What does the brain know and when does it know it

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When discussing any issue, particularly a complex one, it is crucial that the terms be defined. And since reasonable persons might disagree, I will begin with the definitions as I would like to use them. Free will, in first person form, is the sense that "I choose what I do". What does "I" mean? I will reject immediately the dualist view that "I" is my mind, separable from the brain and body. "I" is my brain. I know about "I" because I am conscious (at least some of the time, when I am awake). Consciousness I admit is a problem; its nature and physiology are unclear, and I suspect it will require a new concept in science to understand it. However, for now, I accept the relatively common view that it can be considered "awareness". So the brain is generating an awareness of "I" as a part of what it is doing. It is crucial that "I" is not separable from the brain, but an aspect of its function.

The contents of consciousness are called qualia, and "I" is a quale. Note that consciousness by this view is passive, "awareness", an observation about what is going on in the brain. Qualia are very valuable data about what the brain is doing. It is critical to recognize, however, that qualia can be deceptive.

"What I do" are generally considered movements. Movements are events that can be observed and quantified; the physiology is reasonably well known. For the purposes of investigating free will, movements are typically investigated. Thoughts are also "what I do", but these are less easy to measure, and, like consciousness, we really do not understand what thinking is. Mental events are similar to movements except there is no external manifestation. One way of assessing mental events is the study of imaginary movements. The brain activations in imagining movement are similar to those with actually making movements with the biggest difference being the lack of motor cortex activation (Hanakawa et al. 2008).

Choosing is the sense that there are various alternative movements to make, or not make, at any one time, and that "I" is actively doing that choosing. Choosing is another quale. It is undoubtedly true that at any one time, there are many different movements that a person can make. One question is how that decision happens and how it is executed. Another question is how does the quale of freely choosing arise? A third question is whether there is any relationship between the processes of decision making by the brain and the quale of free will. The quale, as commonly experienced, is that "I" chooses and then the movement happens. This would be the folk psychology view.

Another concept that is critical is that much of what goes on in the brain is unconscious. Only some of it comes into consciousness, generally only one bit at a time. When something is in consciousness, then "I" is aware of it. The relationship between the unconscious and conscious is not clear. Why do certain elements become conscious? Is there particular importance to those elements over those that stay unconscious? The answers to these questions are not clear.

Evidence for the unconscious influences on behavior is very strong, and only two brief examples are given here. The first is what I have referred to as the salted peanut problem (Hallett 2007). You sit in front of a bowl of salted peanuts, and after eating a number of them, you make a conscious decision not to eat any more. Yet, in a very short time, you find that your hand is going out to take some more. (Who

is in charge?) A second example is the recent report of the parole decisions by Israeli judges (Danziger et al. 2011). Judges always seek to be fair and make objective decisions, yet parole is much more likely to be granted just after the judges have had something to eat. Apparently, hunger influences what appears to be rational decision making.

Do those quale in consciousness have any influence on outcome? Specifically, does a quale (or mechanisms in parallel to a quale) play a causal role. For something to be causal, it has to precede the effect and in some way seem to be related to it. As Daniel Wegner has pointed out, the idea has to precede the act in order for there to be a sense of free will (Wegner 2002; Wegner 2003). Hence the timing of qualia and movements are critical in understanding what is actually happening.

It is important to make one more point. Most of the time, most persons go along with their activities without specifically thinking about whether a specific movement is voluntary or not. Movement happens. If it is a pattern of behavior that is repetitive, such as the morning ritual of washing up or driving to work, the motor programs might well be run automatically with hardly any thought at all. If asked, persons would say, yes, the movements are voluntary, but it is not a common concern.

The relative timing of the quale and the movement

The basic experiment in regard to timing is well known. Libet et al. first tried to time the quale of willing (Libet et al. 1983). Subjects watched a clock and gave relative times for the sense of willing, W, and the sense of when the movement itself occurred, M. They also recorded the Bereitschaftspotential with EEG at the same time. Depending on the type of movement, the Bereitschaftspotential was about 1 s prior to movement while W was only about 300 ms prior to movement. M was pretty close to the movement itself. Hence the brain begins planning for the movement far in advance of the quale of willing. The facts are clear and have been reproduced many times; the issue has been the interpretation. What is to be made of the timing of the BP and W? I have often heard it said that the results appear to mean that the brain decides what to do before the person does so. This statement does not make sense. The person is his brain. Hence, the way to phrase this is that the brain decides unconsciously what will be done and consciousness is aware of this only later – but still before the movement, the timing of which is relevant to conclude that W could be a cause of M.

Libet et al. were unwilling to give up the idea that events relating to consciousness could be etiologic. Their idea was that, yes, movement might be originated unconsciously, but that the movement could be consciously vetoed before it happened, and this could be an indicator of free will. Such a veto has been called "free won't". On the face of it, this seems like nonsense. Of course, there could be brain events prior to a conscious veto just like there were demonstrated brain events prior to a movement, and an EEG potential looking like the Bereitschaftspotential precedes voluntary relaxation or decisions not to move in the first place (the no-go potential).

Soon et al. have done a similar experiment with fMRI asking subjects to freely move their right or left hand (Soon et al. 2008). Events in the fMRI signal were identified 8 s prior to movement that indicated probabilistically which hand would be chosen. The probability was low, but significant, showing very advanced brain processes in some circumstances.

We have done several experiments that also show brain events preceding the quale of willing. In one experiment, we asked patients to move "freely" while listening for tones (Matsuhashi and Hallett 2008). If they heard a tone after they had decided to move, then they should veto their movement. Hence this is formally a study of free won't. Vetoes should only be possible in the interval between the quale of willing and the movement. In this circumstance we referred to the quale of thinking about moving, and called it T, since it might be different from W. T was about 1.4 s prior to movement, much longer in advance than W, but still later than the onset of the Bereitschaftspotential measured simultaneously. We explained the difference between T and W as a difference between "probe consciousness" and "spontaneous consciousness". Probing with the tone, we could identify what the brain was doing prior to spontaneous awareness.

In yet unpublished work, we utilized sophisticated EEG methods to identify in real time when the brain was preparing to move. At such moments, we asked people what they were thinking about. Sometimes they were indeed thinking about the upcoming movement, but other times they were not. This appears to be direct proof that the brain can be preparing to move when consciousness is focused on something else.

Another important experiment that speaks to the timing of events, is the work of Lau et al. who looked at the influence of transcranial magnetic stimulation

on M and W (Lau et al. 2007). They stimulated the pre-supplementary motor area and the primary motor cortex both at the time of movement onset itself and 200 ms after movement onset. Almost shockingly, they found that subjects reported different times for both M and W with stimulation of the pre-supplementary motor area (and not the primary motor area). How can it be possible to influence the apparent time of M and W with stimulation after the movement, if these events occur before the movement? It turns out that there is a good answer to this question.

It takes some time from the beginning of a sensory event until the sensation gets into awareness. Libet studied this also, referred to it as the utilization time, and noted that it might be the order of several hundred ms (Libet et al. 1979). This means that what we perceive as the present is actually several hundred ms in the real world past. Actually, thinking about it carefully, this must be true. Consider watching an object touch your hand. It takes time for the visual information to get to the visual cortex and for the signals to be processed; similarly it takes time for the somatosensory information; and then there will be time needed to integrate the two sensory modalities. When all the signal processing is completed the real world event is long over, but, cleverly, the brain projects the apparent time backward in order to approximate the real world time.

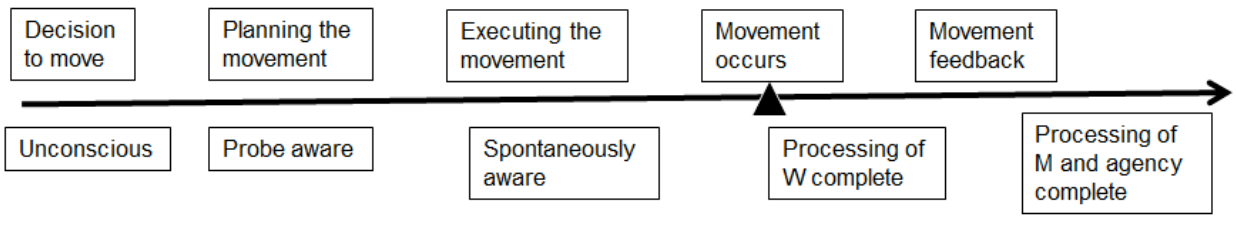
Since M and W are quale and can be influenced after the movement actually begins, it is likely that they are being finally processed after the movement and projected earlier in time. Hence, from all the data, it appears that the ordinary perception of willing is happening during a period from a few hundred ms before to a few ms after the onset of movement. With probing, the intention can be identified earlier, but often other thoughts are in consciousness as the movement is being prepared.

There is another aspect to the sense of volition in addition to the sense of willing, that is the sense of agency or, in this context, self-agency. That quale is the sense that the person is responsible for having made the movement which has just occurred. Willing and agency are separable to some extent. For example, it is possible to will a movement, but it not occur (and therefore no agency)—this might happen with a patient who has had a stroke or spinal cord injury. Agency would ordinarily require two factors, one, the sense of willing the movement, and, two, the movement that occurs and can be appreciated is close to what was willed. The quale of M is related to agency, but also needs the sense of ownership. In any event, it is clear that this aspect of the sense of volition cannot be prior to the occurrence of the movement itself. The timing of the events is illustrated in Figure 1.

Neurological disorders show the dissociation of volition and movement

I have written about this before and only briefly summarize a few here (Hallett 2007; Hallett 2009; Kranick and Hallett 2013). Patients with psychogenic movement disorders (a form of conversion or somatization disorder) make movements that look voluntary, share voluntary brain executive mechanisms, but are considered involuntary by the patients. Patients with Tourette syndrome are often confused by the question as to whether their tics are voluntary or not. They may well say that the movements really are voluntary but they are compelled to make them. Patients who have the passivity phenomena in association with schizophrenia may have movements that look voluntary, but the patient will say that he is completely externally controlled. Patients with Huntington disease may say their typical choreic movement is voluntary. Conversely, patients with anosognosia claim to have made a movement, when they have not. Hence, it is clear that all goal directed movements are not necessarily linked to the sense of volition, and volition can be attached to movements that do not appear to be voluntarily generated as we ordinarily understand them.

Fig. 1. Events in the generation of a movement and the conscious correlates. The arrow is the flow of time, and the real world events are above the arrow and conscious correlates are below.



The physiology of movement

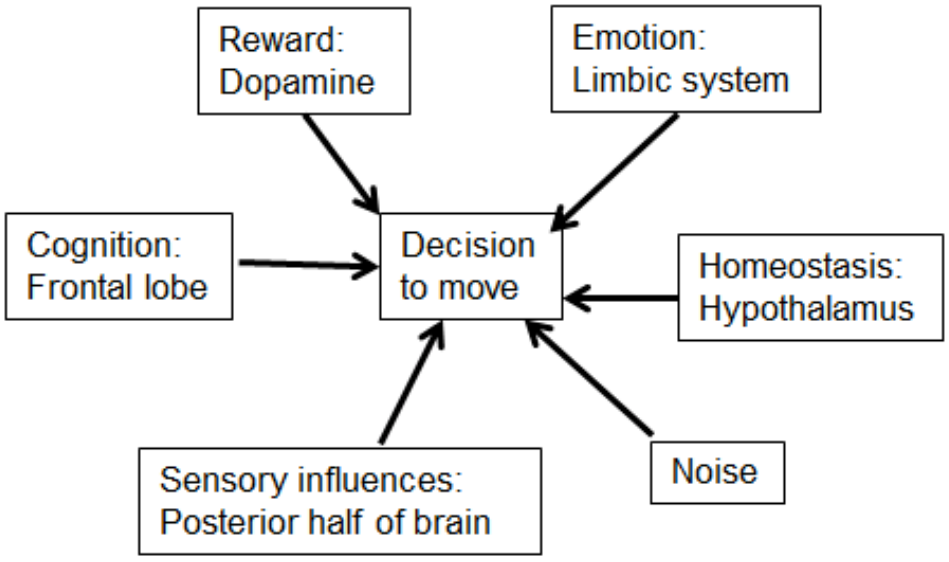
A good deal is known about how movements are made. The movement executive is mainly the primary motor cortex, which can be thought of as being in the center of the brain—at least it is on the anterior bank of the central sulcus. Movements can arise after external triggering or internal generation. External triggering comes in response to sensory stimuli, which generally are processed in the back half of the brain. Internal influences come from the front half of the brain and include emotion, homeostasis, cognitive processes and reward. These four factors arise from the limbic system, the hypothalamus, the prefrontal cortex and the dopaminergic midbrain nuclei, respectively (See Figure 2). External and internal influences are all constantly varying in strength, and there is also noise in the system. The movement that is made at any one moment reflects the strongest signals. Because the influences are largely independent of each other, the outcome can only be predicted in probabilistic terms.

As a movement is generated, the rest of the brain is alerted to this occurrence with a feedforward signal. An important region to be alerted is the temporo-parietal junction region which also receives feedback from movements that have occurred (Nahab et al. 2011). The feedforward signal is likely associated with the quale of willing. The parietal area may well be an important target for the feedforward signal since a lesion in this area delays W (Sirigu et al. 2004) and stimulation of this area (at time of brain surgery) produces an illusion of willing (Desmurget et al. 2009). The successful concordance of the feedforward signal and feedback signal in the temporo-parietal junction region is likely associated with the quale of self-agency (Nahab et al. 2011).

Let's go back to movement generation. The physiology of this generation is clearly complex with a large number of factors. Most of this appears to be unconscious although any of the factors might be conscious at any one time. Does consciousness do any work to help select the movement or is it purely passive awareness of what's going on? If a factor is in consciousness does it have extra weight, or it is that because it has extra weight that it comes into consciousness? Or, is it that the idea that it has a special influence is just one of the brain's deceptions. Certainly by timing arguments alone, it does not appear that the consciousness of willing has any influence, since it comes relatively late in the movement generation process.

One argument in relation to timing is that the events just before movement are not really the critical issue (Mele 2007). They may just play out as designed long before. This is the argument that distinguishes between proximal and distal intentions. What I have been describing is the proximal intention, the event just before an individual movement. The distal intention, in the case of a Libet-like experiment would be the decision to participate in the experiments in the first place and to decide to go along with the instructions of the experimenter. It is the distal intention that manifests free will and not the proximal intention (Mele 2007). It is a thought, a thought that stays in the brain until the right moment where the planned act will be finally done. As mentioned earlier, the physiology of thinking is still obscure. And as noted, my current view is that a thought, such as the distal intention, is an event with analogy to a movement

Fig. 2. Various factors influencing the decision of which movement to make.



itself and the physiology of its generation might be very similar to what I have described for a movement. Hence, I do not consider this argument very strong.

Implications for responsibility

The argument that I have made about free will and movement can be summarized as follows. The brain makes movements based on a large number of factors that summate and compete at any one moment for a particular outcome. Most of what the brain is doing is unconscious and that, on some occasions, the qualia of willing and agency are in consciousness. It is these qualia that the brain interprets as free will, and because the quale of willing occurs before the quale of movement, causality is inferred. However, there is no evidence that because a factor is in consciousness that it is more important than unconscious factors. Consciousness appears to be passive awareness of some (not all) of the goings on in the brain. And most of the time, there is no overt consideration of whether a movement is truly "voluntary".

Does free will then exist despite the fact that there is no support for the idea that the quale of willing has anything to do with the movement made? Since "I" am my brain, it is not necessary to ask this question only in relation to what is conscious. It is possible to say that a brain is free if the brain can function without external constraint. Ordinarily brains seem to do that. There are circumstances where brains are constrained and there are circumstances that raise interesting questions about "freedom". Starting from an easy issue, if the brain is having a seizure then it is being constrained. An overtly external constraint would be if someone is holding a gun to someone's head or being tortured; subsequent behavior would not be considered free. Brainwashing would also be considered, I would think, to take away a brain's freedom. When Patty Hearst joined the Symbionese Liberation Army and robbed a bank, she was likely brainwashed by her kidnappers. But the judicial system must have thought she acted freely since she was sentenced to prison.

What about being under the influence of drugs or being addicted? How about in a hypnotic state?

A more difficult consideration would be education in school. Of course, children have many things to learn, but some are facts and some are opinions. Math seems pretty straightforward, but how about evolution versus intelligent design? If a school only teaches intelligent design and a person acts on that basis, is that person free? Another approach (which fortunately for me most of my influential teachers took) is to make clear that you should not believe anything you are told or read. You should come to your own understanding from your own interaction with the world. That attitude seems to allow more freedom for the brain.

To be provocative, what about religion and religious education? If a child is taught weekly for many years that he will burn in hell if he does not believe in a certain way, it is not surprising that he does believe in that way. Is the brain then free to decide about religious belief? When 907 members of the Peoples Temple died from "revolutionary suicide" in Jonestown, were they acting freely?

In most circumstances, brains appear free to function, but they cannot easily escape their past histories which certainly influence outcome, just as current limbic and hypothalamic factors do. Perhaps it would be most fair to say that even in the absence of apparent external constraints, the range of outcomes that a brain could generate is always limited in some ways by past and present circumstances. The freedom from external constraints is never more than relative.

Assignment of responsibility

Google has developed a self-driving car, and California has just passed regulations allowing such a car to be used on its roads. The cars are very safe, likely safer than with human drivers. However, it is possible that such a car might get into an accident when you are sitting behind the wheel. Who is responsible? You pushed the button to go to the nearby McDonald's restaurant. Is it you or Google? Likely most would conclude that it is Google. Even though you are in the driver's seat, it is the programming external to you that was flawed. However, you still might get the ticket.

Jean Valjean of Les Miserables, was a poor man, who stole a loaf of bread to feed his starving sister and her seven children. He eventually served 19 years in prison and then was branded as a criminal. Still poor without opportunity, he continued to behave as a criminal. Upon learning a life lesson from Bishop Myriel of Digne, he changed his ways and became an "honorable" man. Yes, he was always "doing" the criminal acts, but the reason, at least to some extent, was the nature of the society in which he was living and his personal circumstances. A brief lesson from the Bishop produced a better

outcome than many years (and lots of expense) of prison.

Whether a person is responsible or not for a particular action is usually judged on what was in their consciousness just before that action. Such information is only partial and may even be an inaccurate picture of brain activity. However, it is fair to say that a person's brain is always responsible for what its attached body does. The real question should be why did the person (or his brain) do that. Focusing on "why" rather than "whether" should produce a more rational consequence. Should it be incarceration, education or even medical therapy? Likely our jails are filled with many persons who would be better served given more education and job opportunities, and this might well be better for society too.

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