experience, by consciously cutting out senses and noting down possible outcomes.

Experimenting yourself taking part in the experience in body-stormings, trying to spot out differences for the user's perspective and 'watching themselves' acting and behaving in the situation given.

PRESENTING

THE BEST WAY TO TEST OUR PRODUCTS

Present the progress you reach and note-down, brain-responses and direct feedback.

While presenting, the brains in the audience will decide in seconds whether the ideas, concepts or products will be accepted or liked, or if they will be rejected and forgotten;

Presenting products or their progress along the way should be the key for outlining guidelines for future updated and development;

Some presentations should involve third parts, directly from the target group, in order to get real human emotional response to the experience designed for that specific target group.

In order to identify themselves in the product, users need to believe in the brand and the experience enough to allow themselves to be affected by it and reach together specific goals and targets. Presenting a real experience for the users will allow the formation of a strong relationship between the designer or the brand and the user itself, benefitting both parts, because of the emotional link, created through the experience, in between.

If people live seeking knowledge through reality, designers should reproduce reality-like experiences for people to live and to become part of.

Future Study

For the last decade, neuroscience has discovered a lot about human brain. This has affected many different fields, from medicine to technology, design, and many other more.

Despite the remarkable amount of experiments and accumulate knowledge, the functioning of the brain remains a clue to solve completely.

For example, there is a “mimic” branch in our brain, that allows us to understand and interpret faces, emotions and non-verbal communication (Eagleman, 2011). What was interesting to find out, is that more and more American pre-schools, are feeling the need to teach their children how to recognize and interpret emotions on people’s faces because they apparently never properly learned how to do it.

There is still much more to discover about the brain and to test, in order to amplify the borders of future implementations. We know that there is a power in seeing both sides of the 'same reality', and there are already experiments out there, to allow companies to achieve a better connection to their customers and users. In one of the experiments, for example, participants from the company would experience how to 'feel' through the hands of the user, by wearing special gloves, that would allow them to have an empathetic experience with their target group (Hallet, T. & Kamp, T., 2011) . Would this change their perspective? Likely, it would affect the way they approach the problem, or the generation of its solutions.

These could be initial approaches for a future new perspective. In many fields, the principles for a better understanding, analysis, and presentation of the root problems of our life, while taking the human in consideration as sensitive complex living beings, could probably bring us to find real solutions. Some medicine fields that might be approached are all the brain's malfunctions or conditions like depression or schizophrenia, looking for the understanding of the mechanism, rather than treating the symptoms. Another interesting condition is the Charles Bonnet Syndrome (Anil, 2017), where people who lost functioning parts of their brain, for example vision, and are no longer able to receive inputs from the outside world, would notice activity and self-re-creation of the reality they no longer perceive, from inside their head. Future deeper research could analyze how do those no longer working senses, become hyperactive and excitable, and maybe apply the knowledge achieved for reaching other goals and targets.

We are surrounded by people who see reality in completely different ways, because of brain injuries and gene conditions, and have always been surrounded in the past. The painter

Monet, for example, was diagnosed with nuclear cataracts in both eyes by a Parisian ophthalmologist in 1912. He began to experience changes in his perception of color, and through his works, we can see the subjects the exact same way, as he saw them, unfocused and undefined (Thompson, 2007).

To deepen the researches of this paper, practices like senses substitution (Eagleman, TED conference, 2015) could be the answer to people with partly damaged brain's conditions.

In the present time, where robotics and artificial intelligence are being studied, there is an interesting future ahead to design. Future ways to store knowledge and data inside robots, cars, or 'smart' products, will open the doors for a new relationship between humans and machines.

Many people believe that because of our biological mechanism, that keeps us humans alive, robotics will never reach a point of consciousness. But we have seen that in this world, many ways of being conscious are possible and already happening. So what does it mean being conscious? Would a fair amount of knowledge stored inside a machine, make it able to think or being conscious?

One experiment like the iCub robot from the University of Plymouth, in England, shows how an attempt for the development of an AI, was made following the principles, with whom babies experience the world and learn everything from it. In the experiment, the neuroscientist Eagleman carried on with iCub (2015, pp. 172-174) he could quickly test, that there was not a real mind behind it. Despite all the things the robot could do and learn, it was just following pre-programmed orders.

In the 1980s the philosopher John Searle made an experiment in a room he called "Chinese Room Argument" (Eagleman, 2015, pp. 174-175). He would lock a person inside, with no access to the outside except a small letter slot, in order to receive messages written in Chinese from a mother tongue person writing them outside. By having access inside the room to books that would explain exactly what to answer back to the messages, the person from inside the room was able to copy those meaningless symbols and send the message back. As a result, the person receiving back the answer thought the person inside the room could perfectly speak Chinese. Machines and robotics also follow orders by being able to reach huge amounts of information, without really having consciousness or understand the meaning of any of it. So the question for future thoughts and reflection comes spontaneously: could machines experience reality the way we do, by having internal experiences, or would they just only follow programmed orders?

With a greater sense of understanding, comes a greater sense of wonder and a greater sense of realization that we are a part of and not apart from the rest of nature. And that nature should teach us, how to develop future technologies, to match the process that nature provides.

And when the end of consciousness comes, and reality becomes distorted by external forces there is nothing to be afraid of. The “shows” in our brains will always go on.

“THE SHOW IN OUR BRAINS WILL ALWAYS GO ON”

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Thank for all your encouragement!

Glossary

Absolute Threshold of Sensation	The minimum Stimulation needed to register a particular stimulus fifty percent of the time.
Body Transfer Illusion	is the illusion of owning either a part of a body or an entire body other than one's own, thus it is sometimes referred to as "body ownership" in the research literature.
Charles Bonnet syndrome	A common condition among people who have lost their sight. It causes people who have lost a lot of vision to see things, that aren not really there, known as visual hallucinations.
Cognitive Maps	Mental representations, which serve to decode and recall information about relative locations of familiar physical or metaphorical spacial environment.
Cross-Referencing	The linking of information of different kind for the elaboration of a common meaningful pattern.
Emotion's Blindness	A condition also known as *alexithymia,* in which people are unable to identify and describe their own emotions and those of other people.

Neuroplasticity	The brain's ability to reorganize itself by forming new neural connections throughout life. Neuroplasticity allows the neurons (nerve cells) in the brain to compensate for injury and disease and to adjust their activities in response to new situations or to changes in their environment.
Neural	Of or relating to the nervous system or neurons.
Parallel Processing	The processing of many different instructions (in this case: many different senses) that are elaborated at the same time.
Perception	The top-down process out brains organize and interpret that information and put it into context.
Perceptual Prediction	That process of the brain to generate a sensory prediction from an abstract representation already stored in long-term-memory.
Proprioception	The sense of body position.
Sensation	The “bottom-up process, by which our senses like vision, hearing, and smell, receive and relay outside stimuli.

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Body

Literature Review

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Figures

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Valentina Bezzi