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Whose Anticipations?

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Abstract. The central question in this paper is: Who (or what) constructs anticipations? I challenge the (tacit) assumption of Rosen's standard definition of anticipatory systems according to which the cognitive system actively constructs a predictive model based on which it carries out anticipations. My arguments show that so-called implicit anticipatory systems are at the root of any other form of anticipatory systems as the nature of the "decision maker" in the latter cannot be a conscious one.

Introduction

The notion of anticipation is often linked with that of construction. Robert Rosen's (1985) standard definition of anticipatory systems, for example, characterizes an anticipatory system as one "containing a predictive model of itself and/or of its environment, which allows it to change state at an instant in accord with the model's predictions pertaining to a latter instant". Clearly, this ability requires the construction of the predictive model in the first place. In this paper, I want to go a step further and claim that constructing is all what a cognitive system is doing, making anticipation an integrative part of this continuing cognitive construction.[1] Whereas the standard definition tacitly assumes that the cognitive system is (consciously) constructing the predictive model, I want to challenge this presumption and try to reveal the agent and the processes behind the construction activity. The central question I seek to address is thus: Are we consciously creating anticipations on basis of which we plan and make decisions, or are anticipations and decision making made for us?

In the course of the paper I will first show that anticipation is the driving force in a wide range of cognitive behavior. From magic practices in so-called "primitive" cultures, to superstitious behavior in animal and human beings, to so-called "volitional" cognition. Based on the categorization of Martin Butz (2002) I will argue that what he

[1] Philosophers may argue that construction is an activity carried out by a conscious subject only and which can never be associated with passivity (Olivier Sigaud, personal communication). In this paper I consider construction a process by which a structure—physical or mental—is errected. Later on we will see that the (philosophical) distinction between conscious and unconscious as an a priori condition for cognitive construction may not hold.

called implicit anticipatory systems forms the foundation for all other form of anticipations, whether strong or weak in the sense of Daniel Dubois (2000).

Anticipation and the unknown

Fishing and navigating in offshore waters is a game with the unknown. Weather conditions, sharks, and streams make it difficult if not impossible to anticipate the outcome of your trip, especially if your equipment is simple and your boat is small. For members of primitive cultures it has always been a challenge. Social anthropologist Bronislaw Malinowski set out in the early 20th century to live among islanders in the Pacific Ocean who fished both inshore and offshore. Staying there for several years, Malinowski noticed a sharp contrast in behavior. Offshore fishing beyond the coral reef was accompanied by many elaborate rituals and ceremonies to invoke magical powers for safety and protection. To his surprise, nothing like that he could observe among the inshore fishermen, who carried out their job with a high degree of rational expertise and craftsmanship. Based on his observations he drew the conclusion that "we do not find magic wherever the pursuit is certain, reliable and well under the control of rational methods and technological processes. Further, we find magic where the element of danger is conspicuous", and primitive man "clings to [magic], whenever he has to recognize the impotence of his knowledge and of his rational technique."(Malinowski 1948)

Malinowski considered magic as response to uncertainty. His claim was that magical rituals are carried out in unknown situations where the degree of freedom seems to transcend the degree of control.[2] They reduce the threat caused by the dangers and uncertainties of life. Phenomena for which the individual doesn't have an explanation can be made less threatening by anticipating that a known action pattern will eventually make the phenomena disappear. There is also an emotional aspect to it. Instead of getting overwhelmed by the details of a new situation, humans seek to replace them with familiar activity and behavioral patterns that show a high degree of predictability to putatively gain control again, to be able to anticipate the outcome. Thus, in order to fight the feeling of threat that emanates from the inexplicable humans try to find causes by which it can be made explicable. Often such causes are derived from a single (positive) experience that accidentally linked the cause with a result similar to the threatening phenomenon.

Such behavior is not only typical for humans. Also in the animal kingdom we find patterns that reflect insecurity. B. F. Skinner's article on "superstition in the pigeon" (1948) is a classical description of how birds react in situations which to understand transcends their cognitive capabilities and thus become uncontrollable for them. Skinner presented food at regular intervals to hungry pigeons with no reference whatsoever

[2] In (first-order) cybernetics, Ross Ashby's Law of Requisite Variety expresses straightforwardly what it takes for a system to remain in control over another: "Only variety can destroy variety" (Ashby 1956), i.e, the variety of actions available to a control system must be at least as large as the variety of actions in the system to be controlled.

to their current behavior. Soon the birds started to display certain rituals between the reinforcements, such as turning two or three times about the cage, bobbing their head, and incomplete pecking movements. As Skinner remarked, the birds happened to be executing some response as the food appeared the first time, and they tended to repeat this response if the feeding interval was only short enough. In some sense, pigeons associated their action with receiving food and started to inductively believe that it causes the food to appear.

At first glance, Skinner's conclusion to liken the pigeons' behavior to superstitions in humans seems far-fetched. In the case of pigeons the superstitious behavior is the result of some unconscious cognitive processes. In the case of humans, rituals are developed due to reflections about the current, possibly threatening situation and a desired goal. Professional athletes who carry out some superstitious activities—eating a certain meal, wearing certain clothes, running in certain patterns over the playground to alter the probabilities—seem to be aware of the fact that they consciously assemble their ritual patterns. However, as I will argue later on, this distinction blurs easily away in the light of some neurophysiological insights which were intended to disprove the independency of a free will but which say probably more about who or what constructs rituals and their inherent anticipations.

Before we can turn to this question, we need to look more closely at some basic cognitive mechanisms as employed, for example, by Malinowski's fishermen. Every day they are exposed to experiences, many of them are familiar, some of them new. What does it mean for an experience to be familiar or unfamiliar? In his works (e.g., the 1954 book "The construction of reality in the child"), Jean Piaget proposed two basic principles when it comes to cope with perception and experience. He argued that in the beginning, a newborn knows little about how to cope with the perceptive impressions around her. Faces might be funny or threatening colorful spots and voices unknown sounds. In fact, she doesn't even know that these are colors and sounds. Only by assimilation and accommodation the child constructs a collection of—as Piaget called it—schemata during her ontogeny. Schemata serve as point of reference when it comes to classify (assimilate) new impressions. If impressions are too alien to be aligned to an older, already assimilated impression, they are either not perceived at all or accommodated, i.e., existing schemata are adjusted in order to include the new "exotic" impression. With each of these assimilating or accommodating steps the child constructs another piece of her reality. This means, only what can be formulated within schemata, can be perceived or expressed in actions.[3] Ulric Neisser's (1975) characterization of perception as a schemata controlled "information pickup" describes this perspective best. An organism's schemata determine the way it is looking at the environment, and are therefore anticipatory. The schemata construct anticipations of what to expect, and thus enable the organism to actually perceive the expected information. If a situation gets out of control—because it is unknown, threatening, and

[3] Ernst von Glasersfeld has framed this fundamental principle of piecemeal erection of reality as follows. "Knowledge is not passively received but actively built up by the cognizing subject", and the "function of cognition is adaptive and serves the organization of the experiential world, not the discovery of ontological reality" (Glasersfeld 1989).

uncertain—assimilation and accommodation have reached their limits and humans are more likely to turn to magical or occult powers.

As experiences are made subsequently, they are connected with each other in a historical manner and form a network of hierarchical interdependencies (Riegler 2001a, b). The components of such a network are mutually dependent; removing one component may change the context of another component. In this sense they impose constraints on each other.

Whose constructions?

The picture sketched so far is the following. The individual constructs reality out of the experiences he or she makes. Whether these experiences and constructed reality mirror any outside reality cannot be easily decided, nor can be determined whether the outside reality exists as such. The cognitive apparatus that is doing the constructive work has only unspecific nervous signals at its disposal, i.e., signals which decode the intensity of a stimulus[4] but not its nature or origin. From the perspective of the apparatus, it is therefore of no significance where the signals come from and what entity caused them. However, no rationale speaks against the *construction* that assumes the existence of a reality for practical reasons.[5]

Furthermore, as sketched above, constructions are entrenched in a hierarchical network whose components are mutually dependent. The resulting canalization of future linking possibilities renders arbitrary constructions impossible. That's why we cannot walk through closed doors. It is this ramification of construction details that inherently imposes anticipation, as I have argued in Riegler (2001a, b). Since we construct our own world we limit the degrees of freedom of our constructions at the same time. This apparent paradox could also be read another way, namely that constructs and their unavoidable limitations are *imposed* on us, and all we do is to choose among a few possibilities. Sverre Sjölander (1995) suggests a similar picture. He assumes the existence of an inner "probierbühne" (trial stage) upon which anticipations are formulated, i.e., imaginations about the future in qualitatively (but not necessarily quantitatively) arbitrary ways. (Alternatively, we could think of it as some virtual reality scenario that, detached from "reality", makes it possible to build future scenarios). But who formulates them? Do we have reasons to believe that it is not the I? Who is it then?

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[4] The term is used synonymously with 'perturbation', i.e., the disturbance caused by an entity on another entity.

[5] Actually, as the philosophy of *radical constructivism* claims, this question cannot be decided at all without recurring to the same perceptive processes which are used in making the experiences in the first place (Glasersfeld 1995; Riegler 2001b). To verify the assumption of the existence (or non-existence) of an outside reality, we need an independent vehicle. Means used so far are, for example, religious (*believing* in reality) or social (*authoritatively claiming* its existence). None of both complies with the scientific method.

The answer to this question might be found by taking a closer look at neurophysiological phenomena, especially at neural correlates of consciousness.

Bridging the gap between subjective experience and objective quantities has been a focus of research ever since. Of specific interest are questions such as: Are acts of free will initialized by conscious decisions? Can physiological insights be reconciled with the view that a free will is responsible for our doings?

These were also the questions Benjamin Libet put to himself (Libet 1985; Nørretranders 1998). In the 1960s he had the opportunity to conduct experiments with patients of the neurosurgeon Bertram Feinstein. Their skull cover had been removed and they remained fully conscious during the surgery. Libet's experiments drew on the well-known insight that by stimulating the motor cortex with electrical impulses one can trigger sensations and even motor movements. It is crucial which area is stimulated. Certain associative motor areas of the cortex trigger movement together with the subjective sensation that the movement was of one's own volition. On the other hand, if subcortical areas are stimulated the triggered movement appears to be unintentional. Those subcortical areas seem to be beyond the control of the consciousness.

Libet found out that the stimuli have to last at least half a second in order to be registered by the patient. Below that threshold they remain subliminal, i.e., unnoticed by the consciousness. Interestingly, stimulating the skin is already perceived after 20ms. What causes the big difference of awareness between stimulating the cortex and the skin? Libet designed an experimental setup that allowed him to directly compare both sensations. The cortex of a patient was stimulated in a way such that she would feel a light tingle in one hand while the skin of the other hand was directly stimulated to evoke the same sensation. The surprising result of this experiment was that one has to wait half a second between stimulating the cortex and the hand in order to make the two events subjectively happen at the same time. Stimulating the hand earlier caused the sensation in this hand before the other although the skin stimulus happened after the one of the associated cortex area of the other hand. Assuming that it takes about half a second for a stimulus to become aware, Libet concluded that conscious experiences of events are projected backwards in time. This explains why the stimulus is registered immediately. Processing both the artificial stimulation of the cortex and the natural one of the skin takes about the same time. However, the cortex stimulus is not projected back in time as it is no natural sensation but rather a direct intervention in the electrical circuits of the brain which are not subject to the usual "censorship" of nervous pathways through other brain areas.

After Feinstein's death, Libet continued his research in a different way that borrowed from the pioneering work of Hans Kornhuber and Lüder Deeke. In the mid-1960s they had found out that volitional actions are accompanied by a negative electrical potential that arises shortly before in the cortex. This "readiness potential" starts about half up to 1.5 seconds before the actual cortical motor signal and can be made visible in the electroencephalogram (EEG). The readiness potential appears also when the movement is only intended rather than executed, i.e., the motor cortex is not activated. Therefore, the readiness potential reflects the decision to carry out a movement rather than the actual control of the movement by the cortex. If the preparations for a

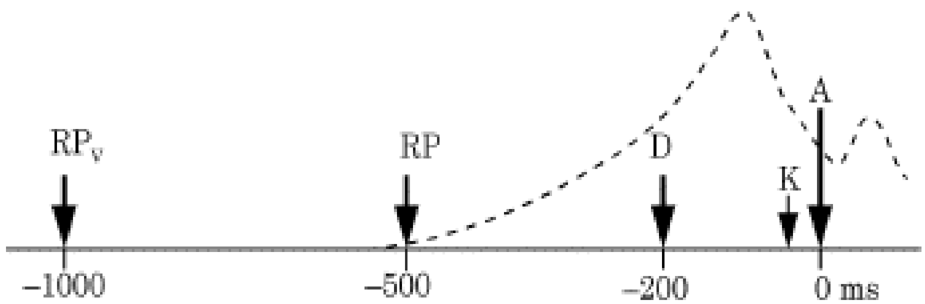

Fig. 1: Sequence of readiness potential (RP), volitional decision (D), and onset of action (A), as well as the control stimulus on the skin (K). If the action is planned ahead, the readiness potential starts already at time RP_v. After Libet (1985).

movement take such a relatively long time, when is the decision taken to start it in the first place? And who decides?

Libet chose the following setup in order to correlate three essential points in time with each other. The start RP of the readiness potential, the moment D at which the subject decides to carry out a conscious action, and the time A that marks the begin of the action, registered by an electromyogramm (EMG). In order to maximize the probability that the action is indeed a spontaneous volitional act it has to be as simple as possible. Therefore, Libet asked the subjects to spontaneously bend a finger or bend an arm. This moment A can be measured by the electrical activity of the hand. The parameter RP can be read on an EEG. In order to determine time D, however, it was necessary to fall back on (a modern version of) Wilhelm Wundt's oscilloscope clock ("Komplikationsuhr") which had become a standard instrument in experimental psychology. This clock consists of a screen on which a dot is rotating around its center in 2.56 seconds. All that the subjects had to do was to memorize the relative position of the dot when they spontaneously decided to move a finger.[6]

After statistically averaging the data, Libet obtained the following correlation among the parameters. $A - D = 200$ ms, but $A - RP = 550$ ms. This means that the decision to act starts, as expected, before the action but after the occurrence of the readiness potential (cf. Figure 1). In other words, the consciousness notices only after 350 ms that the unconsciously working part of the brain has started to prepare the

6 In order to show that this method allows for precise results, Libet carried out control stimulations with the skin that yielded correct measurements.

“volitional” act.[7] Wolfgang Prinz (1996) has framed this remarkable result as follows: “We don’t do what we want, but we want what we do”.[8]

Martian tennis player

Despite the surprising nature of his results, Libet thought to rescue free will due to the following observation. If subjects interrupt an already decided action, the EEG shows nevertheless a readiness potential. This means that the consciousness—albeit informed belatedly—can still veto an action that has already started. It seems that there is an independently working brain machinery that eludes conscious control and which constantly initializes new actions. The role of the consciousness is then to choose from these actions before they get executed.

At first glance this scenario reminds us of Sigmund Freud’s concept of the subconscious according to which the human mind is no longer the “master in its own house”. Following his horse–rider analogy, it is the horse (the “id”) which determines where to move with the rider (the “I”). Similarly, in Libet’s interpretation consciousness and free will seem to be at the mercy of the horse “unconsciousness”.

But what is more important than finding similarities in psychoanalysis is the fact that Libet’s scenario implements Sjölander’s inner trial stage. The independent unconscious brain machinery constructs a hierarchy of schemata out of components of experience. The consciousness merely selects the way these components are put together and carried out.[9]

There is a wide variety of experimental results and insights that support this picture. Quite evidently, unconscious processes play a major role in sports where it is of crucial importance to be able to anticipate the opponent’s next action. Studies show that the difference between expert and amateur players is based on how they perceive movement. Skilled players read their opponent’s game: they look at the right cues and make the proper anticipations from these cues. Looking and making anticipations, however, are no conscious processes. As shown by a many researchers (e.g., Kourtzi & Shiffrar 1999), the perception of motion of a human body is constrained by its anatomical and biochemical properties. So the perception of an opponent’s actions is influenced by the unconscious knowledge of the constraints caused by these properties. As Karl Verfaillie and Anja Daems (2002) have argued, this implicit knowledge can be

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7 In order to eliminate the possibility that the projection back in time is the reason for the readiness potential RP to occur before the volitional decision D, Libet made a control stimulation K on the skin, which subjectively takes place 50 ms before the stimulus. Later on, the results of Libet’s have been confirmed both directly and indirectly by others such as Keller & Heckhausen (1990) and Haggard & Eimer (1999).

8 “Wir tun nicht, was wir wollen, sondern wir wollen, was wir tun.”

9 One might feel tempted to ask for the underlying basis on which the consciousness makes its decision. Unfortunately, such questions lead directly to the qualia problem when trying to reduce the selection criteria to a mere algorithm. Fortunately, we don’t need to investigate this dilemma as we are interested in the construction process rather than in judging these constructions.

used to anticipate sequences of action. When playing tennis or squash, expert players anticipate the trajectory of the ball from the opponent's body posture and its dynamic aspect before the opponent even hits the ball. Such implicit knowledge is the result of a long and continuous training, or "habit learning", as Ann Graybiel (1998) calls it. This becomes possible by chunking standard perception and action sequences, which can be recalled and replayed without an interfering consciousness.[10] The brain has created a template that can produce the learned behavior as if it was still under conscious control. As a result, a human professional would appear quite inept when playing against a Martian player with a different and therefore unpredictable physiology.

There are two indications that anticipation—whether in sports or other activity—is unconscious. Firstly, the time for conscious responses is, as Libet (see above) has shown, with 500ms much too long in order to react swiftly enough. Secondly, the activity pattern in the brain is much more spread out in unskilled beginners than in experts, indicating that handling the task still needs full attention rather than running smoothly and stereotyped through a small unconsciously working part of the brain. However, if test subjects are asked to pay close attention while carrying out the learned task the symphony of brain activity in the frontal parts of the brain starts again. At the same time, the behavior of the subjects becomes less smooth as if the presence of the consciousness interrupted the execution of the task in an unconstructive manner. (Taking up many areas of the brain while learning the reply to a new challenging situation is also the reason why we can consciously focus only on one single task while in the background a great number of unconscious activities can be carried out in parallel.)

The part of the brain that seems to be responsible for stereotyped habit learning are the basal ganglia (Graybiel 1998). Interestingly, due to their central position they form a bottleneck, which affects all sorts of cognitive activity. Knowlton, Mangels, and Squire (1996) describe the "weather prediction" experiment where subjects are asked to figure out the link between a configuration of cards with geometrical figures and a weather situation. As the authors point out, the mapping between the cues and the outcomes is too complex for the hippocampus, which is usually responsible for learning such propositional representations. Therefore the success of the subjects in this experiment must be attributed to unconscious mechanisms.

We find chunking anticipations on even higher levels of cognition, such as the abstract problem of recalling positions in the game of chess. Already in 1927, Djakow, Rudik, and Petrovsky demonstrated that masters are able to recall the position more accurately than non-players. In his 1946 book, Adriaan de Groot (1978) presented a study according to which a grandmaster can remember up to 93% of the positions of the pieces, while a beginner gets typically only about 50% right. Since the board was presented to the subjects for only a few seconds the propositionally working hippocampus couldn't be made responsible for this surprising performance either. It has been argued that while the novice sees only a random assemble of pieces, the master recognizes well-ordered sets of possibilities. In other words, like the tennis player, the chess master draws on the unconscious ability to learn nonrepresentational constraints

[10] For a cognitive architecture that features anticipatory chunking, see Riegler (1994).

and canalizations that are the result of the rules of chess. As Herbert Simon and William Chase (1973) proved, strong players do not recall random positions better than beginners, i.e., configurations that are not the result of the applying the rules of chess.

These results strongly suggest that unconscious anticipations based on the ability to exploit constraints are used in a wide range of cognitive activities, from the sensorimotor level to highly abstract tasks. This seems in agreement with Libet's results. A free consciousness that chooses from what the unconscious suggests.

The helpless spectator

According to Gerhard Roth (Haynes et al. 1998; Roth 2001), the situation could be more threatening for the free will than Libet claims. The part of the prefrontal cortex, which is considered the highest authority for planning actions, is under influence of those subcortical areas that elude conscious control. Only through basal ganglia it can access the cerebral cortex which is responsible for motor control. The basal ganglia exert a censorship function and are for their part again under the influence of certain parts of the limbic system that are beyond conscious access. Since the basal ganglia are ultimately under control of the limbic system, the veto-option of the consciousness is considerably reduced if not rendered impossible. Roth attributes an evaluative function to the limbic system, which—based on experiences—is ready with quick reflex-like yet inflexible solutions to many problems. Therefore, it is suggested to be responsible for emotions and can swiftly react in well-known and well-practiced situations. These problem solutions are implemented in form of compact neuronal systems, which are the result of repeated practicing. What presents itself as a new problem for which the brain machinery cannot find a ready-made recipe, will be dealt with by the integrative and flexible yet slowly working consciousness. As the problem occurs repeatedly, new cortical networks are created which transform the solution into an established routine case, which is taken care of without an interfering consciousness. This way, consciousness becomes the deputy sheriff of the unconsciously working evaluation system. It seems to be used in complicated new situations only.

Whether the Libet-Roth picture is valid can't be confirmed yet as the original experiments of Libet are met with vehement criticism (e.g., Gomes 1998; van de Grind & Lokhorst 2000). However, these critics refer mainly to the conclusions Libet draws from his experiments, and to the assumptions that gave rise to his experimental setup. But despite his disapproval even Gilberto Gomes must commit, "I believe we can agree with Libet's conclusion that voluntary acts are nonconsciously initiated" (Gomes 1999) And this is everything we need from Libet's experiments as empirical evidence. After all, the original question was: Who is constructing?

In the late 90s of the 19th century, T. H. Huxely wrote that consciousness is just watching behavior and isn't able to do anything. Julian Jaynes (1976) refers to it as Huxley's Helpless Spectator Theory, and refers to it as follows. "Consciousness can no more modify the working mechanism of the body or its behavior than can the whistle of a train modify its machinery or where it goes. Moan as it will, the tracks have long ago decided where the train will go." Jaynes himself developed a controversial theory about the origin of consciousness. After studying the work of Homer intensively, Jaynes arrived at a remarkable conclusion. He maintained that there was no such thing as consciousness 3000 years ago. The ancient Greeks (the Myceneans of Homer's "Iliad") simply did not have it. He stressed that they heard auditory hallucinations, "voices of gods" instead. There was no sense of subjectivity, no introspection in the modern sense. Rather, the voices of the gods told them what to do and which decisions to take, similar to what schizophrenic experience. In some sense their brain was divided into two—the disassociated hemispheres with different working modes, as Jaynes proposes—resulting in a "bicameral mind". Only later Greeks, like Homer's Odysseus, developed a new "worldview" where the voices of the gods have gone and the mental world of people is enriched by a consciousness instead. Jaynes (1986) wrote: "In his everyday life [bicameral man] was a creature of habit, but when some problem arose that needed a new decision or a more complicated solution than habit could provide, that decision stress was sufficient to instigate an auditory hallucination." Instead of holding an internal monologue in which a person considers different alternatives by making anticipations about the results of a certain action, planning and decision making seem to have happened at an unconscious level and then proclaimed to the person.

We feel immediately reminded to the scenario of an unconscious part in the brain that according to the Libet-Roth model runs the body and informs the consciousness only afterwards. The consequences are evident. When Butz (2002) refers to a "decision-maker" who takes predicted future states into account, the nature of that decision-maker is not the conscious mind, as implicitly assumed. Anticipations are constructed at a level that obviously eludes conscious access. If this view holds water, my claim that "anticipations are the result of internal canalizations which *inevitably 'force'* a particular path" (Riegler 2001a, my italics here) applies to all kinds of anticipatory systems, and not just to implicit ones (in Butz's terminology).

Conclusion

The goal of this paper was to go one step further than my original examination of the nature of anticipation (Riegler 2001a) where I connected anticipations with canalizations in the physical and abstract realms of behavior and reasoning. However, I owed an explanation how these canalizations come about, who or what is responsible for assembling the elements in our hierarchical network of schemata (to use Piaget's terminology).

The answer to this paper's central question is challenging. The interlocking of elements in the hierarchy of schemata, which originate in our experiences, results in interdependencies among these elements and thus in canalizing forces. This puts limits to the accessibility of arbitrary future states. So although the subjective world-view of an individual is the result of a construction process by which elements of experience are linked together, the construction process itself is not arbitrary. In our cognitive repertoire we have constructs like "wall" and "walking" but no "walking through walls" as a valid option. Do we consciously construct concepts like "hard objects" that populate our cognitive space, or does their construction happen "somewhere else"? The evidence presented in this paper speaks in favor of the latter. As our cognitive space forms a hierarchy of interdependent elements, any anticipation we develop is also necessarily subject to canalizations. This is what I referred to as "being firmly rooted in the system rather than being dependent on (deliberately) built internal models" (Riegler 2001a). What follows from the arguments in this paper is that the "generator" of anticipations is buried in layers inaccessible for the conscious experience. While we can a posteriori reflect upon these anticipations we don't produce them in the first place. Whether this restricts volition and free will depends on whether the "spectator consciousness" has a Sjölanderian selection and/or Libetian veto option that prevent us from becoming marionettes in the sense of Huxley.

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