# What is it like to be a neuron?

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**Abstract**

Although we face controversial debates on the nature of consciousness without an agreed solution today a widely accepted position is that mind is what the brain does. Hence it is assumed that with the intense investigation of neuronal mechanism our understanding of consciousness will enhance. However, there is a serious foible with this position: With the assumption that we *are* a bunch of neurons we face serious problems with respect to the *quality* of our scientific knowledge per se as in this case we never saw, described or investigated a lightwave *before* it impinged the retina and underwent some neuronal processing: What we call "lightwave", for example, turns out to be just some kind of neuronal representation of something. Whereas we might ignore this crucial aspect of relativity in many scientific fields we are unable to ignore it when we try to investigate the *constitution* of our observations per se, thus when we try to investigate the brain. Hence prior to any scientific investigation of the brain we need to clarify the relation between our observations and the brain: What does it actually mean to *see, hear, feel, think* something? This essay investigates the intense correlation of our subjective experience, some objective world and the very special role neurons play in this correlation. And along this way an astonishing idea of what *we* might actually be shows up: Potentially more like souls than just some bunches of neurons.

### What is it like to be ...

In 1974 Thomas Nagel published his famous essay "What is it like to be a bat" which initiated widespread debates regarding the existence of the very subjective experience to be "something" and the inability to *know* what it is like to be anyone or anything else although we might of course guess how at least other humans feel.

With his essay Nagel renewed the fundamental question about the limits of scientific knowledge with respect to the subjective experience of having a pain, seeing red, etc. The question of subjective experience actually *is*, of course, the question of consciousness, a question so amazing and fundamental that - following Nagel's considerations - even a substance dualism would not be able to explain *how* the brain or any kind of something is able to generate consciousness.[1] However, one might get well the impression that with the concentration on the question *how* consciousness could be possible the very fact *that* it is possible went occasionally a bit out of focus.

Once again, like many times before in the history of Philosophy, we identified the *necessity* to discard any dualistic concept of mind and matter and are to focus solely on the brain to understand ourselves, to understand consciousness, to understand the remarkable fact of the subjective experience of being someone or something in this world. Thus, a physical monism became the premise of all possible theories of mind. Under this premise several possibilities for the realization of consciousness were considered:

**Identity:** A conscious, "mental" or "phenomenal" state is actually identical to a neuronal state in a similar manner as water is identical to $H_2O$; whatever we observe as a neuronal state from a "third-person-point of view" is actually identical to a mental state, to a subjective experience.[2] Hence, neurons somehow possess or generate subjective experience, a "first-person-point of view" on the world. Thus *we* actually suffer from a "first-person-perspective" provided by two handful of neurons although these neurons are able to operate without this "perspective" as far as we - from the third-person-point of view - are able to *observe*.

[1] Nagel (1986, p.29)

[2] Identitytheory initially raised by Place (1956); Feigl (1958); Smart (1959), see e.g. Kim (1998); Pauen (1999); Crane (2007) for some recent considerations.

**Elimination:** As, again following our *observations*, evolution is very effective some might suspect some inconsistencies here: Why a kind of "superfluous" perspective without effective relevance? Thus we considered as an alternate possibility whether subjective experience might be just a kind of fiction: With the advance of science we already learned that a storm does not represent some anger of god but is explainable with quite simple natural laws; in a similar manner we might understand someday that we are not really "angry": "Mental States" like witches simply do not exist.[3]

**Selfish Matter:** The question of fictions regarding the existence of phenomenal states finally led us into debates about the role of a "self" which does not appear to have an home within the brain: Are we to consider the self as a simple though useful fiction? We began to wonder whether we might still be bound to a kind of Cartesian "devil", a persistant dualistic way of thinking in terms of mind and matter, which prevents us from understanding the *brain*. It was Daniel Dennett who pointed to this possibility.[4] He proposed an evolutionary understanding of consciousness: At some time in evolution simple "replicators" showed up with the aim to replicate themselves. To ensure replication it was necessary to create a *point of view*, to distinguish between the favorable, the unfavorable and the neutral.[5] Based on these simple replicators consciousness developed in a very similar manner as complex computer software consists at least of Zeros and Ones.

**Meaningful Matter:** However, John Searle (1992) pointed to the question of *meanings*, meanings which *we* assign to any computer program including the basic Zeros and Ones. But these meanings are not *intrinsic* to the system, they are assigned from "outside", assigned by the programmer. Intrinsic *meanings*, however, seem to be an essential property of the former Cartesian category "Mind" but nevertheless still an essential feature of consciousness. Thus Searle suggested *not* to discard the Cartesian category "Mind" but to *revise* categories: Intrinsic meanings, "intrinsic intentionality" is generated by a special kind of biological process.

[3] Eliminative Materialism, Churchland (1986)
[4] Cartesian Materialism, Dennett (1991)
[5] Dennett (1991, p. 173)

**Conscious Matter:** After all some skeptics survived the debates and dualism got back in the game of theories, even though just in a "small" and harmless form as "property dualism": subjective experience has to be considered as so different from anything we *observe* in nature, that it must be a (non-effective) property on the level of particles. The non-effectivity of subjective experience or consciousness, however, led us directly to the "hard problem of consciousness": *Why are we "conscious", why do we appear to have phenomenal states?*[6]

Meanwhile, as brain research proceeded, we learned more about the brain and its curious effects on human behaviour following brain damage,[7] but the debates about the right view on consciousness in a physical universe did not come to their end.[8] Or did they reach the dead end of a path and move now in circles?

In spite of Nagel's postulate of unsolve-ability much brain research nowadays focusses intensively on solving *how* the brain generates consciousness: The "neuronal correlate of consciousness" is one of the most controversial discussed but nevertheless top hunted items. Hence, we started the search for one, two or many "neuronal correlates of consciousness",[9] we tried to classify activation schemes in neuroimaging data in order to detect consciousness within the brain, or "decode" consciousness from brain signals, respectively.[10]

But what is meant by a *neuronal correlate* of consciousness? What exactly do neuronal activation schemes tell us? Neurons spike and thereby emit neurotransmitters which might instigate spiking in other neurons as well. Is this spiking equal to "consciousness"? Under which conditions? What exactly do we expect to find within the brain when searching for consciousness or "neuronal correlates"? And *what* do we consider to be the proof of correctness?

The arguments exchanged in the course of discussions about color realism are tightly coupled to the question of consciousness and illustrate the urgent need to gain a concept on consciousness, to gain a

[6] Chalmers (1996)
[7] See for example Sacks (1985); Crick (1994); Ramachandran and Blakeslee (1998)
[8] e.g. Tye (1995); Warfield (1999); Bennett and Hacker (2003); Chalmers (2003); Dennett (2003); Searle (2004); Dennett (2005); Brown (2010); Stapp (2010);...
[9] See for example Dehaene et al. (2003); Block (2005)
[10] For example Goldberg et al. (2008); Haynes (2009)

concept with respect to the relation between a brain and the world this brain *observes*: Are colors really outside or just in our minds, don't they exist at all? Some argue in favor of color realism, argue that colors are properties of physical objects, specifically "reflectance types", argue that colors are really outside whilst a range of others do not agree.[11] Optical illusions form a very special problem for color realism: How is it possible to see a red after image of something although there is nothing red outside? In this case a color realist has to insist on the fact that it is just an illusion, just a false "proposition"[12], whatever this might mean in concrete.

Color eliminativists in turn address this slight inconsistency by arguing that there are no colors at all. Whereas the common and obviously wide-spread assumption that colors are just "in the mind" appears to be very old fashioned - already supported by Galileo[13] - and hence suspected to be even dualistic thus questioning physicalism per se.[14] So: Are there colors outside, just in my head or simply nowhere?

If it is impossible to gain a commonly accepted idea regarding the redness of tomatoes what do we actually *know* about about red tomatoes? And how shall *we* ever be able to agree upon an idea regarding the nature of consciousness?

Obviously we cannot do more than trying, trying to make our way towards a "most productive" science of consciousness[15] with the terms "unscientific" and "dualistic" being almost synonyms in all these debates.[16] Is this indeed justified?

However, based on the results of brain research and our observations regarding the laws of nature, most of us, when asked the question constituting the title of this essay, might find themselves even *forced* to state:

"Well, you know very well what it is like to be a neuron or at least a bunch neurons, respectively:

*it is like you experience yourself in this world.*"

[11] Byrne and Hilbert (2003a) and Byrne and Hilbert (2003b)
[12] Byrne and Hilbert (2003a, p.5)
[13] Byrne and Hilbert (2003a, p.4)
[14] Byrne and Hilbert (2003b, p.793)
[15] Compare Dulany (2008) for an overview of recent approaches.
[16] See as well Dulany (2008, p.87), Sheldrake (2005, p.42): "....there is nothing unscientific or dualistic about this view...."

Thus in spite of a missing concept how to understand consciousness, in spite of all the difficulties with mind in a physical universe, as they are reflected in the debates, we find ourselves somehow *forced* to *believe* in a physical monism as the premise for all possible theories of mind: Our observations, the laws of nature and the efforts in brain research seem to provide no other reasonable possibility.

But, as all so far mentioned *observations* already indicate, this premise, the physical monism, is based on our *observations* of the world or, to be consistent and more precise, on the "observations" a bunch of neurons collected about this world and the conclusions they drew out of these observations.

In the first part of this essay I intend to outline the consequences of the very simple and obvious circumstance that any "naturalistc", "materialistic", or physical view of the world *forces* the acceptance of its own relativity and hence takes at least its own premise ad absurdum, given the very special role of neurons as far as *we discovered it*: Not only we ourselves but as well the world, our observations, our valuable natural laws simply degrade to just a "neuronal point of view", to at last a neuronal state.

Some might argue that this is right enough as it works quite well: Neurons appear to live and survive very well with their point of view. But the limits become very obvious with the aim to understand ourselves, to understand consciousness or consequently speaking - with the aim of a bunch of neurons to understand a bunch of neurons. From a "neuronal point of view" reasonable theories about consciousness appear to be not only difficult but rather impossible. Theories, which are nevertheless essential to understand the brain and its world. We *need* a useful and *realistic* concept when observing neurons.

Hence it might be desirable to keep a deeper touch with reality than just a "neuronal point of view" which constitutes the subject of the second part of this essay, where a computer will prove to be an inabdicable component when trying to understand relations between the world, our neurons, perceptions and sensations and what some people tend to call "self".

## Part I: Observations and natural laws

### 1 Settling the world

Let us begin by specifing what we are talking about. I prefer rather simple things and hence figure 1 is meant to show just a simple tree and a simple apple. It is important to clarify that I am just talking about a simple tree and a simple apple - really existing out there. I am not talking about any complex problems of naming or referencing. I am just talking about the simple things we observe in our daily life as for example apples and trees.

**Apple** **Tree**

Figure 1: Just a simple tree and a simple apple.

Now I hope you will still agree that during our life we are actually observing a lot of things, forks, spoons, spaghetti or what ever you like. I would like to call all these things simply $x_i$ so I do not have to list all of them explicitely.

$x_1$ $x_2$

Figure 2: Still a simple tree and a simple apple, just using a general notion $x_i$

Further more we are observing some contexts with and between our $x_i$, an apple might fall from a tree for example. Of course there are many different types of contexts we observe or rather *concluded*. Water freezes (observable with enough patience), the earth moves around the

sun (concluded) and so on. I would like to call all these different types very general simply a context $C$. Hence

$$x_1 \; C_x \; x_2$$

might express the circumstance that the apple falls from a tree.

Where necessary we might identify a specific context by $C_{something}$ without the wish nor the need to be more explicit so far. Further more we constructed tools to enhance or support our senses in order to get to know more about our $x_i$, for example microscopes. With the support of such tools we detected that our apple and our tree consist of cells, further on of molecules etc. Thus we observed that our $x_i$ consist of some smaller parts $y_i$ and again we observed some context $C_y$ between these $y_i$. Also we detected contexts not explictely related to our senses: electricity, magnetism etc.

All together these observations make our picture of the world as a hierarchy of parts $x_i, y_i, ...$ and respective contexts $C_x, C_y, ...$, our "natural" laws (compare fig. 3). However, the last layer ($Q$, Quantum mechanics etc.) is not really clarified. For the beginning let us just ignore this small inconsistency. On higher layers everything seems to be well organized and explained.

**Our world and its natural laws**

$$\overbrace{x_1}\quad C_x \quad \overbrace{x_2} \qquad (1)$$

$$\overbrace{y_1 \; C_y \; y_2} \quad C_y \quad \overbrace{y_3 \; C_y \; y_4} \qquad (2)$$

$$\overbrace{...}\,...\,\overbrace{...} \quad ... \quad \overbrace{...}\,...\,\overbrace{...} \qquad (3)$$

$$(...)$$

$$(Q)$$

Figure 3: Our world and its natural laws as we observed, detected or concluded in a very general, hierarchically organized notion from layer 1 to Q.

But now we discovered neurons.

## 2 Neurons enter our world

For the beginning, this is not a special problem: All we can *observe* about neurons fits very well in our natural hierarchy on the just normal level of cells, molecules etc. Hence in line with our simple notion of natural laws (fig. 3) introduced above

$$n_i \; C_n \; n_j \qquad\qquad (I)$$

would simply express the circumstance that some neurons "spike", emit neurotransmitters etc. in absolute agreement with and within our hierarchy of natural laws. We might well refer to (I) as a "neuronal state".

But we discovered more.

Doing studies with people suffering from epilepsy or a stroke we noticed that obviously *we* are entirely dependent on our neurons. An explicite excitation of some neurons in the brain of epilepsy patients before their surgery lead to complex experiences, even movements of limbs, fingers, etc. as reported by Wilder Penfield, for example, the person who discovered the senso-motoric representation of our body in the brain.[17] Following a stroke we might loose our capability to speak, understand speech or even both. Depending on the location of the stroke and the according cell death we might experience our leg suddenly as a "foreign" leg: Patients suffering from "Anosognosia", the medical term for not recognizing a disease, asked the medicine to amputate their leg because they simply did not experience their leg as belonging to their body any more.

Hence, we discovered a range of strange effects in conjunction with several damages of the brain as all the case studies of Oliver Sacks and many others illustrate.[18] Moreover, Alzheimer desease is known to lead to an immense amount of cell death, death of neurons, which is obviously combined with the loss of almost all cognitive capabilities we obtained during life. Hence the conclusion widely drawn seems to be more than self-evident: *Actually we are just a bunch of firing neurons.*[19]

[17] Penfield (1975)
[18] e.g. Sacks (1985)
[19] "The astonishing hypothesis", Crick (1994)

## 3 Neurons take the world

An underestimated issue with respect to above conclusion is that it simply implies that a bunch of firing neurons is drawing a conclusion about a bunch of firing neurons.

How does this conclusion fit in our hierarchy of natural laws? Actually it does not fit at all. We cannot *observe* this circumstance in the same way as we observed all the other items in our natural hierarchy.

However, the circumstance that the earth moves around the sun was - first of all - not observable as well. It represented at the beginning a hypothesis able to explain observed planet trajectories. Later on this hypothesis was justified by more and more data and finally commonly accepted. And today the movement of the earth around the sun is even observable with the support of space telescopes or - for the last skeptics - by hiring a space shuttle.

With respect to consciousness and "the astonishing hypothesis", as Francis Crick called the circumstance that probably *we* are nothing more than a bunch of firing neurons, we are not able to talk about a commonly accepted hypothesis yet. But similar as with the earth-and-sun-movement question we might be able to collect enough data in the future and finally understand one day that the basic hypothesis behind consciousness, behind *ourselves*, is indeed true.

But so far we have to consider it as a bare hypothesis: The hypothesis that all our feelings, perceptions, sensations etc. actually *are* a neuronal state (Identity), do not exist (Elimination or Selfish matter), are generated by neurons or some kind of biological process (Meaningful matter) or are a property at the level of particles (Conscious matter). Although there are differences with respect to the concrete implementation of consciousness, subjective experience is considered in any case as the result of some kind of neuronal *processing*, some kind of neuronal *representation* of something, whose concrete mechanisms are so far not explicitely or finally understood.

Using the observed neuronal context (I), noted above, we might thus for the beginning just define a neuronal representation $R$ as

$$R : n_i \; C_n \; n_j \qquad\qquad (II)$$

which expresses a certain state of neurons, for example when feeling

pain, seeing a tree or an apple, allthough we might not yet understand its exact configuration. As we are talking about neuronal processing or a neuronal representation of *something* we have to establish a correlation between these representations and our world. For this purpose let us consider a concrete example: What happens when we see something like a tree?

Lightwaves ($x_L$) reflected from a tree or any object $x_i$ hit the retina ($n_R$) and lead to neuronal activities ($n_i C_n n_j$) finally representing a tree ($R$).

Thus we might define the neuronal representation of the experience to see some $x_i$ as:

$$R_{see}(x_i) : \underbrace{x_i C_L x_L}_{\text{a}} \underbrace{C_R n_R C_n}_{\text{b}} \underbrace{n_i C_n n_j}_{\text{c}} \qquad (III)$$

with
a = Lightwaves ($x_L$) reflected ($C_L$) by $x_i$
b = hit ($C_R$) Retina receptors ($n_R$) and lead to further neuronal activities
c = Phenomenal state "see $x_i$"

Equation (III) expresses a very simple though important relation: Following our lightwaves reflected by the tree through the retina we end up with "simple" neuronal activities. But neurons *themselves* do not appear to see anything nor do they really need to *see*. Also, we are not able to access the picture of the tree on the retina: Without our visual cortex we obviously do not see anything. Without neurons we obviously do not hear anything, touch anything nor experience anything at all. We are entirely dependent on neurons to access the world. Moreover, as brain research told us, the excitation of some neurons alone might be sufficient to see something: Consider optical illusions, hallucinations or the named experiments with epileptic patients. So **where** is the tree we are talking about? Just in our heads? Thus the question is not only whether colors are just in my head but whether the whole world is solely in my head.

So far lacking a substantiate-able answer, we have to admit at least that we are not able to talk about some "real" trees and apples "out there", some $x_i$, but we are talking about the result of the neuronal processing of these $x_i$ respectively about the neuronal representations of $x_i$. Hence we are to modify our picture (compare figure 4).

$\mathbf{R_{see}(x_1)}$ $\mathbf{R_{see}(x_2)}$

Figure 4: No longer a simple tree and a simple apple but a neuronal representation $R$ of some unknown $x$.

Accordingly we would have to modify our set of natural laws to consider that we are just talking about neuronal representations of some $x_i$ rather than some $x_i$ itself.

If we now state that a phenomenal state actually *is* a neuronal state we would even be forced to state that a tree actually *is* a neuronal state. Hence all we experience as "outside world", all we experience about or as our body actually *is* a neuronal state or actually *is* a neuronal process (compare figure 5).

**Neuronal State 1** **Neuronal State 2**

Figure 5: If a phenomenal state actually *is* a neuronal state, what we tend to call apples and trees actually *are* neuronal states or neuronal processes.

But moreover we are to reconsider our contexts $C$ as well; if we consider us to be actually a group of neurons we have to consider that *whenever* we observe or conclude this is actually a neuronal way to "observe" or "conclude". Thus:

$$C_{someting} = R(C_{something})$$

By now things already went a bit odd. Are our natural laws really that fixed if they are just a way of neuronal representation? And does

it make sense to state that a tree is actually a neuronal state? Does it make sense if everything turns out to be actually somehow "neuronal"? However, we have many senses and things "outside" seem to be quite stable with our neuronal view. So probably the neurons do a good job and have a suitable "view" of the world. But nevertheless we are dealing with "simple" neuronal representations and by premise we all can use *only* neurons to access this world. So how can we assume that we have true and secure knowledge about this world?

However, now things even turn worth. Neurons belong as well to the stuff we observed. Thus we are actually not talking about neurons but about neuronal representations of neurons. Hence we enter into a very strange recursion with our hypothecially defined neuronal representation $R$:

$$R : R(n_i)\ R(C_n)\ R(n_j)$$

Which pushes the question whether $R$ is really well defined and our representational account was really useful: The result is a kind of loss of our world, a drift to relativity with respect to everything including our natural laws. Given this limited and relative view of the world does it really make sense to make theories about things we are not even able to *observe*, theories about the premise of our observations, theories about *ourselves*, theories about consciousness?

We are no longer talking about lightwaves hitting the retina but about the neuronal representation of lightwaves hitting the neuronal representation of the retina leading to neuronal representations of neuronal states leading to the neuronal representation of a tree. And of course, whatever we call "hit" or "lead" is as well just a neuronal representation of something. The only possibility to avoid this strange recursion is to postulate a kind of special status for the neurons: We might postulate that our observations regarding neurons are actually the only real and somehow "abolute" stuff in this world. Then actually neurons turn out to be probably the only thing of some reality in this world. But in either way our premise for our conclusion that we possibly *are* just groups of neurons is taken ad absurdum: Either we have only neuronal knowledge or only knowledge about neurons. So: Is there really a tree out there?

## Part II: Observations and ourselves

### 4 Neurons and trees

Obviously we need a suitable approach to put our knowledge about the trees we expect to be outside onto a reliable base. We need to distinguish between neurons and the trees we see, touch or hear when the wind is blowing through their leaves. The representational account, sketched so far, does not lead to any satisfying success. Obviously, we need to incorporate the aspect *that* we observe this world in a reasonable way in our considerations. Hence let us begin again by talking about the world as far as we observed it and agreed upon: *There are* some physical laws, and *we have* some subjective experience, some perceptions, emotions, sensations, some feelings. Let us investigate the role neurons play in this correlation between objective world and subjective experience.

Subjective experience seems to be something that neurons *themselves* are not capable of; neurons are thought to operate according (at least) physical laws and we lack physical laws that incorporate feelings, for example. One stone hits the next, the apple falls from the tree - no active wish to do this, no alternate possibility, no fear to fall or hit a(nother) stone. Hence, neurons *themselves* are not sad or happy, they do not see or hear, they do not wait, attend or get bored, they spike, as far as we are able to *observe*.

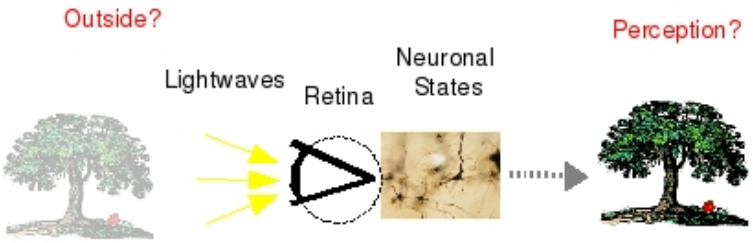


Figure 6: What is the relation between assumed "outside" objects, e.g. a tree, the neuronal processing and our perception?

But this enough: Following our observations there seems to be a direct, observable and very natural connection between sensory receptors, some intermediate neurons and motor neurons finally driving muscles to produce some actions adequate to the sensory input. So why somehow "additional" sensations and perceptions, dependent on neurons thus obviously produced by neurons which are not required on the neuronal level itself (figure 6)?

In this respect Daniel Dennett referred to a "myth", the "myth of double transformation"; he referred to René Descartes who thought that light waves are first transformed into neuronal activities and afterwards these neuronal activities are transformed again, at a special location (the famous 'pineal gland'), to the non-physical medium of mind.[20] Following Dennett, nowadays there is almost nobody who believes in such a non-physical medium when dealing honestly with "mind". However it might not be necessary to focus on specific locations in the brain nor on a special "non-physical" medium or substantial considerations but it is definitely necessary to clarify what we are talking about (in this case at least trees, light waves, and neurons) and *why* we are able to talk about these items.

Let us consider the the introductory named optical illusions as a concrete and challenging example. We all face a very striking example of an optical illusion when watching TV. Just a sequence of static images is presented outside, on the TV screen, but we neither realize that only every 40 ms a new (static) image is presented nor that every single pixel of the TV screen is black for more than 90% of the time: We **see** people moving around as in the expected "real" world, in a park for example.

Hence, although our *picture of the world* and the *outside world itself* might appear to be identical in many cases, optical illusions teach us that this is not necessarily the case. Furthermore, we learned that various kinds of sensual illusions might occur by simple neuronal excitations without anything being outside, as demonstrated by the experiments of Penfield (1975), for example. Hence we need to acknowledge that the brain actually *generates* pictures, impressions of what *we* expect to be outside, that we do not experience some outside world "itself".

Furthermore, if we still assume that the fact *that* we observe is equal to any kind of neuronal state or neuronal representation we have to admit that we have no access to light waves *before* their neuronal processing. Hence, even under a physicalistic premise we need a way to understand this transformation and our knowledge about the world: We need to understand the relation between our perceptions, our theories and the brain. For this purpose we might need to think about "mind" in other terms than "ghost".

[20] (Dennett, 1999, p.91/92)

I would like to propose to achieve this understanding with the support of a component where we observe as well transformations: From coloured pictures on a scanner to binary codes in a computer and further on, via a second transformation to coloured pictures on the monitor (compare figure 7).

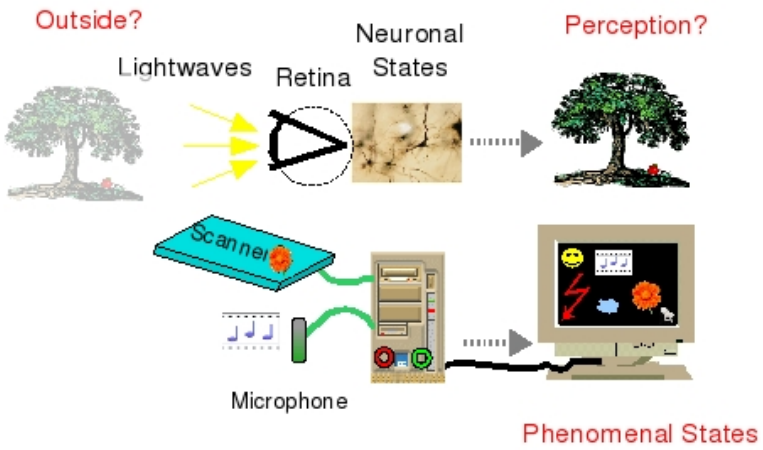


Figure 7: Relation between world, brain and perceptions illustrated with the support of a simple computer metaphor, including transformational devices as scanner, microphone and screen.

Signals from the outside world are transformed at interface components of the brain in a similar manner as pictures on, for example, a scanner or sound via a microphone are transformed into a binary code by a computer. However, this simple transformation does not yet make the picture of a tree or a piece of music, the computer simply operates on some binary codes. But we might consider the kind of "double transformation" we all observe when using computers: A picture lying on the scanner is transformed into some form of binary code. When this piece of binary code needs to be presented on the screen, it is the responsibility of the device driver for the screen to care for the respective presentation and hence for another transformation. Thus we might consider the computer screen to illustrate our perception of the tree, the aspect of hearing, seeing, feeling etc. which appear to be dependent on neuronal activities and some outside world but which we experience to be different from neuronal activities (we see trees) and from the outside world (we experience occasionally various kinds of perceptual illusions). Let us consider this analogy step by step in a bit more detail.

## 5 Computers and Brains

Facing similar difficulties computers and brains are widely considered as almost equal hot candidates to possess or generate consciousness.[21] However, with respect to the programming of computers there are serious objections: Every computational device, every machine, has a user and was constructed and programmed by humans. But brains developed obviously by evolution, following natural laws without an explicit constructor.[22] Hence computer analogies are to be handled with care within our scope, especially because various interpretations and assumptions already haunt the mind/brain debate.[23]

Nevertheless, there is certainly a reason for the strong presence of computers within the consciousness debate. And this might be the circumstance that brains as computers are thought to "compute" by some means or other, and both appear to operate with some kind of code: Computer operate with some kind of binary code where brains obviously operate with some kind of neuronal code.

In order to avoid conflicts with respect to the question of the programmer and the assignment of meanings from outside the computer system, let us for the beginning simply compare this aspect itself: the simple fact that both components, brain and computer, operate with some kind of code. We might not know much about the concrete decoding of these codes nor how they evolved, but our observations tell us that neuronal/binary codes are used within the brain/computer and *differ* from the environment of brains or computers.

With respect to environmental interfaces let us now consider just a simple scanner and microphone for the computer and eyes and ears for the brain. Traditionally we assume that light waves hit the retina or some moving molecules hit the hair cells in our ears, for example. As already outlined in the previous sections, these environmental signals are thought to lead to various forms of neuronal activity within the brain. In an analog manner environmental signals (i.e. a picture on the scanner, or molecule movements at the microphone) are transformed into the binary code with which the computer operates.

[21] Compare for example the overview on machine consciousness by Gamez (2008).
[22] Compare f.e. the objections of Searle (1992) and Dreyfus (1992) against artififical intelligence
[23] eg. Tononi (2004); Mainzer (2007); Gamez (2008)

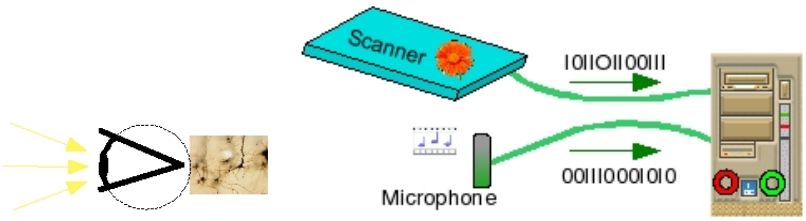


Figure 8: Computer Interfaces. In a similar manner as the brain is connected to an environment via eyes and ears, for example, a computer might have environmental access: Peripheral devices transform something that is different from transistors (e.g. light, sound) into the binary code with which the computer operates.

Hence, the comparability of the interface components for brains and computers results from the aspect that both components transform environmental signals into a neuronal or binary code, respectively, which - just following our observations so far - *differs* from their respective environment (figure 8).

Now what about phenomenal states - feelings, sensations and perceptions?

I have at least the impression that I do not experience neuronal activities but rather a world outside of myself and somehow "inner" feelings. And I am quite sure that everybody has these experiences although they are not accessible from a third-person-perspective; we are not able to *observe* these experiences in the same way as we observe apples occasionally falling from trees.

This third-person-perspective, our observations tell us that "feelings" are neither experienced by the neurons themselves nor are they necessary for their operation. We do not assume that neurons themselves see or hear something. So what does it actually mean to **see**? Where to find phenomenal states within the computer? Would it be suitable to state that the computer is so far able to really *see* or *hear* something?

Of course we might hire a programmer, start simulations, what ever we like. But in any variant this simply implies that some kind of external programmer is *necessary* to achieve phenomenal states, that some kind of external programmer assigned his own meanings, his own picture of the world to the computer. But who should have programmed our brains in such a way?

Moreover, the aim of this anlogy is *not* to learn how a computer could become conscious but to understand, for the beginning, the relation between the world, a brain and what we tend to call perceptions, sensations, feelings. Hence, let us omit a mystical programmer.

The computer, as we currently just *observe* it, operates on binary states only. What ever he might process or represent with "higher" binary states these will still be binary states, so far incapable of any *qualitative* differentiation between "sound" and "vision", for example. Hence, from a "computational point of view" a binary code received via a scanner and a binary code received via a microphone might be considered identical because coincidentally both codes were identical.

But I am very sure that I would never state: What I see is actually *identical* to what I hear. Some kind of "qualitative jump", a kind of qualitative ability, is obviously missing when aiming to represent us and our relation to the world with a bare computational device and its various sensors.

In this respect the screen of our computer represents an ideal component to acknowledge this circumstance. A screen represents as well a kind of qualitative jump compared to the binary states used within the computer. Presentations on the screen are different from but dependent on the operational activity of the computer although these presentations do not influence the operational activity of the computer if we consider the computer as an autonomous actor in the very same way as we consider brains to be autnomous actors, both not requiring metaphysical progammers. Hence in decisive aspects the screen of an autonomous actor computer is comparable to phenomenal states for a brain: as different, as dependent and as superfluous for its actual operation. The contents of the screen simply represent and illustrate feelings, sensations and perceptions - all the things we cannot find in the brain but which *we* nevertheless experience. These contents, these presentations on the screen, are different from but dependent on the operational activity of the computer, and are as superfluous for an autonomous actor computer as are phenomenal states for neuronal operations, at least following our observations so far.

Furthermore, we are able to illustrate the similarity between the stuff we expect to be outside and our perception of it, at least with respect to visual impressions. However, it would not make sense to

use loudspeakers as an illustration for "hearing" because a computer certainly does not hear the sound leaving the speaker as it does not see the pictures on the screen. The screen simply represents **our** experienced qualitative aspects of vision, audition, sensations, feelings etc.

The screen of our computer constitutes a device to represent phenomenal states and enables us to verify their relation to neuronal states and the outside world with the advantage of a kind of conceivability: We now have a picture of relations which does not break natural laws. Phenomenal states, the screen, exists although brain and computer appear to operate independently of them. Actually we are so far even well in line with most modern theories of mind: We might consider the screen as the result of the "neuronal" first-person-perspective (for identitytheorists, eg Pauen, 1999), as the result of a special kind of biological (Searle, 1992) or physical (Chalmers, 1996) process.

Turning now back to some knowledge we have concerning normal computers, we might think of the searched neuronal correlate of consciousness as a kind of *device driver* for the screen: Which neuronal states, which *neuronal capabilities* lead to conscious percepts, sensations or feelings? And much more importantly *why* does this happen?

With real computers used in our everyday work we usually have presentations on the screen because some kind of user interaction is necessary. Further more the contents presented on the screen appear in a format understandable to the user: We do not have to operate on the Zeros and Ones directly to do our daily work.[24] Using this knowledge, we might well consider the relation between neuronal and phenomenal states as a kind of *translation* provided by the neurons. Obviously neurons do *more* than absolutely necessary to operate within the world at least following our observations so far: They seem to somehow *translate* the stuff "out there" into perceptions, sound, smell, taste, etc. The screen, our phenomenal states go somehow beyond the stuff necessary for the binary operation of the computer, for the neuronal operation of our brains, as all actions are determined by the binary states within the computer, by the neuronal states of the brain. For an autonomous actor computer a screen is as superfluous as a phenomenal state for a brain under the premise of physical monism.

[24] A picture in a similar manner also used by Schwindt (2008)

Hence, keeping the picture of relations in mind, we are able to discover the unique role of the brain as a kind of interface component to our environment. And we are even able to talk about an option in the mind/brain debate which we originally considered necessary to discard: An interactive dualism. Hence we are able to address a key question with respect to consciousness:

*Why* do phenomenal states exist?

## 6 Mindful users

So far we detected the brain as an amazing component: Following all our observations and intending to keep at least a roughly consistent picture of the world we are to recognize the brain as a kind of interface component to the world, to whatever there might be outside. Of course we still have to acknowledge that our knowledge of the world is somehow limited: We are not able to have a short look to the items on the scanner to see what is really going on. But we are able to understand our dependence on neurons and with the computer analogy in mind we might be able to ask old questions with a new background: What actually *is* an object? How are object properties "bound" by the brain and what might be the role of the "device driver" in this case? What actually *constitutes* an object and what does this tell us with respect to the world on the scanner?

But so far a central question remains to be addressed - the question of a "self": Has the self to be considered as an element on the screen, something generated by the binary states within the computer, by a separate process? Or has the self to be considered as the sum of all experiences, the screen as a whole?

A major advantage of our, lets call it "complete computer analogy", as it considers not only an equivalence of neuronal and binary states but illustrates as well phenomenal states and their relation to the brain and the world, is hidden in the possibility to ask as well for the role of a kind of "computer user" (compare figure 9).

We are able to think about this computer user as being someone or something who experiences the outside world, someone who has perceptions and who experiences as well "inner" feelings potentially generated solely by the brain. Hence is it possible that the self corresponds to "something" in front of the screen? An unknown "**x**"?

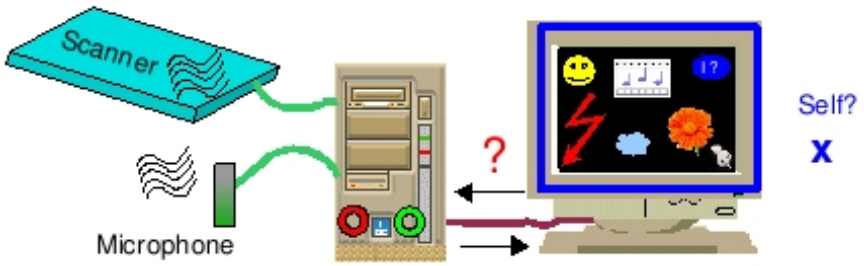


Figure 9: The Complete Computer Analogy. Given the screen for the illustration of the relation between phenomenal states, brain and the outside world, we are able to discuss the question of the self: Has the self to be considered as an element on the screen, as the result of a dedicated process? Or has the self to be considered as the sum of all experiences, as the screen as a whole? Or is it possible that the self corresponds to some unknown **x** "in front" of the screen?

In this case we would need to consider the screen in the analogy to be more a kind of *touchscreen* and the connection between the screen and the computer to be bidirectional. Using the computer analogy we face the ability to ask for the existence and role of such an user and we are able to compare this possibility with other options, hence we are able to look for corresponding empirical findings substantiating either view.

Considering a range of neurological diseases (Anosognosia, Neglect, etc.)[25] we are at least not able to exclude this last "user"-option but find ourselves enabled to understand why these phenomena might disappear without any neurological changes observable:

We do not have access to the outside world directly; it is not possible to have a quick look to the "thinks in itself"[26], to the picture on the scanner, to understand that a leg is no longer represented within my internal body image but nevertheless belongs to my body. We appear to depend on some kind of neuronal activity, some kind of "neuronal translations" which might in these cases lead to an inconsistent picture of the world with my body in it, taking a while to get integrated by our "**x**".

With the computer analogy in mind we are also able to reinvestigate

[25] "Neglect" patients appear not to recognize half of the world in spite of an intact visual field.

[26] Immanuel Kant (1781/1787)

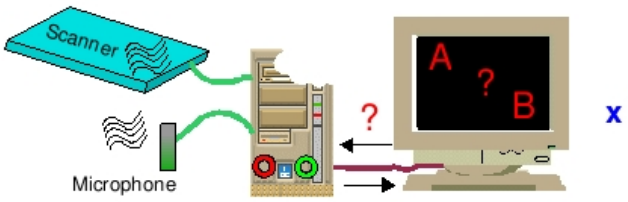


Figure 10: Neurological deseases represented with the complete computer analogy: The computer appears to be damaged to a certain extend which leads to inconsistent presentations on the screen.

the old question regarding the source of attention:[27] Is it possible that we are able to direct our attention to certain issues amongst our *phenomenal* experience? Is it possible that as soon as we direct our attention to our left hand or a forthcoming movement of our left hand, for example, is it possible that this attention somehow leads to an increased neuronal activity which would imply that a rather small object more at the border of the screen now jumps to the middle of the screen, in the focus of our attention? Is it possible that an increased neuronal activity *following* such changes in the focus of attention is even *measurable* in terms of the famous readiness potential, for example?[28] Hence is it possible that we are to distinguish between the *imagination* of a finger movement, the *concentration* on a movement, the *direction of our attention*, and an actual *decision* to move?

In this respect, a closer look on the experiments of Benjamin Libet might shed some light. In Libet (1985) the results of the so-called "Veto"-experiments are reported as well. In these experiments the participants were required to prepare a finger movement, hence to *concentrate* on this movement but to abort the intention to act in the last moment. And in these cases the so called "readiness potential" showed up as well; thus we see a readiness potential, hence an increase in neuronal activity in the corresponding cortical areas, without an actual movement. And there are many more experimental investigations which report a *measurable* increase in neuronal activities solely depending on the attention of the subjects.[29]

[27] A question already addressed by James (1890) and Penfield (1975)
[28] Libet (1985)
[29] See e.g. Egner and Hirsch (2005)

## 7 Meaningful attention

What actually is *attention*?

I have at least the impression to direct my attention amongst the items of my phenomenal experience, hence amongst the items on the screen. But of course, my attention might well be the result of some processes in the brain, enhancing one or the other neuronal activity and thus bringing one or the other item in the focus of my attention, to the center of the screen.

However, if we are to look for neuronal processes somehow distributing "attention" within the brain we face in any thinkable implementation the problem that neurons do not know anything about the content, about the *meaning* of their processing. In this sense Daniel Wegner (2002) suggested a theory of operational and monitoring processes within the brain to explain a very common phenomenon: If we intend *not* do think about something the result is very often a kind of amplification of this very issue. Wegner considered a "foible" of the conscious will to be responsible for this phenomenon: Whenever we have a conscious desire for something, a "monitoring process" for this something is launched; independently whether we really want this something or *not*. Thus, in case of not wanting something an "ironical process" is launched:

"The desire to distract oneself from pain, for example, normally initiates a monitoring process that sensitizes one to the very pain one is hoping to ignore."[30]

Hence, we find us forced to assume some "ironically" processes to be instantiated within the brain, some "monitoring" neurons start to spike. However, these ironical cases find far more easy *neuronal* explanations if we consider that we seldom direct attention to nothing but rather to something *else*.

Let us consider these ironically cases with the support of the computer analogy: Obviously a presentation appears on the screen which we would like to close - the experience of pain but as well anything else (see fig. 11).

On normal computers we are able to click off unwanted applications but in the context of the computer analogy we seem to lack this ability:

[30] Wegner (2002, p.311)


Figure 11: Experience of pain in the computer analogy: The experience of pain dominates all other experiences.

We are not able to *not* direct our attention to this something. But we are able to direct our attention to something else. If we direct our attention to the sound of some nice music, for example, the pain seems to jump somehow in the background of our current experience (see figure 12). Actually we use this kind of distraction very often with children when they got hurt: We point to some other events. And suddenly the pain is not that terrible as before.


Figure 12: Experience of music. In this case the sound of music dominates our experience whereas the pain somehow "jumped" to the background.

What is the reason for this change in experience? Which kind of knowledge about the phenomenal qualities of music compared to pain would neurons require to initiate this change?

From an evolutionary perspective it simply does not make sense to listen to some music instead of dealing with the heavy pain in the hand. Hence, *who* is able to prefer the sound of music against the feeling of pain?[31] Which kind of "higher-order" process within the brain would be able to solve the task, which "master neuron" in the brain is able to prefer music against pain? Neurons simply spike. So what does it actually mean to "prefer" or "dislike" something? And what actually *is* attention?

[31] Or vice-versa, dependent on personal preferences.

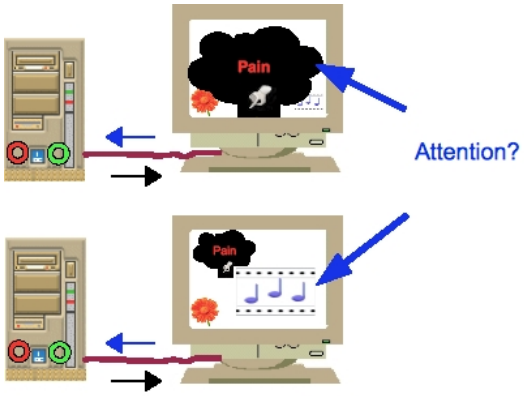


Figure 13: Change. What is the reason for the change in experiences? Which knowledge would any kind of brain process, neuronal state or at least neuron need to have to initiate this change? Is it indeed possible that attention is a mere effect of processes within the brain? Or is it much more plausible to consider attention rather as a *cause* than an effect of neuronal activities in these cases?

We prefer or dislike items of our phenomenal experience and we direct our attention amongst the items of our phenomenal experience. This phenomenal experience appears to be dependent on the brain. But does it make sense to assume this dependence as well for *attention*?

In this case we would be forced to assume a kind of hierarchy of brain processes and thus come close to the assumption of a kind of "central controller" within the brain, which - nevertheless - has no ideas of *meanings*.[32] Moreover, the "central controller" should remind us on Dennett's fundamental criticism:[33] It does not make sense to assume such a controller within the *brain*. This assumption comes at least close to the aim to understand the *brain* with the concept of a Cartesian Mind. With the support of the computer analogy we are able to acknowledge this criticism: We are able to observe the brain without this concept and track the path for explanations by asking for relations.

With the question regarding the source of *attention* and the inability to assume any kind of *brain* mechanism to distribute an attentional equivalent amongst the neurons, independent of the "items" they currently deal with, we also face Searle's invention with respect to some

[32] Compare Searles objections regarding the assignment of meanings from *outside* a system to explain its behavior or the evolution of consciousness, Searle (1992).
[33] Dennett (1991)

missing meanings within the brain.[34] Somehow we indeed discovered a biological process generating meanings: There are phenomenal states. There is a screen. And hence somewhere somehow a kind of "device driver". And it seems to be related to neuronal activities. Although our neurons appear to follow solely natural laws lacking any *meaning*.

Neurons do not attend, they do not know, they not like or dislike something. They spike.

At least as far as we are able to observe and conclude. Following our scientific picture of the world. A picture of the world which neurons do not have. They do not see, nor hear or feel anything.

But we do.

Actually we finally (re)opened a common but nevertheless new perspective in the debate regarding the relation between brain and mind: Based on the consideration that any "non-material" or "mind" stuff can never be able to move particles around the world (or the brain) we initially considered ourselves *forced* to believe in a physical monism as the premise for all plausible theories of mind. However, as already outlined in the first part of this essay, this premise led to different but nevertheless tough kind of problems: *Why* do we have phenomenal states? Do we really have them at all? How could phenomenal states be related to neuronal states? With the support of the computer analogy we were able to generate some respective ideas which obviously led us directly back to a kind of interactive dualism. Did we make a mistake?

*Where* is the world, where are our neurons and what is the relation between the world and our perception of the world? Whatever we see appears to be dependent on our brain. Our brains are responsible for our perceptions. Our brains actually constitute the way we perceive this world. But neurons do not see trees. They do not touch trees or hear the rustling sound of the leaves, they do not even need these concepts to survive in their environment, to survive within brains. But *we* have and need these concepts. And we are unable to ignore this item because it simply constitutes the world we are talking about. Obviously we are to face a kind of interactive dualism back again. But maybe the computer analogy might take us a step further in understanding, a step beyond the idea that "mind stuff" might be something similar to a funny ghost called "Caspar" (Dennett, 1991, p.35).

[34] Searle (1992)

Many interactional theories focussed on the concrete mechanism of a potential interaction; they searched for a certain *location* (e.g. microtubuli, pineal gland) of or physical mechanism (e.g. quantum mechanics) for this interaction, hence they aimed to *localize* one of these "substances" (mind) *within* the other "substance" (matter).

But considering the circumstance that *if* we think dualism as a dualism of two very different *substances*, having nothing in common, should we consequently not look for an interface between them somewhere in the middle of the way? An interface which represents a kind of compromise between the aspects of the two?

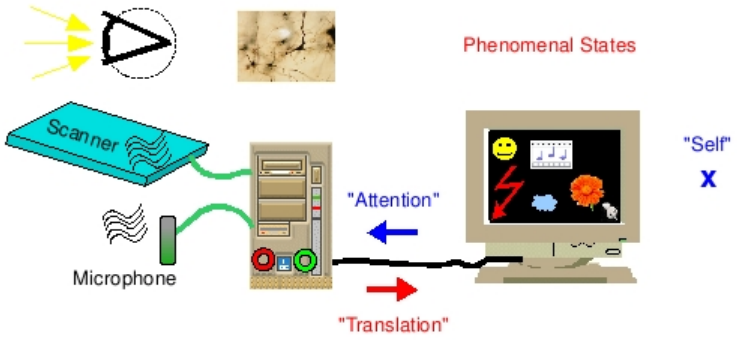


Figure 14: The complete computer analogy.

Considering phenomenal states in their relation to the brain and the world with the help of the computer analogy enables us to consider them as a kind of *translation* provided by the neurons, potentially because the *computer user* only understands this language: colors, sounds, smell, taste, etc. These phenomenal states themselves go somehow beyond "pure" material stuff and its natural laws, as far as we observe: Neurons do not need these concepts, they seem to operate on a spiking level. Thus, the brain does something more than absolutely necessary under the premise of a physical monism, something that goes beyond itself. Hence these phenomenal states themselves form a candidate for one part of the "interface". And *attention* is at least a hot candidate for the interaction in the "opposite" direction.

### ... just some neurons?

Nowadays brains obtained a unique and sole reality; as I tried to outline in the first part of this essay this appears to be almost necessarily the case. But, as I also tried to outline, this emphasis on the brain and its world does not really lead to a consistent picture of something. The remainder of the essay was actually an attempt to sketch an idea of relations which finally led to a quite obvious circumstance: There *must* be something more than brains, neurons, molecules and particles as otherwise we would simply not know anything about brains, neurons, molecules and particles.

At this point you might feel a weird feeling within your stomach: What is this all about? And of course, you are right. It might be about nothing less than an idea of something formerly called "soul".

I, personally, needed quite a while to recognise this. For a substantial amount of time I was busy thinking about the screen and asking myself where I made the mistake.

Hence, this essay has an history. And its premise was definitely not the soul. I did not start as a religious person with a certain believe about things. But as a scientist I wondered, like many others, about the world and the neurons. And somehow stumbled across this computer analogy some day.

Why a screen where nobody looks upon? Does the screen really make sense in the computer analogy? *Where* is the world, *where* are the neurons, and *where* is our perception of the world? What actually is a "color"? What actually is a "sound"? Are molecules colored? Are particles? Why do we hear moving molecules? And *what* actually is moving there? The deeper we dig into matter the less we find.[35] But for some reason or others our brains appear to build a nice and compact picture of this stuff out there.

Which idea of the world do neurons have? Following our observations they do not have nor need an idea about the world but exchange neurotransmitters with connected neurons. But right by the way they seem to provide some translations for us. There is a screen. *We* have a picture of the world.

[35] See for example Schwindt (2008) for a nice overview with respect to the famous "loss of substance" in physics and the role of an "interpreter" with respect to our physical picture of the world.

Of course, even with the complete computer analogy in mind we still do not know what really is "out there". No access to the picture on the scanner. But (brain) research against the background of relations might provide further clarification about the items on the scanner including our neurons, and maybe even about our "**x**": Why do we stumble at the level of quantum mechanics? Why do we fail to understand the big bang? Maybe we are able to generate some new ideas with a picture of relations between the world, the neurons and our perceptions in mind.

Hence, physicalism reached its end because our observations constituted this physicalism, because *we* are the premise of any physical monism. A premise unable to get eliminated because it simply constitutes the world we are talking about.

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