Towards Perceptional Control Theory – A coherent, intuitive and empirically testable model of action

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Foreword

I am writing this essay as a trial and study work to get acquainted with Perceptional Control Theory (PCT) created by William T. Powers (e.g. 1973/2005) and to create a personal synthesis and understanding about it. I will approach it from the point of view of my current semiotic theory of action (see my recent publications: https://wiki.oulu.fi/display/~epikkara/Julkaisut+_+Publications) and thus make probably some illegal misinterpretations. So if you want to get interested in PCT you can read this essay but if you want to study it seriously you should consult the Resources below.

Resources

Powers, William T. *Behavior: the Control of Perception*. First edition 1973 and second, corrected 2005 – This is the basic book!

Powers, William T. *Making Sense of Behavior: The Meaning of Control*. 1998. An introduction to the theory written in layman´s terms.

Some sites in Internet with large collections of introductory and informative materials: http://www.pctweb.org/ - http://www.pctresources.com/ - http://www.livingcontrolsystems.com/ - http://www.iapct.org/

For me the discussions in the CSGnet mail list have been irrecoverably important in digesting the basics of this new theory. I acknowledge that I also use ideas from many messages – answers to my questions - in that list without citations in this text. See https://lists.illinois.edu/lists/arc/csgnet/

Revolution?

PCT is literally and self-consciously an aspiration to drive a scientific revolution á la Kuhn in psychology and life sciences. Consequently it encounters a continuous resistance or rather a brushing aside in scientific discussion forums. It is only slowly growing fame mainly in here and there is the peripheries and boundaries of human and life sciences. According to PCT human and other living beings are not reacting to external stimuli and thus the environment does not determine, guide or causally affect the action of living beings. This assumption foils most of the experimental research in behavioral sciences. But on the other hand action is neither a carrying out beforehand made intentions and plans, like humanistic and cognitive psychology assumes. Instead action is plainly – and somewhat cryptically – the *control of perception*. What does that mean?

Action as semiotic feedback loop

One problem with PCT is that it is developed to discuss with American (behaviorist) psychological science and so one of its basic concepts if behavior which sounds alien and awkward to European non-psychologist's ear. I seems that often they use behavior where I would use action (Handlung) and action where I use doing. But this is a small problem.

I have defined *action* as a special case of two way interaction between two beings. (I will return to the general concept of interaction later.) In action the other one of the beings is called *subject* and the other one *object*. The subject is the one which acts causing some events in the object. The other side of the interaction is that the subject perceives the object or rather the way how the object if affecting (the sense organs of the) subject. When we observe or imagine action it is usually quite clear what being is subject but the object is not always as clear, may seem that the subject affects different object than that which it perceives. That's why it is often helpful to use the concept of *environment* as a collection or whole of the objects with which the subject is in interaction.

The main difference between the subject and the object / environment is that we assume that the subject has *competences*, the special internal features which cause or make it possible for the subject to act in ways it acts. Competences consists of the *descriptive* (or semantic) competences i.e. abilities to do something special like walk, grasp something, drive bicycle etc. Which is still more important they contain those which are called *modal* competences and which are always in any action connected to the descriptive competences. The main types of modal competences are presumably those described by the modal sub verbs *want*, *can*, *know* and *must*. It is just because of these presumed competences that we differentiate action from any other forms of events and interaction – and because of them we say that action is always action of some subject: the subject is the owner of the action.

The action of a subject is only partially observable. We can usually perceive the doings of the subject and their consequences in the environment. Also we can in principle perceive the same aspects of the environment which are also perceived by the acting subject whom we observe. But we cannot perceive the competences of the subject. They are not directly perceivable, we can only infer their existence from their consequences in the visible doings. Thus there is an invisible part of action and we suppose that it contains also something which is often called thinking or mental activity. I call this invisible side internal action and visible side external action. External action is that which is called behavior in psychology. (Behaviorism defined psychology as a study of exclusively behavior and thus as purely empiricist research. Cognitive and humanistic psychology instead is following scientific realism and allowing unperceivable i.e. non-empirical concepts of internal action to be studied, too.)

Until now I have used a figure like below (Figure 1.) to depict the model of action in my theory. It forms a feed-back loop which became a famous general way of thinking after the work of Uexküll and later cybernetics. The top arrow is the output effect and the bottom arrow is input. Typically it is thought here that some input is in such a relation to the competences of the subject that the subject settle on doing some deed and thus causes a change in environment. After that begins immediately a second round and the perception of the change in environment gives feed-back to the subject about how the doing succeeded. Thus every doing continues from earlier doings and every perception is about a change from the previous perception. The linkage from perception to doing is not mediated by a causal chain but instead by a meaning effect, which is dependent on the competences of the subject. Secondly this linkage is not necessarily always immediate but more or less delayed. We assume that at least during these pauses there may take place the internal action about which we have some introspective experience. In principle this internal action – thinking, deliberation etc. – is about manipulation of the meaning effects.

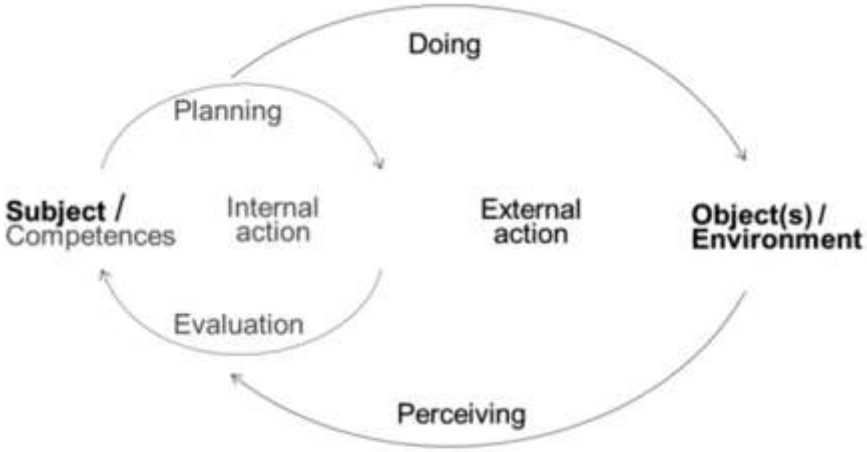

Figure 1. Model of action

That model has many logical and empirical defects. The first and worst one is the vicious circle in the definition and recognition of action. If the definition of action is based on competences which are unperceivable as such and only judged from perceivable action, then we have no theoretically sound way to empirically differentiate the action of some subject from all other events and interaction surrounding that subject. To this and some other obscurities the PCT offers ingenious solutions.

Action as control and feedback of control

PCT is based on control theory, a general theory of controlling systems which was created in the first half of twentieth century by engineering scientists as part of broader cybernetic and system theoretical movement. What is peculiar about control systems theory is that it is conceptually simple and clear, technologically effective and mathematically manageable. Many of our technological equipment are control systems, like thermostats and cruise controllers. To be a control system, to control, means that the system 1) perceives the level of some environmental variable – thermostat perceives warmth and cruise control speed – 2) has some goal or reference level for this variable and 3) has some means to draw variable to the reference level if it is not there and then keep it there. This is a continuous circular process, a control loop. And so it seems that this is a new way to express the model of action described above. In principle this opens possibilities to model action mathematically and also program computer models about it. There is already much evidence about accuracy and fruitfulness of these computer modellings in PCT literature.

From 1950 William T Powers started to create a general theory of human action based on control theory. The basic book Behavior: The Control of Perception was published 1973. I introduce the general model of simple control system unit by simplifying (and also a little complicating) the diagram 5.2 in that book (see Figure 2). In that diagram there are two areas or poles like previously: the system (“subject”) and its environment. The system consists of three boxes and three links. The input function is for example a receptor nerve which is perceiving some aspect of the environment, say light. It transforms this effect of light to a perceptual signal p which is a nerve current with a strength which correspond to light intensity. The comparator compares p with a strength of the reference signal r which represents an internal inherited or learned standard level. If there is a difference between p and r – between actual and wanted – then the comparator sends the error signal e to the output function. The strength of the e correspond the amount of difference – error – between p and r. If the light intensity perception happens to be stronger than the wanted reference level – a positive error, too much light – then the error signal can be said to be negative:

r-p=e. This means that the output function of control system tries to cause such effects in environment which would lessen the amount of light coming to receptor and thus weaken the perception signal to the wanted level. This kind of model is of course a coarse simplification of the real biological control unit, but nevertheless it often helps to explain and predict events with almost perfect accuracy.

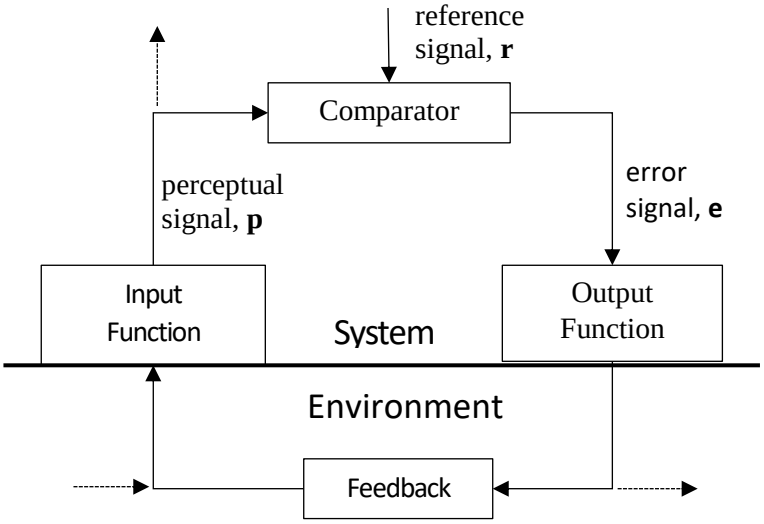

Figure 2: Control system unit

It is important to stress that the control system is strictly speaking not controlling its environment or any object in its environment, but only its own perceptual state. It does the control because its perceptual state is immediately important to its own wellbeing. It only happens to be that it is the environment which affects its perception, and by affecting the environment – giving feedback to it – it can return or at least try to return its perceptual state to wanted condition and keep it there. This means that the system does not wait and see what will happens in environment and then decide what to do, but as soon as perception starts to depart from wanted level it starts to resist and compensate this difference – just like thermostat or cruising control.

Ontology of composition

As a part and basis of my action theoretical semiotics I have utilized a certain kind of ontological theory. This theory is a simplified application of the ontological views developed by C B Martin and more recently John Heil. I call it a simplified Martin-Heil ontology. The duty of this kind of theory is to offer an understandable, coherent and reasonably plausible view of what kind is the reality basically. It should be first of all consistent with current scientific physical facts and possibly explain them conceptually and predict future facts. Martin-Heil ontology represent quite traditional substance-property ontology, according to which if there exist some properties then there must be also some substance or object whose properties they are. The properties are not independent beings but they are just ways of being or modes of that substance whose properties they are. (More theses later.)

One of the most important feature of this ontological theory is what I call compositionality. It means that all object which we can observe and consider are composites built of smaller objects, and the smaller object again of still smaller, etc. Also the properties of any considered object are composed of and based on the properties of the smaller objects. These composites are not only a quantitative sum or heap of smaller objects but its structure is a definitive determinate of its way of being – it is a composition, not collection. This idea could be also described by the concept of fractal: The properties of the whole and the parts are

different but there must be something similar because the previous are based on the latter. This principle applies also to PCT and this was one reason why I found it interesting.

The previously described control system unit was clearly not any independent actor or organism but a tiny part of some larger system. Any living being is more complex and especially a human being consists of probably at least millions of this kind of small units. These units have a certain kind of structure which will perhaps never be known by detail but there are good reasons at the moment to see it as some kind of hierarchy so that there are both vertical and horizontal relations between them. The whole human being is a control system which consists of control systems and which uses its uncountable small control systems to control some bigger lines and affairs. This idea can be continued and social organizations can be similarly seen as control systems consisting of either smaller organizations or human beings.

The internal structure of the human being – seen from the view point of action – such that there are both parallel systems and nested systems. As we saw in the Figure 2 there was drawn a reference signal as an arrow coming to the comparator from above. Where does it come from? It is an output of another control unit which is hierarchically above it. The lower system is a part of the environment of the higher and that higher uses the lower to control its own perception by defining the reference level of the lower. The dotted line in the upper left side of the diagram (it is not in the original) depicts that the higher system is also controlling a perception which is based on the same input function as the perception of the lower system. I would describe this situation so that the higher system is controlling its own perception by such means that it "orders" the lower system to control it to the level which is suitable to the higher system. The higher system uses power over the lower – if not even repression – but there is no reason to see here any injustice because literally the will of the higher is the will of the lower. But why there is this kind of layered system? Wouldn't a straight one be more effective and faster?

We must broaden our metaphors from repression to bureaucracy to see the answer to the previous question. The control system that we used as an example in previous chapter is connected only to a very tiny aspect of the environment of the whole organism: light intensity from some direction. In a human being there are uncountable similar little systems which all control their own perception of very narrow angle to the environment. There are colors of light, warmth, pressures in skin, ears etc., different types of chemicals in mouth, nose etc. etc. From these very narrow perceptions we must build – compose – our whole perceptual picture of our reality – and the essential parts of that total perception must be also controlled. This requires a kind of bureaucratic procedure where certain interconnected small perceptions are collected to larger ones. Thus one higher system receives perceptions from more than one lower systems and respectively it produces reference signals back to these.

Epistemology of control

The representatives of PCT regard ontological considerations with very great suspicion. This is based on the epistemological consequences of the theory. According to it we "know" only our own perceptions and we cannot know anything about what in our environment causes them. In this regard PCT reminds very much the Kantian epistemology. We can assume there is some *Ding an sich* but we cannot conclude anything about it based on our perceptual knowledge. But this same restriction is as valid also in relation to ourselves and other controlling systems. We cannot "know" whether living and human beings really are like they are described in the theory. Luckily the perceptions are not only basis for our knowledge but much more important is the experience from controlling: what we can control and how. Scientific theories should not be regarded as naively realistic descriptions of the reality but rather hypothetical models about one probable possibility how reality could be structured. These models are built on the basis of both perceptions and controlling trials i.e. experiments how environment can be affected. Of course ontological theories belong also to these rival models.

PCT is Kantian not only in relation to this criticism on naïve realism. They both have a somewhat similarly structured constructivist view about how knowledge is created in human beings. This construction of knowledge happens in a layered or phased machinery starting from sense perception and ending to rational concepts. Kant assumed that sensation creates the form of place and time to knowledge. Then the categories of reason add ideas of objects, relations, causality etc. PCT offers a little bit different view of this process in a theory which is sometimes called HPCT or Hierarchical Perceptual Control Theory. This theory is a simplified inferred description of the "bureaucratic" structure of control systems to which I referred above. The lowest level of this hierarchy consists of those control systems like our example above whose input functions (receptors) sense the effects coming from the outside of the organism and whose output functions (muscles) respectively affect the outside environment. Here is the most striking problem to understand and accept that our qualitatively rich inner view and the presumably qualitative rich external world are mediated by myriads of nerve currents which are all qualitatively similar, only their quantitative features vary. (Though it is important to note that this is not a picture of digital computer with only one and zero alternatives, but nerve currents vary analogically to strength of the effects.)

At the moment in PCT there are eight (or ten) other levels above the lowest one. The lowest level is about intensity perceptions. Independently of the receptor type the perceptions are qualitatively similar as such. These are really tinier than we usually think about our senses: for example one warmth receptor and one hair elevator muscle. The qualitatively different sensation perceptions – the quale like philosophers of mind say – take birth on the second level where many intensity signals get united in one sensation control system to a kind of a vector sum of single intensities. These are typically like colors, warmth, weight, forms etc. The third level is called configuration control. Here perceptions correspond the idea of objects as collections of properties. In the next level there are transitions of the configurations: for example movements and changes of the objects. The next level consists of sequences of transitions. These five levels are quite nearly connected to empirical world and based on lowest level perceptions. The higher levels then represent more the creativity human mind and contain internal modelling – I would say natural theorizing. This threshold corresponds to the Kantian separation of the forms of sensation and categories of reason.

The sixth level is perceptions of relationships – between sensations, configurations, transitions or sequences. Seventh level is the locus of problem solving as it is usually understood. It is the level of programs. Program is collection of cases from all other levels AND conditional decision points or branches, just like computer programs. But there are still higher – and for us more important levels. The next level is the level of principles and it controls what programs are used in different situation. For example a principle "get rich" may select different programs than "act honestly". The highest level perceives and controls what is called system concepts. These are large wholes containing or determining some collection of principles, programs etc. Examples of these are clubs, associations, societies, cultures, religions, countries and the "I" or self.

In PCT there is no Kantian demarcation between perception ("intuition") and reason, but all these levels are levels of perception (c.f. Herbart!). So our ideas of honesty, democracy, marriage are all perceptions and very often they are normative perceptions which we try control to some level. Controlling any higher level perception consists of setting reference values for many lower level control systems and so on until to the lowest level where the output functions finally affect our environment. What is remarkable, this whole system is more flexible than the ideal bureaucracy where every unit has only one boss. Instead any lower level control system can be in the service of more than one higher level system. This flexibility causes the possibility of a predictable problem: If two higher level systems happen to send opposite reference signals to one lower level system this lower level system go into the state of conflict and it cannot function anymore. This opens up one important practical application area of PCT, but we cannot discuss it here.

Respectively to the ensemble of control systems in a human being also our perceptions or our whole mental contents form a compositional structure which is flexibly hierarchical. This suits well to the structuralist semiotics according to which all meaningful expressions are composed of small elementary units. Also this view fits well to the aspiration of edusemiotics to get rid of the mind vs. body dichotomy. In this model the mind is – in a way at least – identical to the nervous system, and actually the whole body if the input and output functions are regarded.

Learning as memorizing, problem solving and reorganization, and about conflicts

Powers differentiated three forms of learning starting from the most modest one to the most radical one. The first for is based on memory. It means collecting details from the occurring perceptions to later use. This can happen during the action, memories about controlling something with success or not. Or it can happen quite passively when the perceiving systems are in so called observation mode. The gathering of memory does not alter the overall structure of controlling systems and our mental contents. The second form, the problem solving can mean either using existing programs in a new way in old situations or using then in new situations. This form does neither alter the structures of controlling systems. The third form called reorganization is the most important and interesting because it causes and explains all the remarkable changes that happen in ways of action, control and perception of organisms during their lifetime and also during the evolution of species.

How, why and when does reorganization take place? All the examples of controlling systems above have been about external or environmental control but there exists also another type of system which in a way is much more important. That other system could be called internal or physiological and it perceives and controls the physiological perceptions internal to organism which are immediately vital for the life of the organism. These contain perceptions of energy levels of all organs, sugar, oxygen etc. levels of blood, different chemical balances and so on. These basic level systems are necessary also to most simple and primordial living beings even without any nerves or proper environmental action. Evolutionally it can be thought that nerves and organs for environmental action have developed to help these basic level systems to succeed in their controlling. And so it seems that these basic level systems have a power to constrain reorganization in environmental systems if they cannot help controlling those necessary internal perceptions.

Powers used an older expression (from Ashby): blind variation and selective retention, to describe the mechanism of reorganization. If the internal system cannot cancel its error signal it starts to reorganize i.e. cause blind variation in some parts of the environmental system. This continues as long as the error remains and it slows down if the error starts decrease, and it stops when error is small enough. Thus this is kind of trial and error learning and corresponds what I have called pragmatic learning. There are problems that the direction of this learning is undetermined, the variation is blind just like evolution, and the forms which happen to lessen error are retained independently of their reasonability evaluated with any other criteria. Also it is at least theoretically unclear how the internal reorganizing system can know in which parts of the system the reorganization is needed. It could blindly change the well-functioning parts and retain defective.

There is one strong solution suggestion in PCT to the previous problem in the case of human learning: consciousness. It seems namely that the special human self-consciousness is developed to guide the reorganization. This is also quite clear from every day experience that we can best learn any knowledge and skills if we consciously think about them. I would add another explanation which I have long stressed in my theory. It is the principle that we learn only in action. This would mean simply that only those system units which are in a heavy use are prone to reorganization – during the action or perhaps soon after it. In

addition to the internal control error as the cause of reorganization there is also a presupposition that long continued error in environmental systems will start reorganization. How long that that must be is still to be studied in the future, but I would assume that there is some time to try to solve the problem using memory and programs before reorganization would start. And perhaps it will not start without the help of consciousness. Any way reorganization is a risky business because of its blindness.

If we want to cause reorganization in teaching we have a little and suspicious means to that. We should of cause not cause physiological problems to others. (For ourselves the fast and other asceticism can be a suitable tool for learning.) But we normally do cause continued error situations. An easy way to do that is to cause a conflict. AS I mentioned earlier the conflict is a situation where some control system receives two contradictory reference signals and consequently it cannot follow neither but instead gets practically paralyzed. A cognitive dissonance is a typical example of that. In the area of modal and moral learning I have touched upon the conflict between modalities of want and must. If you want to do X and you know you must do some not-X then you probably cannot do neither which causes a double error. If the situation continues there will probably happen some reorganization sooner or later somewhere. (There is a PCT based therapy school called Method of Levels which has developed a consciousness directing methods to solve these kind of persisting internal conflict which seem to be behind most mental problems.)

Towards empirical research

The methods for researching straight the neural structure and functioning of human control systems especially the higher levels must be waited for until unknown future. But there are already two ways to research human action from the perspective of PCT. The other one is the mathematical and computer modelling which gives a lot of very accurate information at least about simple motor action but also for example action of human groups in sociology. The other and at least as interesting is the method called Test of Controlled Variable (or shortly Test). I mentioned in the beginning that we cannot know from outside what the studied subject is really doing and what is just happening by a chance or from some external causes. The action is dependent of the goals (references) of the subject and only the subject herself can know them and very often even she doesn't know them herself. Only the controlling subsystems "know" their references – but they won't tell. But action is controlling and controlling is to bring some perception to its reference level and to keep it there. If some external effect (called disturbance) tends to move the perception from that wanted level then the controlling system starts immediately to produce some output which should resist and cancel that disturbance. In the Test we deliberately cause disturbances to the environmental variables which we think that could be controlled by the studied subject. Now if the subject starts to resist our disturbances then we can conclude that it is the variable she is controlling. Of course this is roughly simplified description of the method – but observe that this is how we often do in every day interaction, too.