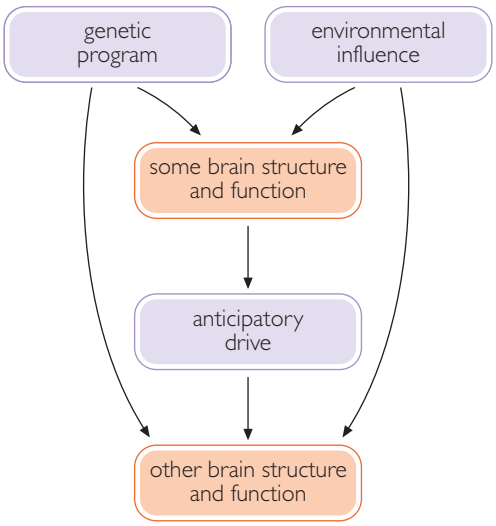

Figure 3: Some brain structures are created by the genetic program and environmental influence. These produce the anticipatory drive, which creates the remaining brain structures and functions in combination with the genetic program and environmental influence.

a unified theory of the brain. Despite this, the evidence for an anticipatory *drive* generating brain structure and function is somewhat tenuous. However, I believe there is a fourth view, besides the three I have presented above. *Assuming* the anticipatory drive exists may turn out to be an excellent guiding principle for inferring structure and function in various parts of the brain. In this view, the principle of the anticipatory drive is true, but acausal. Let me explain this statement through an analogy.

The principle of least time

9 Pierre de Fermat, in 1662, proposed the Principle of Least Time, which can be paraphrased as, *light travels between two points along the path that takes the least time*. This has been confirmed repeatedly (in a slightly revised form) through experiment. It explains, for example, why the surface of a road appears wet in the distance on a hot day. It happens because the air close to the surface of the road gets heated up and becomes less dense. Light travels faster through a medium of lesser density, and therefore light from straight ahead curves downward as it comes towards us (the observer), and makes the road look reflective, or wet. Fermat's principle can also be used to derive the laws of reflection and refraction, among other optical phenomena. In fact, the principle is so well-accepted that it has long been taken as the definition for a ray of light (Schuster 1904).

10 A moment's thought, however, reveals Fermat's principle to be acausal. It determines the path that light will take, based on where it will end up. In other words, when we hear that light takes the path of least time, it makes us ask, *how does it know?* How does it know where it is going, and how does it calculate the appropriate path? The answer, of course, is that it doesn't know. Fermat's principle is more appropriately viewed as an *effect*, i.e., a consequence of a deeper theory (Salmon 1998: 169). In fact, it has been shown to emerge from Huygens' wave theory of light in the classical framework, and from the main principle of quantum electrodynamics in the quantum framework (Feynman 1988). However, it remains a widely used principle in optics for deriving the paths of light rays in many practical problems.

11 I believe that the anticipatory drive may turn out to be like the principle of least time, i.e., acausal, but very handy.

The Role of Sensations in the Anticipating Self

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1 In his target article, Martin Butz introduces a new learning mechanism: an anticipatory drive, enforcing the formation of bidirectional anticipatory brain structures – a thought-provoking idea.

2 Such a pre-disposition for incorporating anticipatory relationships would indeed make sense in the light of evolution. Reliable forecasts about future states are most certainly rewarding in an array of niches. A large number of chemical, behavioral and cognitive mechanisms endorsing proaction have been naturally selected throughout the history of life. It is not unreasonable, it is perhaps even probable, that a learning mechanism such as an anticipatory drive has been selected. The hypothesis of an anticipatory drive is well worth pursuing in specifically designed studies.

3 Having said this, I would like to highlight a mechanism that is vital for the anticipating self: the formation of sensations detached from the current environment. Without a sensing self it would be impossible to project oneself into possible futures of a certain kind – futures that are simulated in the kind of inner world that provides the subject with affective experiences.

4 The author of the target article identifies the above mechanism to a degree, but chooses not to deal with it. In §97 it is argued that the so-called binding mechanism must be involved in subjective qualitative conscious experience, but that the qualia-debate is out of the article's scope. The author is right in discarding this philosophical squabble from the account (in passing, I agree that there is no evidence for conscious experience being immaterial).

5 However, there is a risk of throwing out the baby with the bath water if one reduces the role of subjective conscious experience to the topic of the qualia quarrel. This experience might actually be central to the concept of the anticipating self. The "feeliness" of the self, seeing red and tasting chocolate, seems to be essential to having a feeling of a self, in *being* a self.

6 This is elegantly portrayed by Humphrey (1997, 2006), who argues that the perception and the sensation systems might be distinct and not necessarily dependent on each other. By using examples from blindsight patients (and other rare disorders) he makes a case for the fact that it is possible to have perceptions without sensations (and the opposite). The important point is that if one has perceptions that are decoupled from sensations then no experience of a self in relation to those perceptions exists. When a blindsight subject is forced to report on visual perceptions it is experienced as a complete guess or as if taken out of the blue, something quite unrelated to *oneself*.

7 From this, it could be questioned whether it is actually valid to speak about self representations that are not experienced as *self* representations. To put it in other words, does a non-feely self-representation represent the same self that is felt, or would it perhaps be less confusing to use other terminology? What if the sensations very much constitute the self (as is indicated by Humphrey)? What then is all the rest?

8 This is somewhat off topic and also implied by the author in the discussion of Legrand's (2007b) distinctions. However it is still worth a moment's thought as it might have implications for how the suggested anticipatory drive could be said to be involved in the construction of the *self*. The author is admittedly vague on how the non-feely representations of the self merge together into a subjective conscious experience, into the feely self – they might in fact be distinct non-overlapping systems.

9 Regardless of whether the sensational system is the result of an anticipatory drive or not, it does seem to have point-blank anticipatory value when it is mentally detached from current environmental stimuli. It enables sensations stemming from potential future environments and it produces pre-feelings that can be compared to the current situation and serve as a decision device. Scientists and philosophers from various fields and epochs have considered the idea of an inner mental world that is similar to the real world in that it evokes sensations in the subject. In contemporary science one can identify at least three major directions that are based on empirical research and have started to cross-fertilize one another.

10 One direction is the field of mental time travel, which mainly deals with episodic memories and prospections. This field was founded by Tulving (1972), who also introduced the concept of "autonoetic consciousness" (providing first person perspective on mental episodes). Then there is the neurological approach that, among other things, has invested interest in the so-called wakeful rest state of the brain, a state that is highly associated with the sensed inner world. A seminal work in this line of science is the paper by Ingvar (1979). He also coined the idea of "a memory of the future." A third field is that of affective forecasting, which investigates abilities to forecast future mental states in different scenarios. In the front line of this research stand Gilbert and Wilson (e.g., 2005).

11 The above three directions have somewhat different approaches and address partly different questions. However, they reach some common conclusions. One of these is, perhaps ironically, that humans are inaccurate in matching the construction of an inner world to the past real world or the future real world. Despite this lack of truthfulness, the construction of a sensed inner world appears to be highly adaptive. Another important consensus that could be derived from these research directions is that the inner world probably serves its best function in relation to potential futures, and not to the present or the past.

12 Arriving at the core of the argument: the subjective experience of the self, and perhaps the self itself (whatever it is), is necessary to unlock the inner world of potential futures that impact current decision making in radical ways. If you do not feel it is *yourself* in that future, you will have no reason to act according to the prospection.

13 Furthermore, you will naturally never be able to visit the future with the sensing self if deprived of sensations because *you* would simply not exist in that future. This leads to the intriguing question: is the sensational self mainly an adaptation for anticipation? It might be that an immediate situation does not require the strong sense of a self that is needed for projecting it into a mental future. However, one should bear in mind that even if the sensed inner world is indeed mainly an adaptation for anticipation, it does not follow logically that the sensing self should be such an adaptation.

14 Nevertheless, from an evolutionary perspective, it certainly raises the possibility. The target article hints at the fact that the sensational self indeed is an anticipatory adaptation; if this could be comprehensibly explained by the anticipatory drive, then this concept would have proved its worth to me (my sensing self).

Maladaptive Anticipations

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1 The author highlights the benefits of an anticipatory drive for a variety of abilities and intelligent behaviour, including motor control, cognition (e.g., decision making, information seeking), and social capabilities (§5, §77, §80). However, there are circumstances when anticipation can be maladaptive. In the following paragraphs, the occurrence of maladaptive anticipation will be illustrated in reference to psychological disorders (depression, generalised anxiety disorder, social phobia). It will be shown that anticipation does not always lead to improved control of oneself and the environment and that anticipation is not always beneficial. Finally, the question is raised of whether it is the strength of the anticipatory drive or the content of the anticipations that is the important factor in the development and construction of the self.

2 "Learned helplessness" refers to situations in which a person has learned to act or behave as if helpless, even when they have the power to change unpleasant or harmful circumstances. The concept of learned helplessness was originally invented on the basis of learning studies in animals. In the experiments (Seligman & Maier 1967; Seligman 1975) animals were exposed to unavoidable shocks. Subsequently they were brought into a situation in which they were able to escape the shocks. They were not able to learn this task (control animals that had not been exposed to unavoidable shocks did learn it). This was attributed to the fact that the animals had previously learned that they could not escape the shocks. This behaviour may generalize to situations other than the learned ones. Learned