Brain, Mind and Cognition

Essay

EMBODIED COGNITION

by Lawrence Shapiro

When I looked at the beginning of the table of contents and began flipping through the book, I had the impression that the book is very well structured. Each chapter has one introduction, one summery and a suggested reading. I thought it would be easy for me to read the book and understand the intention of the author. However, after the first two chapters I recognized that my first impression was mistaken. Although the author adorned his explanations with lots of pictures and lots of examples, it was hard to understand what Lawrence Shapiro wants to say to the reader.

In each chapter he described the various experiments, which are carried out and a lot of examples. Furthermore, he presents many quotations and opinions from various scientists. Lawrence Shapiro told a lot of other scientists, what they consider to be useful and how they related to different topics. Because of that, it was very difficult for me to recognize, what the authors opinion to the individual topics is about.

Essentially, Lawrence Shapiro describes the basic ideas of cognitive perception. The main three topics are the following:

“Conceptualization, which means, that the concepts an organism can acquire are determined, limited, or constrained by the properties of the organism's body.”

“Replacement, which means, that the dynamics of an organism's bodily interaction with the environment replaces the need for representational processing. Thus, cognition can be explained without the appeal to computational processes or representational states.”

“Constitution, which means, constituents of cognition extend beyond the brain, so the body or world does not play a mere causal role in cognitive processes.”

The author wants to present, what embodied cognition aims to explain and how it relates to and important ways departs from, standard cognitive science. By means of these three basic topics, Lawrence Shapiro tries to visualize the differences between embodied cognition and cognitive science.
In the introduction Shapiro introduces two ideas: On the one hand, the computational theory of mind and on the other hand the idea that since “cognition begins with an input to the brain and ends with an output from the brain, cognitive science can limit its investigations to processes within the head”. In addition, he mentioned the decision tree with which he wants to work. The decision tree is about the differences of embodied cognition and cognitive science. In other words, in which degree they differ.

In the following chapters he talks about standard cognitive science, challenging standard cognitive science, conceptions of embodiment and embodied cognition (The Conceptualization Hypothesis, The Replacement Hypothesis, The Constitution Hypotheses). In the end he comes back to the decision tree and gives a short conclusion.

Now I want to talk about these parts of the books, which impressed me the most.

In this book are a lot of interesting views. For example the concept from Varela, Thompson and Rosch, which is called the World Building. They are talking about two points, the body with various sensorimotor capacities and the second that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological and cultural context.

Another concept, which impressed me, is the embodiment of color. This concept includes two basic statements. On the one hand, "color provides a microcosm of cognitive science", which means in so far that our understanding of color draws from the disciplines of psychology, linguistics, philosophy, neuroscience, and artificial intelligence. On the other hand, "color provides a paradigm of a cognitive domain that is neither pregiven nor represented but rather experiential and enacted". This view brings us near to the idea, that colors are created in experience through a kind of activity, where this activity is the product of specialized equipment that in turn creates opportunities for a unique sort of coupling. This second conclusion brings us to the hypothesis of Conceptualization:

“Color Conceptualization: color experience is created through a unique sort of embodied coupling.”

The dynamical systems is also a part which interests me, because I heard a lot of different courses, at the University, about robotics and automation technology. Hence, I had a basic knowledge about dynamical systems, exactly, what it is and what it does. So it is easier to me to understand the concepts proposed by Shapiro.

The last idea which stayed in my mind was the human tendency of gesture while speaking. Gesture is a theme that is shared by all people. It reinforced
often the predicted. Especially, southern countries such as Italy or Spain use their gesture. It is surprising that men use earlier and more pronounced gestures than women.

Finally I can’t decide on one topic, because there are a lot of nice and inspiring views.

After I referred which are the most appealing or interesting ideas to me, I come to one of the most self appearing questions you ask yourself after reading this book. If Lawrence Shapiro’s book stimulate thoughts inside of me about what it takes to build intelligent technical systems? To ask in accurate words, do I feel like I can build intelligent technical systems respectively do I want spend more time in this issue in my future?

The author has not tried to motivate the reader closer to altercate with the theme.
I have only received a broad overview of the different approaches and different ideas, but I do not know which are leading to something and which are not. I find it very sad that the opinion of the author did not come to light.

It was very difficult for me to read this book, maybe you need a certain pre-knowledge about embodied cognition to understand more about the different views from the various scientists. The many examples and the different opinions of the scientists made it often difficult for me to understand the relationships exactly.

Therefore I do not feel encouraged to occupy myself with the embodied cognition. So this book does not stimulate thoughts inside of me to build an intelligent technical system.

On the whole, I don’t like this book because I had to concentrate very hard to follow the thought, which the author processes. Often, I just did not understand what Shapiro was trying to tell the reader. Especially, compared to the book "On Intelligence" by Jeff Hawkins and Sandra Blakeslee: By reading I got the constant feeling that Jeff Hawkins seeks to increase the reader's understanding.
In contrast, Lawrence Shapiro brings many examples, conducted experiments and lots of statements / quotations from a variety of scientists from different fields. Thus, I often did not know where his position is and what he meant at all.

In conclusion it can be said that this book was very difficult for me to read. The many lists and opinions from the different people from different fields seemed more like a summary of the topic embodied cognition.

Now I had read this book, I feel neither inspired to continue dealing with this issue, yet to be creative myself to make my own concept for intelligent machines.
Embodied Cognition - Lawrence Shapiro
Book Report

I would like to start by saying what I did not like about the book because the ratio between ideas to which I agree to and those which I do not is around 50%.

First of all I don't understand why do the traditional cognitive science ideas take around 30% of the book. It has been shown by others, for example Hawkins, that this manner of analyzing intelligence, cognition and the mind and brain in general lead us almost nowhere; that the AI is the wrong way if we want to actually create something intelligent. How can the mind and our brain be calculating all sorts of algorithms, very complicated algorithms on such short notice, without us even noticing. Even in this book it is mentioned that those ideas come from the understanding and developing of PCs (from Touring’s machine and other ideas). The idea of having amodal and arbitrary symbols seems a little bit strange. I strongly believe that the solution to describing our brain, cognition, what intelligence is and how to make something intelligent, should represent a simple and elegant solution. The framework should be wrapped around this nice, simple and elegant solutions.

Not to mention the language used in the first part: scientific language should not be as complicated as possible just so you can show off, but should be able to transmit the ideas, to make other people understand you. I found it to be a little amusing that in the first part, when he was presenting the “old” ideas, which are also very complicated, he used a heavy language, whereas in the second part, when presenting new and simple ideas the language was much more “user friendly”.

Another idea which is totally disagree with is the fact that the world is perceived as a discrete source of signals, from which representations are made. It is certain that representations are used, but in no case are they discrete. So what that we have discovered digital electronics, so what that it works much better in almost all the cases than analog electronics, that doesn’t mean we have to apply it to other
problems. This is similar the story with the hammer, in which one has only a hammer as a tool and sees every problem like a nail. I strongly believe that nature itself and everything which surrounds is analog.

The third and maybe the most annoying statement found in the book, which I did not find to be dismissed by the author, is that “a system including the brain plus pieces of the world is a foul hybrid – a nasty mess that is not amenable to scientific scrutiny”. I really don’t understand how can one see the brain and its activities, in all the complexity and how it connects to the “pieces of world” which we use today/ have been used can be considered a nasty mess. The devices/tools (the phone one uses, the computer, the paper, even the tools used in The Middle Ages, etc), we consider to be so important that some people might even believe to be impossible to live without (although, I agree, this is a bit exaggerated), connect and interact all the time with our mind. To say that it is not even worth scientific scrutiny is like saying that biology, or maths, or engineering is not worth while. I am actually amazed how come the author found such a remark appealing. To me such a paper is not even worth reading, to the sense that I would rather stare at the wall and think of immortality.

Now coming to the ideas which I like, ideas which where situated in the second part of the book, because I can say that this book presented some really interesting points and conclusions. I would describe this book as being a place of contrasts. Probably the most interesting idea which I can take from the book is Constitution. Yeah sure, one might argue that analyzing the embodied cognitive actions through the apparatus of dynamical system theory is also pretty impressive, because it proposes a solution which can actually be implemented with the tools available today (an idea more appealing to engineer). The catch here is that this is, like the author also presents it to be , just an extension to the standard cognitive science’s tools.

Constitution, I believe, is different than the standard cognitive science, even though is just because it “draws a wider the circle” to map the cognitive elements. There is
a significant part which we loose if we limit ourselves to analyze only the brain. Sure, this is the initial step, but as Hawkins said, we already have a lot of analyses and results on the brain alone. We should study also the way we interact with the world, and how certain products, language, culture influence us an in particular out cognition.

I was particularly impressed by the Parity Argument. It gets closer to a good explanation by presenting a really simple idea with a simple solution and example. I found Adams or Aizawa points to be not only wrong but actually more aimed at explaining particularities rather than general stuff. Even the fact that Constitution goes on top of what is described as standard cognitive science is a sign that scientists need to take it much more serious. It is clear that standard cognitive science is inadequate in the way that it doesn’t go the full way, and that certain ideas cannot be accepted as they are.

Now it is not clear to me weather HEMC (Hypothesis of Embedded Cognition) is better suited for the beginning step, rather than HEC (Hypothesis of Extended Cognition). As Rob Rupert presents it, HEMC does not totally carry the burden of proof as it is not nearly as extreme as HEC. To be honest HEC seems very interesting, but for now we could stick with HEMC more like a middle point, prove it till it becomes stable, and then try to go to HEC. Maybe the author is right in the way that it is not more than a linguistic issue.

I cannot think but to link the ideas and directions presented in this book and the one presented by Hawkins, when thinking of building some intelligent system. It is now clear that we need to take into consideration the fact that a certain device/robot/etc will be defined as a cognitive system along side with the “tools” it will be using when performing a certain task. It might not be clear how the system will be intelligent, but for sure the “tools” it will be using, have the potential of making it more intelligent. The question which arises is how cognition is linked to intelligent and if they are the same thing. I think they overlap to the point that they can be mistaken to be the same thing.
“Embodied Cognition”, Lawrence Shapiro's book praised to be an outstanding book within its context of cognitive sciences, left me with a feeling of discontent after finishing it, making the answer which concept or thought was the most interesting one a rather difficult one.

Shapiro, throughout the book, has a habit of wandering into all manner of different topics and explanations, from the way one should formulate a hypothesis to experiments from robotics and dynamic systems, a lot of topics I would not have associated with cognitive sciences. This, by itself, would not make the book a bad book, but didn't quite satisfy my curiosity about the topic. When reading about “embodied cognition”, I would have expected a bit more of an explanation about the bodily functions behind cognitive processes. “Embodied” summoned images of robots with human bodies or explanations about biological processes to my mind – which were not included in the book to that extend. This lack of information becomes especially apparent in comparison with “On Intelligence”, Jeff Hawkins book, which displayed a brilliant combination of topics from computer sciences, biology, and psychology.

On the one hand, while dabbling into each of the subjects, Shapiro does not take the time to look further into them, weakening his explanations. Of course, one could fill a book just writing about dynamic systems (or their usefulness in describing cognitive processes), and some deeper explanations of the topics scratched would have easily used up as much space as Shapiro's entire book – they would have been much beyond it's scope. But in his search for experiments and hypotheses favouring embodied cognition, Shapiro, in my opinion, loses sight of the details. While the question whether or not a robot needs a representation of his surroundings for performing as good as a biological counterpart surely can be discussed for ages, leaving out facts already found from different sciences makes the book very vulnerable to criticism, even more so with Hawkins book in mind. An example of this would be biological knowledge. Having the read “On intelligence”, I was waiting all the book for a look into cortical regions, or a more satisfying implementation of mirror neurons into Shapiro's work. I waited in vain.

Similarly, the total lack of definition on what kind of embodiment was meant was highly frustrating. Sure, a cognitive scientist considers the processes in the brain to be separated from rest of the world, like a black box. But were does a brain start? Were does it end? Does the nervous system still count to be part of the brain? Does it still count as a brain in a black box when talking about an ant, which does not sponsor a brain in the normal sense at all? What about
hormones and their creating intestines? Are they considered part of that box, or a variable dependant on the brain and therefore not important? Either Shapiro had a painful lack of knowledge about these facts, or, sitting in his ivory tower, considered himself to be above such matters. Whatever the case, this made most of his findings not very logical or well proven for my standards. One could, of course, argue that for a professor in philosophy, these matters pale in comparison to the greater concepts. But then on the other hand, Shapiro does enter subjects like colour vision (a very in detail topic), just to skip answering the question of were the embodiment starts. Is the pre-processing, done by the neurons in the eye and on the way to the cortex (which, by the way, can be very well explained with computational and control engineering concepts), already part of the brain, or is THIS the embodiment? And why were people with reduced colour vision, most prominently those with a red-green disorder (erythrocholoropia), not mentioned at all? I was tempted to guess that their examples, maybe weakening Shapiros already weak theses further, were left out intentionally. The same is true for the Chinese room, to which Hawkins smartly added that the intelligence and understanding is not found in the writer of Chinese characters behind the wall, but in the one supplying him with rules to scribe them. No real new ideas about this example was given in “Embodied cognition”, making the mention of the example questionable, be it an interesting read or not.

But was there no concept to take from the book at all? Luckily, I would not come to this frustrating conclusion. Shapiro gave a nearly perfect overview of research topics in the area, with gems like the influence of language on our thinking and the A-bot-B error in Thelen's work. With this foundation being similarly brilliant than Hawkins book, the one idea I took from the book was this: Just forming a good state of the art, and scratching a lot of topics in search for supporting evidence to a theory, in the end does not make a good theory.

What sets apart Hawkins book from “Embodied cognition”, even though the topics are only partly related, is that Hawkins really gave the impression of having UNDERSTOOD all the topics needed for his theories. And even if maybe some of his assumptions later prove to be wrong – I'd not dare to question them myself – his easy and very efficient explanation of topics complicated even for people studying the subjects makes his work unique. What I will take away from “Embodied cognition”, therefore, is, apart from a lot of useful background knowledge, the reminder to try and understand subjects before making assumptions. And, as an extension of this reminder, while trying to get a look at the concepts behind the miniscule details, not loosing my grasp of the reality behind the theoretical framework, and getting back down to earth sometimes to see if I haven't lost sight of the things I wanted to achieve.
This, surprisingly, makes “Embodied cognition” maybe even more useful for me when thinking about intelligent technical systems.
While “On Intelligence” taught me to see the bigger image, “Embodied cognition” made it perfectly clear for me that first getting a grasp of the concepts is essential.
It might not be necessary to know every variable of a task to build a robot to solve it – sometimes it's even worth building a robot not for solving tasks, but for emulating human behaviour. But it is of the essence to see if an explanation from another field of studies exists for certain behaviour, or for solving a certain problem. And in the same way as bringing an algorithm for playing chess to perfection will not yield an intelligent robot as the result (but a robot good a playing chess), entangling one's self in theoretical thoughts about what could be and what could not be, and whether certain terms are fitting or not, will neither yield any results.
While engineers sometimes get stuck with the details – and their habit of playfully trying to enhance their creations without a look at the bigger picture – Shapiro, as a philosophy expert, gets, in my opinion, stuck in the bigger picture, not finding any facts of use for reality. A team of a philosopher and an engineer – paired with a biologist maybe – on the other hand might bring forth some interesting results.
For example, the “linguistic determination of time conceptions”, as Shapiro called it, opens up several interesting topics. Is a different outlook on time (moving downwards instead of forwards, as a person with an Asian background would use it) beneficial to a robot? Does a robot maybe have to take it into account when dealing with different cultures? But whether or not this has something to do with embodied cognition is not only insufficiently pointed out in the book – it might play no role at all for technical tasks.
The control of the power output of a steam engine, as pointed out in the book, is a good example of why computer scientists (or engineers in general, to leave Shapiro's generalization) should bear in mind the beauty of easy, uncomplicated solutions over algorithms. Occams razor – the simplest solution often is the best one – applies to this example especially. While a computational approach in this case might be clumsy, difficult and prone to errors, the physical, simple approach yields perfectly fine results – real time, without power consumption.
So, to wrap things up, the concept of embodiment, taking into account further details like
hormones, the nervous system and so forth, can be a good pool of ideas for engineers. Why not learn from the body in its way of adapting to systems no matter how they change? Or, for that matter, even independent of the availability of sensor input? A blind person, surprisingly, can improve his sense of hearing and smell to compensate for the lack of vision. A robot with these capabilities would be worth several Nobel prices, to say the least. Even if Shapiro left out these concepts in the book, the embodiment theory will surely see some adaption in the robot world. And dynamical systems – even in computerized form, to the dismay of enemies of computerization of cognitive topics, will be an important factor for robots and cognitive systems alike.
From Conceptualization to Constitution the author indicates explicitly the relationship and difference between Conceptualization, Standard Cognitive Science, Replacement and Constitution. Meanwhile the author quote several theories and sentences of philosophers and scientists to detail the theme. This book is very interesting.

I prefer to talk about the researching of Constitution. Constitution indicates that constituents of cognitive processes extend beyond the mind. And the body is constituent of the mind. There is a easy example. We have not only minds but also the generator of mind, namely our brain, and the processor (also our brain).

We can easily proof that this opinion is not correct. if C is constituent of the process P, C exists only when P exists. And another proof is the Argument of Evatment:

a. If processes outside the brain are constituents of the cognition then the brain alone does not suffice for cognition.

b. An evatted brain suffices for cognition.

Therefore processes outside the brain are not constituents of cognition.
Later the theories of perceptual experience is provided. The perception lies in the doing. And perceptual experience is just a mode of skillful exploration of the world. But this opinion is also one-sided. In short, Aizawa’s point that sensorimotor activities are not, in fact, necessary for perceptual experience extend beyond the brain, for it limits the constituents of experience to knowledge which, presumably, is represented in the mind.

Clark thinks that Constitution is most evident in systems involving loops of self-generated inputs that extend beyond the brain. On the other hand Willson thinks that the impartiality of computational descriptions have nothing to say about the location of the constituents of algorithmic processes, opening the door to the possibility that cognitive processes incorporate parts of the world.

Some scientists indicate that there are two kinds of systems, one is brain-constrained cognitive system, the other is the extended cognitive system. And there are quite different. They seek to show that those things we would be willing to recognize as constituents of a cognitive system might as well be outside the brain as inside.

The most important thing is that the ability of extending depends on the framework of this system.

Comparing with the Standard Cognitive Science. The scientists use the central concepts of the Standard Cognitive Science to explain the Constitution. So they have a really tight relationship. Although they are related, they have difference. Standard cognitive science
is unwilling to extend its explanations to incorporate non-neutral resources, it will often fail to see the fuller picture of what makes cognition possible, or will be blind to cognition’s remarkable ability to self-structure its surrounding environs.

I’m a supporter of the Constitution. And my point is that the cognitive system has a relationship with the environment. And all of the cognitive systems have memory (or has a connection with memory, like our brain). At first, the memory system will record what’s happened outside and what is the reaction of the cognitive system. Then a algorithm of this perception is produced. For instance, when it is the first time we touch the water, we must don’t know what it is, then someone tell us it is water and it is cold. So we store the information of water in our brain, and this two characters are combined together, namely ’water’ and ’cold’.

When the next time we touch the water, we can feel that it is cold. And we know this cold thing is water.

So I think the cognitive system has the property of self-learning. And comparing with the point of O’Regan and Noë, I don’t think the body is constituent of mind. Combining with the example above, when the body is constituent of mind. We can learn nothing from the nature, we don’t know what is water and what is the cold thing. In a word we don’t have the ability of self-learning. Unless our mind contain all the things in the nature at the beginning. But it is impossible!
Essay
“Embodied Cognition” – Lawrence Shapiro

1. What do you think is the most interesting thought/concept proposed by Shapiro?

Lawrence Shapiro’s book “Embodied cognition” is a balanced introduction into the field of cognition science. I see the main intention of the author as trying to develop the central themes of embodied cognition, an important trend in cognitive science and to show which role the environment plays in the development of cognitive processes.

Being a professor of psychology and having his research focus on the philosophy of psychology he is explaining his theories in a way more difficult to read and to understand. I see the book as a very analytical perspective of his thoughts, concentrating on the general themes that appear in the literature illustrative of embodied cognition.

Shapiro proposes several ideas in his book. In my opinion the single most important thought is the way he has tried to define the term of Conceptualization. Conceptualization gives accordance to “were organisms to differ with respect to theirs bodies, they would differ as well in how they understand the world”. His thesis is that “To conceive of the world as a human being does require having a body like a human being’s”.

Experiences determine how humans conceptualize things. Language plays an important role, as Benjamin Whorf and other researchers have shown: “people have the same picture of the universe only if they share a language.”

In my opinion the experiment with English and Mandarin is very interesting. The fact that the different concept of time influences the human mind and way of thinking is very intriguing for me. Because time, in English, is described as having horizontal
dimensions, and in Mandarin is described in vertical dimensions, English and Mandarin speakers will think differently about time.

I have never thought about the different conceptions and understanding of a word before facing an argument in an official trail between two foreign parties. A short while ago I attended an oral proceeding over a patent document. On the one side was the French inventor, on the other side the English opponent. I saw that they were arguing about the meaning of the word “generally”. In French it means “most of the time” or “the most common option” and in English “every time we do that” (You do not have another choice). The way the opponent saw it, it was novelty destroying thus leading to the amendment of the patent document.

I was really surprised to see that there is such a big difference in perceiving a word and that it could have such a huge impact. What also impressed me was the fact that the two sides were originally not so different from the cultural background, like for example English speakers and Mandarin speakers.

In the example shown in the book, we can see that there is a big difference in the way that people handle life and think. English speaker were quicker to respond to target sentences after horizontal primes in an experiment. For Mandarin speakers, researchers found the opposite effect.

This phenomena occurs because English speakers use horizontal metaphors to talk about time, so they might grow to think about time horizontally. For the same reasons, Mandarin speakers might grow to think about time vertically.

Also relating to language, the example about sex for objects was really interesting to read. I think it is very funny to see how different people are thinking about the same object just because of the different sex the object has in their native language.
As a foreigner living in Germany I can be myself in the same situations. It happens often that because of the different language characteristics I see things different then my German colleagues. Personally, I don’t think of this as an obstacle, I rather see it as a good thing because of the different points of view on the same situations. This can be of great advantage when trying to overcome some problems, technical or not.

2. **Does Shapiro's book stimulate thoughts inside of you about what it takes to build intelligent technical systems?**

In comparison to Hawkins book “On Intelligence”, this book is not really stimulating actual thoughts inside of me about what it takes to build intelligent technical systems.

I think, the analytical way of presenting things, and the more complicated style of Shapiro's book makes it for me more difficult to really imagine something. His way of explaining the concept of embodied cognition is not as fascinating and spectacular to me.

Though, a fact that I like about his theory and I agree with, is that the components of the intelligent technical systems must be **coupled**. I think, it is a good start to think of the machine to be built to have coupled equations that include variables ranging over a brain, a body and the environment.

The example found in the book about the human understanding of the spatial terms like up, down, front, back, in out, near and far is good in order to show us how important the body, the environment and the coupling between them is in our day-to-day perception. "Because human beings stand erect and human movement typically involves changing or maintaining this up-down orientation, humans develop or innately possess the concepts up and down".

My belief is that it would be a good approach to modulate the agent and its environment as a nonlinearly coupled dynamical system which, as such, is unified and not decomposable into separate parts.
In his book "Embodied Cognition" Lawrence Shapiro outlines different views and issues connected with embodied cognition and points out its divergence to standard cognitive science.

In the first chapter he introduces the thesis of standard cognitive science, which sees cognition mainly as computational. The human thinking is compared with a programmable algorithm. The steps people perform at a means end analysis, which is finding a way from a problem to its given solution, can also be described well by an algorithm. The computational explanation fits good as long as one assumes that the whole process in finding a solution is conscious. But Sternberg's analysis of memory scanning already shows that the description of a thinking process of a subject doesn't always fit to the reality its reaction time indicates. Another problem introduced is the computational vision program. To compute the position of an object out of the retinal image of both eyes is a quite challenging task.

In embodied cognition the mind isn't seen as separated from the rest of the body. Thus for example determining a position gets much easier, including the changing view caused by body movements in the solving process.

All in all, Shapiro explains embodied cognition as cognition depending on the body with all its sensorimotor capacities and its experiences. Mind and body are inseparable connected to each other.

Before I explain the, in my opinion, most interesting hypothesis of embodied cognition I want to shortly list all of them introduced by Shapiro:
The Conceptualization Hypothesis:
properties of the body determine the concepts one has of the world, differences in the meaning create different worlds for different kinds of organisms

The Replacement Hypothesis:
cognition is not symbol processing, but a dynamic system depending on the outside world and the body

The Constitution Hypothesis:
the mind isn't located only in the brain, it extends beyond the brain over the whole body

In my opinion the Replacement Hypothesis is the most promising one. But let me first explain, why I don't agree much with the other two Hypothesis.

The Conceptualization Hypothesis seems to be onesided. Of course an object has different meaning for different kinds of organism. For some it may be a tool, for others food or just a barrier. But this doesn't automatically mean, that the concepts have to be diverging. A concept should offer the whole interaction with an object one can imagine, and this leads to offending the Conceptualization Hypothesis. Knowing the properties of other bodies than one's own guides to a concept, that isn't only determined by the one body.

Thinking of the mind as extending over the whole body is for me quite difficult. I can use my body to make cognitive processes maybe easier, for example with writing down my thoughts, but for me this correlation doesn't say, that the body belongs to the mind in a direct way. I would see it more as a tool, that helps to perform a task. I can think of things I already know without using the whole body and solve problems with my brain, but my body without the brain would be quite helpless. Thus for me there is only a connection between mind and body, they are not the same and that's why I disagree with the Constitution Hypothesis.
The Replacement Hypothesis explains such a connection with a dynamic system. The mind is influenced by the body and influences the body also, making body and mind dependent of each other. The system has no point where it starts or ends, it is continuous. Shapiro gives the example of two different kinds of robots having the same task. They have to drive through a room with barriers. One robot uses an standard computational approach, forming the inputs to symbols, which then are processed. Eventually the symbols are formed to an output. This robot has many difficulties with orientation in the room and therefore needs much time to perform the desired actions. The other robot Shapiro introduces works with a dynamic system, without representations in the form the standard robot did. The inputs are directly connected to different layers, which each react to the input given at the moment. Via a kind of hierarchical structure between the layers the output of the system makes the robot perform the right way. There is no need for a build-in map, because there is a flow of inputs that lead to an immediate response of the system.

Interpreting cognition as dynamic system with the body and the outside world seems promising, hence there are forward and backward connection between the neurons in the brain. So if there is already a build-in dynamic system within the brain, why shouldn't it interact with the rest of the body in the same way?

Shapiro's discussion of representation gave me a different view on cognition. The Replacement Hypothesis excludes mainly representations, which I thought to be essential for cognitive processes. Thinking of an immediate response to a stimulus, there is in fact no necessity for representations. Assuming that the mind functions in large parts as a dynamic system how does representation come into play, when only thinking of an object without seeing it?
Before starting to read the book “Embodied Cognition” I always associated cognition as a cluster of learning, reasoning, language and decision making. On reading the title, I was confused. I started to think, what the difference between cognition and embodied cognition was because I always associated cognition with one’s body. Our five senses, various motor sensors work with the brain to enable learning in us. If they were really different things, as the author claimed, I was under the impression that I would be introduced to the real meaning of cognition and how cognition is implemented in human beings while reading.

At the start of the book, the author introduced the standard cognitive science and how it approaches the problem of cognition. For a standard cognitive scientist, a problem can be broken down into steps and transformed into symbols which the brain can process. The brain would take inputs, process them with some algorithm and produce an output. All research was dedicated into coming up with representations and deduce how an actual brain actually processes information. Standard cognitive scientists claim that the brain is the sole producer of cognition and completely ignores the presence of the environment and the dependence of brain on the body.

Next, the author introduced a new research subject, “Embodied Cognition”. As the author stated, in its core, embodied cognition disagrees with the core of standard cognition. While standard cognition considers the brain to be sole producer of cognition, on the other hand, embodied cognition researchers believe cognition to be the product of interactions among the body, brain and environment.

The author cited many examples; many thought experiments and many theories related to embodied cognition. Some of these made sense, and some were too philosophical in the explanation. At one point in the book, the author introduced the concept of symbols, and put forward the question of “How does the brain comprehend symbols”. This had always intrigued me. As a child, I always thought that why was the number 2, written as 2, and not 4? Why is the sentence “Boil the water” correct but not “Boil the air”? If they are all just symbols, what difference does it make to our brain? The author does provide with some explanation with the theory of perceptual symbols, affordances and meshing, yet the phenomenon is unclear to me, and I seek for a better explanation.
As I read through the book, it was the replacement hypothesis which came close to completely rejecting the classical approach of computational framework which standard cognitive scientists follow in order to understand cognition.

Instead of viewing cognition as an input-output problem and mapping the experiences as symbols, the dynamists, as the author call the researchers in the field of replacement hypothesis; have a completely different view to this problem. The dynamists make use of a dynamical system theory as a means to understand many cognitive systems. They claim that cognition emerges from dynamical interactions among the brain, body and the world. A classic example of this could be walking development in an infant. As Thelen and Smith explained, the whole development of walking in an infant emerges from the dynamic interactions between the brain, the muscles of the leg and the surface on which the infant walks. The walking of the infant is not the output of some special cognitive plan which the brain came up with. It was the result of many dynamical states and interactions between the body, the brain and the environment which enabled the infant to walk.

Another example is the case where a specimen is made to stand on a horizontal surface and is asked to identify the shape of the object falling right on its head. If the specimen was asked just to stand and make no movements or was restricted from any kinds of interactions with the environment, it would be next to impossible for the object to identify whether the falling object is a circle or a diamond. However, imagine the case where the specimen uses his legs and turns around his face while moving in order to guess the shape of the object. If this happens, the specimen would in most of the cases guess the shape correctly. The movement of the legs and the movement of the eyes continuously relay new information to the brain, which then uses its past experiences to decide the shape of the object. Hence, it could be said that cognition is a product not only of the brain but emerges as a result of interactions among the brain, body and the world.

**How to build intelligent systems**

In the course of the book, the state-of-the-art research of embodied cognition was presented. Various thought experiments and arguments against the standard cognitive science were also explained. The basic fundamental which distinguishes standard cognition from embodied cognition lies in the theory that while the former associates cognition with the workings of the brain, the latter lays emphasis on the role the environment and the body
have on the production of cognition. However, at no place was a special emphasis on intelligent systems made.

If cognition is the ability to learn, reason, make decisions and produce outputs, then the author has provided certain theories on how cognition works. However, the implementation of cognition again brings us back to the point on how the brain processes information. I completely agree with the theory of embodied cognition as presented by the author, however, I cannot fail to notice that no particular theory on how exactly embodied cognition functions in human beings was put forward.

As I can recall from the book “On Intelligence” by Jeff Hawkins, building up intelligent systems not only includes good sensors and high processing capability, but of course the capability of the machine to learn from experiences. If learning holds a key step in making intelligent systems, then I am compelled to say that some theories of embodied cognition such as the replacement hypothesis may prove to be useful in making such machines.

However, the question that still stands unanswered is how to describe embodied cognition. The book pointed to several hypotheses such as Conceptualization, Replacement and Constitution which are all working towards explaining embodied cognition. Though some approaches are philosophical such as those of Constitution, yet certain theories from Replacement come close to be able to apply in real systems.

Embodied cognition on learning seems to be a very philosophical concept, but throughout the book only debates and various experiments were mentioned. The next question waiting in line to be answered is how one would implement embodied cognition in a machine. Even if one picks up a specific theory and starts working on in, there is no clear roadmap on how to implement such a system in a machine.

Another dimension, which the book failed to mention, was the relation between intelligence and embodied cognition. All in all, the author did an excellent job in providing the reader with the current research in the field of embodied cognition, but did not provide information on how this knowledge can be put to use to making useful systems. Only with some real applications of embodied cognition, could its importance be measured.
Essay

Embodied Cognition by Lawrence Shapiro

When I started to write the essay, the questions for the new book had not yet been updated. Therefore I have just overtaken the questions asked for the last book.

Before I start on the questions I have to admit, that I found the book a pretty hard reading. The book was that difficult to read because of the high abstraction level on, but what is still more is the complexity of presentation. Most difficult I found that that many views on the topic were presented. On the on hand it is nice to get a topic introduced in many viewpoints, here psychology, philosophy, a little neuroscience, technology, .... . But the many viewpoints get confusing with time and it is hard to associate afterwards which concept refers to which author or viewpoint. Furthermore the author does not really rate the collected data like Hawkins did in the last book. Only the last chapter gives a short summary and assessment. On the one hand writing is such less biased, but it is much harder do form an own opinion as one cannot filter the essentials out of that much different information. Still I hope that I could grasp the main issues and form an own opinion on embodied cognition.

What do you think is the most interesting thought or concept proposed by Shapiro?

As I already said in the introduction I am kind of confused with the quantity of information presented in the book. I found it quite interesting that there are people that in my view follow a completely misled course of how to describe cognition. That is standard cognitive science, or at least the part that thinks of the brain as a symbol processing device like computers are. After reading “On Intelligence” by Jeff Hawkins, I cannot believe in the brain working like that. I do not think that the brain could even be modeled as symbol processor. I think the book does not account
sufficiently for modeling at least roughly the brains working as one of the most important parts of the cognitive system.

Opposing standard cognitive science, the book introduces concepts summarized with the expression “Embodied Cognition”, as the title proposes. But what does embodied cognition really mean? I got the feeling, that pursuers of embodied cognition do not really provide a working principle for cognition yet. They only offer a bunch of concurring ideas of how cognition should be pursued in future, parts of the body/environment/... should be considered in cognition and how that should be implemented. But I did not get the impression that there is one curse of survey that could be called embodied cognition rather a whole bunch of different approaches.

So what did I learn about embodied cognition? When reading the book I tried to match the read with the concepts acquired by “On intelligence”. I really got the feeling that cognitive science does not really fix upon how our brain does work. It does not rely on neuroscience, but rather tries to make a model of how cognition is or could be implemented in computers. This model is then transferred to and tested on humans. I think this is a wrong approach if we want to make machines as successful in cognition and general purpose computing as humans and animals are. And for that we need a central computing device that works similar to a brain, i.e. intelligent. The computer is embedded into a body, i.e. its periphery that provides sensing and actuators. The kind of sensors and actuators are important as what the system can accomplish. Therefore we need a general computing device that can learn what the inputs by the body mean and how to act upon them. I want to emphasize that for me learning is a very important feature of cognition completely neglected by the book. The book goes on about single tasks like vision, language understanding, math problem solving, ... . It proposes how certain methods could be programmed to solve these issues. As far as I know there is not yet a single algorithm that fulfills these tasks sufficiently. Therefore something has to be wrong with the approaches or at least could be done better. I think it has to be kept more generally. An
algorithm, that could learn and accomplish every possible task without previous programming, what exactly it should do if certain events occur. Therefore I do not think that this approach provides a useful base to build truly autonomous cognitive systems. An approach that I think will rather lead to a result is the sensorimotor body combined with a general learning brain that interacts with the environment. By interaction with the environment it learns what the information acquired by the sensors mean, which resources it has and how to act.

Summarizing: what is the most important concept for me out of all that information? Out of the many differing concepts I would say it is the concept called “Constitution” in the book. It allows for a smooth transition from standard cognition to a modern approach to cognition, which on the one hand takes into account the real workings in the brain and on the other applicability in technology.

**Does Shapiro’s book stimulate thoughts inside of you about what it takes to build embodied cognitive technical systems?**

As I said above I think that besides the sensors and actuators it needs a general purpose data processing device or brain. Cognition is so complex, that not every possible situation can be preprogrammed. Therefore the organism has to learn how to behave in certain situations. It has to get experience. Then it will be most successful in the environment it “lives” in or works in. I think we have to view the expression “Embodied” as property how to view our brains. We need the body and the environment around our brains to accomplish the outstanding and most diverse tasks we do. We learn trying out things and such “optimizing” our behavior. We should first try to understand truly how animals and humans process information, i.e. understand intelligence, before we could copy that behavior. I think, that all other approaches, like e.g. viewing the brain as symbol processor or only considering dynamic systems, will not lead to a result anywhere as successful as ecological cognition.
The book Embodied Cognition is a perfect example of how to critically analyze a new theory, compare it with the existing one and predict its implications on understanding of the subject matter. Here the author, Lawrence Shapiro presents a case where embodied cognition takes on the more traditional standard cognition theory. The approach of looking at an upcoming theory in light of an existing theory is commendable. The author first introduces and elucidates various concepts of embodied cognition with sufficient examples. Often he plays the role of a devil’s advocate critiquing the new theory against the old one. This approach helps to bring to fore the strong holds as well as the loop holes of the proposed ideas.

The author categorizes the work going on in the field of embodied cognition into three broad categories.

1. Conceptualization – This idea argues that the properties of an organism’s body directly influences the way it conceptualizes the world.
2. Replacement – This idea removes the need for an internal representation of the world which forms the core of standard cognition.
3. Constitution – The body is constituent of the process of cognition rather than being a mere interface to the world outside.

Out of these ideas I feel that replacement theory is the most important idea of the book. According to standard cognition principles, the world is represented in the form of symbols and all cognitive activities involve manipulation of these symbols. Contrary to this view, the replacement theory argues that cognition occurs as a continuous interaction between a brain, a body and a world. The replacement theory advocates the embodiment and close interaction than symbol manipulation which is the core of standard cognitive science.

In order to prove this point the author explains two important ideas. Use of dynamical systems to explain cognition seems to be a logical approach as these systems have been used to study any system that varies with time. From an engineer’s point of view this is exciting because description of dynamical systems is tractable using mathematical equations describing the
system. Any dynamical system consists of a state space which is a set of all possible states that a system could take. Given an initial condition and the state space, a set of differential equations are used to predict the state of the system in the future.

The author explains the work of Randall Beer and his experiment using a simulated agent to explain the ideas of dynamical systems. Beer’s agent acting as the dynamical system is trained to engage in scanning of objects falling from above. If the object is a circle, it centers itself to it and if it is a diamond, the agent avoids the object. The main aim of this simulation is to show how the agent successfully acts without having any representation of the circles or diamonds that is approaching it. Though the simulation is quite successful for this agent performing a simple task, I feel that it would be close to impossible to mathematically explain the complex behavior of our brain. Nevertheless, this approach definitely provides a way ahead to design intelligent machines if not replicate the human brain.

Yet another interesting topic that supports replacement theory is the one which most engineers would understand and appreciate. It is the work of Rodney Brooks which explains cognition by actually building systems which can perform cognitive tasks. Brook’s robots are very fascinating as it uses a completely different architecture compared to the traditional ones. Instead of the usual sense-model-plan-act architecture, Brook’s robots use a behavior based model. In this model each layer acts on the input received directly instead of acting on the output of the previous layer. This makes each layer independent of other layers and eliminates the need for representation of the world outside in the form of symbols. Brook’s robots have proved to perform better in comparison with the robots with traditional architecture.

With the help of these ideas the author examines whether the idea of replacement could better explain cognition and thereby uphold the concept of embodied cognition over standard cognitive science. It turns out that the replacement theory wins over the standard cognitive science in some cases but cannot explain all the cognitive processes. I feel that with more research, replacement theory will become stronger and more robust.

Despite its inability to explain all the processes of human cognition, replacement theory has a lot in it for design of intelligent machines. Cognition in technical systems has been and will be an area of interest for engineers. From robotics to radio interfaces, there are a lot of applications for
cognitive systems. As I see it the ideas of replacement theory go a long way to help our machines perform better and faster.

Traditionally, all the technical systems we study are ideally based on a hierarchical layer based architecture. The example which I would like to bring here is the ISO open system interconnection (OSI) layered architecture. The main reason behind making layered architecture as I believe was to make implementation of systems modular and simple. This may not be the best way to design a technical and we might have to think of alternatives. For the case of OSI model cross layer optimization has been considered and it has proved to provide a better user experience. This clearly illustrates the need for rethinking our hierarchical architecture of technical systems.

The most fascinating idea that would help us build intelligent systems is the behavior based subsumption architecture. This architecture has proves beneficial in case of robots and might be good alternative for other technical systems as well. The key idea behind this approach is to allow each layer of our architecture to interact directly with the outside world. This would enable each layer to adapt itself to the environment. Consider the case of wireless networks with layered OSI architecture. As I told earlier cross layer optimization strategies are being used to adapt the transmission to the environment. Instead of making layers and then optimize them jointly, we could allow an architecture as proposed by the author in this book to enable each layer adjust itself according to changing environment. The concepts of Cognitive radio and software defined radio systems take a similar approach and are expected to be future of radio communication. Instead of having a fixed and layered architecture on hardware, software defined radio relies on flexible software which adapts itself to the environment in which it is operating.

Looking at these developments it is very clear that we could not design intelligent systems without considering our environment into account. This brings us back to the argument of a strong coupling between mind, body and world which is essentially embodied cognition. The book might not be conclusive in proving that cognitive process of our brains are embodied, but it definitely makes sense to design technical systems which interact with the world rather than operate in isolation.
Embodied Cognition
by Lawrence Shapiro

In the book *Embodied Cognition*, written by Lawrence Shapiro and published in 2011, it comes to embodied cognition. In the whole book Shapiro is trying to give an introduction what embodied cognition is all about and how it differs to the casual cognitive science. He was one of the first persons who ventured at this topic.

This is not like the book *On Intelligence*, written by Jeff Hawkins, therefore, that the author would like to declare his own opinion on this issue, but to give the reader an insight and overview of embodied cognition or in general cognitive perception.

The book is divided into seven chapters, which is again divided into introduction, body and conclusion. Except of the seventh chapter, because in this chapter Shapiro sums up the differences between embodied cognition and cognitive science. In the first chapter he comes to a decision tree which he would like to work off, so he comes to three basic themes of the embodied cognition includes. These three basic themes are defined by Shapiro as following:

**Conceptualization**, which means, that “the concepts an organism can acquire are determined, limited, or constrained by the properties of the organism's body.”

**Replacement**, which means, that “the dynamics of an organism’s bodily interaction with the environment replaces the need for representational processing. Thus, cognition can be explained without the appeal to computational processes or representational states.”

**Constitution**, which means, “constituents of cognition extend beyond the brain, so the body or world does not play a mere causal role in cognitive processes.”

These three basic themes pervade the entire 7 chapters based on different concepts, such as Varela’s, Thompson’s and Rosch’s (VTR) description of colour vision, Lakoff and Johnson's analysis of the role of metaphors in thought and the Indexical Hypothesis proposed by Glenberg as support for the Conceptualization Hypothesis.
For the Replacement part, he describes some different key ideas developed in dynamical systems theory and contemporary robotics. For example, he was talking about the classification of “representation-hungry” problems by Clark and Toribio.

In chapter 6, Shapiro describes the last theme “Constitution”, by focusing on the lively debates between, on the one side, scholars such as Clark, O'Reagan and Noe and Wilson, and, on the other side, Adams and Aizawa. The topic of the debate is the purported extension of cognition, that is, whether or not, as the Constitution Hypothesis states, the “body or world plays a constitutive rather than merely causal role in cognitive processing.”

In the last chapter, he sums everything up, and goes through the decision tree, he mentioned in the first chapter, which the book is more or less all about.

Once I have named a few concepts, I come to the really interesting question: Which of those mentioned concepts is the most appealing to me?

What I like the most, is the description of colour vision by Varela Thompson and Rosch (VTR).

The embodiment of color includes two basic statements. On the one hand, "color provides a microcosm of cognitive science", which means in so far that our understanding of color draws from the disciplines of psychology, linguistics, philosophy, neuroscience, and artificial intelligence.

On the other hand, "color provides a paradigm of a cognitive domain that is neither pregiven nor represented but rather experiential and enacted". This view brings us near to the idea, that colors are created in experience through a kind of activity, where this activity is the product of specialized equipment that in turn creates opportunities for a unique sort of coupling. This second conclusion brings us to the hypothesis of Conceptualization:

“Color Conceptualization: color experience is created through a unique sort of embodied coupling.”

However, we must not leave out of consideration that very living being has a different perception of color. So, " the vastly different histories of structural coupling for birds, fishes, insects, and primates have enacted or brought forth different perceived worlds of color ".

After I gave a conclusion of which one is the most appealing or interesting idea to me, I come to one of the most self appearing questions you ask yourself after reading this book. Due to this explanations and concepts, which are offered in this book, is it possible for me, to build such a system/machine? To ask in accurate words, do I feel like I can do this?
But if this book inspired me to make myself an intelligent machine and familiarize myself because of the concepts discussed in the book in such a subject?!

In this case, even less than in the previous book. Since the author actually not tried, in any way, to make the subject palatable (exaggerated told). As mentioned earlier it seemed, after or even during, I had read the book, the whole front as a summary of some of the concepts to explain embodied cognition.

Unfortunately, I must say that I found the book very difficult to read. Sometimes I didn't really get what he was trying to say, because he just listed some concepts and didn't tell what he wanted the reader to understand. Although he gave summaries at the end of a chapter, I didn't quite come through to what he was trying to say. Sometimes everything went too fast and I found you could follow him in his train of thought not always.

Added to this is also that he had discussed a lot of different concepts, a lively jumble for me was to tackle such a problem. Compared to the book by Jeff Hawkins and Sandra Blakeslee, was that the authors opinion got forced upon the reader or more pleasant one is forced to a certain track.

Furthermore, I had this feeling that you had to have some kind of pre-knowledge of this matter to understand it better. Although he gives a glossary at the end of the book, it is sometimes a little bit complicated to comprehend the correlations he is using in his book when he refers to older, already presented, concepts.

Basically the book gave some good views/insights into the concepts of embodied cognition or also general cognitive perception, especially because the book, as opposed to <On Intelligence> is still quite current. As initially written, it was published in 2011.

In summary, this book seemd to me more like a collection of individual already existing concepts about three basic themes for embodied cognition. What you could also see that after every chapter or conclusion of a sub point, the references have been given to read. So I must admit in all honesty that after I read this book, I neither feel inspired to get creative in order to establish one original concept for intelligent machines, even encouraged me to feel fit into this matter. So it doesn't stimulates me, in such a way that I am able to build such a complex system or to write an algorithm in order to tell a machine how it has to behave, as already mentioned in the book, there are different directions of how you can look at a problem (color vision, language comprehension, and so on...).
Essay

based on “Embodied Cognition” by Lawrence Shapiro

Embodied Cognition by Lawrence Shapiro, as the second book from our course, has showed me another side of cognition science. For cognition being a complicated topic in general, it has also a bunch of different approaches to it. On the contrary to the book of Jeff Hawkins, which describes more or less engineering approach to brain structure and cognition process, eventually aiming to build an intelligent system, Embodied Cognition reveals the philosophical side of the concept. The structure of the book was also surprisingly different: the author explained the keynote of book by causing a clash between others’ controversial concept and theories. This way of narration appeared to be profitable, at least for me personally, since I was able to get a deep insight into what is currently going on in the cognitive science and make the acquaintance with the most recent theories and concepts. Though, another surprising point for me, the timing for works the author is referring to varies a lot, from 1966 (Gibson) to the most recent 2007 (Aizawa); I am wondering whether it is correct to compare the concepts which had been developed with such the timing gap in-between.

Because of the mentioned above peculiarity of this book, the question whether it stimulates some thoughts about building intelligent machines becomes ambiguous. Exposing the non-engineering approach, this book doesn’t address the question of constructing a system, at least not directly. But it is not useless in that sense, though; I would say that it showed me the way how one shouldn’t build the machines. By contrasting different theories, the author discloses them from all the sides, revealing, among the other things, also their weaknesses.

After reading the book, I can assess the ways of building intelligent systems. For instance, now I think that the pure computational point of view, which was mostly referred to as “standard cognitive science”, is actually dead-end approach. This is not directly stated in the text, the author, due to the goals of his work,
avoids judging until the book’s conclusion, but this is how I interpret the content. By not paying attention to the surrounding, or “body” in any sense, while developing something intelligent, one would omit the essential part of the system. It is hardly possible to separate the perception and information gathering from the actual “computation” and decision making. This fact seemed to be natural to me, while considering the study of human body and human cognition, but I have never thought of applying it to the artificial intelligence as well.

On the other hand, some approaches appear to be very ubiquitous and for that reason also impractical. For instance, the constitution hypothesis may be suitable for considering the philosophical aspects of cognition and also good in the sense that it complements the standard cognitive science and does not oppose itself to it (according to the author’s concluding thoughts), but it seems to be not applicable in practise. By precisely following the constitution approach, one admits that the brain exploration by itself doesn’t have much sense (though all the embodied cognition assumes it, but the constitutionists go further), and we have to include not only body, but also the whole world in our model, and the cognition is not separable from the body. The modelling, to my mind, becomes too complicated and practically irrelevant, if we assume the hypothesis to hold true completely.

But the replacement hypothesis seems to be more applicable, at least the dynamical hypothesis, as being part of the replacement. It does not only tells us what to consider as a part of the cognitive system, but additionally provides us with the insight into the relationship inside such an extensive system, which is actually very good suitable for simulation and modelling. Of course, as the author states, the theory more or less contradicts with the standard cognitive science, basically devaluing the former approach.

The task to choose the most interesting thought of the book is also quite complicated for me. I would not say the book stimulated some really breakthrough thoughts, as it was with the previous Hawkins work. I think that the questions discussed in the book, where to draw a circle around the brain, how do the
constituents communicate and what should be considered as the cognitive system, generally depend upon the goal you aim to achieve. The thesis that the cognition does not exist without being complemented by the perception and the world around us appears to be thought provoking, but not so new; one could have thought about it, since even the biology does not consider the human as a pure biological being, but rather as biosocial.

Regarding the comparison of the three major hypotheses, the most interesting for me was the constitution, even though I have assessed it above as practically irrelevant; I even think, I can describe it as the most interesting thought of the book, mainly because, as I already mentioned above, this hypothesis goes a bit further than the others. The thought experiment about Otto and Inga appears to me being not obvious at all. It addresses the question how far one can go in expanding the term of cognition system: by expanding it widely one can get to the higher abstraction level and gain a better perspective on the topic from it; but then the question becomes pure philosophical, that could be too much even for the cognitive science, not to mention our goal to get the insight into how to actually build an intelligent machine. From the other side, drawing the circle too close to the brain itself could lead to the lack of some essential components. Otto’s notebook is a good example for it.

After all, the Shapiro’s book left a good impression to me. The way how the author manipulates with other theories in order to argue for and against the different concepts was very enjoying for me. I think that for the task to build intelligent machine it is necessary to explore all the sides of the topic. I expect some people to argue that this philosophical side is not of the great importance for engineers, but I would disagree with it. Although I would expect the breakthroughs in the cognitive science going from the lower abstraction levels, e.g. from the neural network simulations or from the biological side of neuroscience, I think one should keep in mind also the higher levels, e.g. the concepts stated in this book, at least in order to remain at the right way and in the right direction.