The Myth of Dual Consciousness in the Split Brain:

Contrary Evidence from Psychology and Neuroscience

Gonzalo Munevar
Psychology Program Lawrence Technological University
Southfield, USA
gmunevar@ltu.edu

Abstract— **In his Nobel acceptance lecture in 1981, Roger Sperry, who was awarded the Prize for Physiology or Medicine, argued that his research and that of his collaborators had demonstrated that the right hemisphere of split-brain patients had a rich cognitive and emotional life that might be said to rival that of the left hemisphere in many respects. This cemented the belief that two consciousness may exist side by side, so to speak. Such a belief is not uncommon, even amongst distinguished researchers. It arose in great part because some split-brain patients have been afflicted by the "wild-hand syndrome," in which the patient, say, would reach for an object with his right hand, only to have the left hand block or undue the action. This phenomenon made a strong impression on many observers, who then concluded that the two hemispheres, each with its own consciousness, were in conflict with each other. However, many considerations from psychology and neuroscience lead to a simpler and more nuanced explanation without recourse to extraordinary claims: The different hemispheres are conscious at different times, depending on the task. For example, in classical experiments by Gazzaniga and LeDoux, it seems obvious that the split-brain patient is not conscious of what his right hemisphere has processed. It is not merely that the patient is not able to verbalize his experience, or that he is confused. For the patient is quite confident, indeed adamant, that he has seen nothing, and even resorts to confabulation to explain his choices. Whatever mental process takes place in the right hemisphere clearly meets the McGovern-Baars operational criteria to qualify as an unconscious process. Moreover, lesions to the SMA also create the "alien hand syndrome" without any mysterious dual consciousness. The case of split-brain patients operates on similar mechanisms.**

Keywords-dual consciousness; split-brain; action control; operational definition; neuroscience

I. Introduction

In his Nobel acceptance lecture in 1981, Roger Sperry, who was awarded the Prize for Physiology or Medicine, argued that his research and that of his collaborators had demonstrated that the right hemisphere of split-brain patients had a rich cognitive and emotional life that might be said to rival that of the left hemisphere in many respects [1]. This cemented the belief that two consciousness may exist side by side, so to speak. Such a belief is not uncommon, even amongst distinguished researchers such as Koch [2]. It arose in great part because some split-brain patients have been afflicted by the "wild-hand syndrome", in which the patient, say, would reach for an object with his right hand, only to have the left hand block or undue the action. This phenomenon made a strong impression on many observers, who then concluded that the two hemispheres, each with its own consciousness, were in conflict with each other. For example, Joseph was led to such conclusions after observing the bizarre behavior of one of two split-brain patients: "Indeed, [Patient] 2-C's left arm and leg not only engaged in controlled, directed, and purposeful behavior, but at times performed activities which his left hemisphere found objectionable and annoying. In some instances, physical struggles involving the right and left extremities of this patient were observed" [3]. As we will see, however, many considerations from psychology and neuroscience lead to a simpler and more nuanced explanation without recourse to such extraordinary claims.

II. Operatinal Differentaion of Consciousness

A split-brain patient is typically an epileptic whose corpus callosum, the bundle of axons that connect the left and right cortical hemispheres, has been cut to reduce the severity of the symptoms. This operation, called corpus callosotomy or commisurotomy, was used as a last resort until some 17 years ago, but it is still occasionally performed in extreme cases. There are also some people born without corpus callosum (acallosal), but this paper will refer to those who have experienced the operation.

In any dispute regarding consciousness we meet some daunting challenges right away. Eric R. Kandel, winner of the Nobel Prize in medicine, wrote that "Understanding consciousness is the most challenging task confronting science." Dehaene and Changeux echoed him when they said that such a task "has become the ultimate intellectual challenge of the new millennium" (p. 1145) [4]. The difficulty of the challenge becomes obvious when we try to settle on a satisfactory operational definition of a conscious state, given the fact that about the one thing that most experts agree on is that there is no general agreement on a definition of consciousness [5].

The best solution may probably be found one experiment at a time, by proposing an operational definition that a majority of investigators would find acceptable in the context of the specific experiment. For example, in an experiment involving temporary blindsight, Lau and Passingham [6] concentrate on awareness (as given by verbal reports of visual experience), a choice that allows them reasonably to interpret their results as suggesting that "the prefrontal cortex is important for the essentially subjective aspects of conscious perception," even though some investigators believe that it is possible to have consciousness without awareness (p. 18763).

For most experimental purposes, however, it may be difficult to improve on the proposal by McGovern and Baars (p. 180) [7]. They propose to consider mental processes as conscious if they "can be reported and acted upon… with verified accuracy… under optimal reporting conditions." Conversely, they define mental processes as unconscious "if their presence can be verified… they are not claimed to be conscious… and they cannot be *voluntarily* reported, operated upon, or avoided… even under optimal reporting conditions." In accepting McGovern and Baars's proposal, however, we should be aware of the possibility that pragmatic choices of this sort may often have to be supported by additional theoretical argument.

The task of isolating the conscious state is also daunting because that state is likely to be correlated with many other states that may contribute to its conscious character, even if they are not conscious states themselves.

The issue comes to a head when we consider experiments such as the following classic split-brain experiment by Gazzaniga-LeDoux [8], itself based on the famous Sperry-Gazzaniga studies [9]. Most split-brain patients show few psychological abnormalities under ordinary circumstances, but experiments such as the one by Gazzaniga-LeDoux's (shown in Figure 1) yield some surprising results.

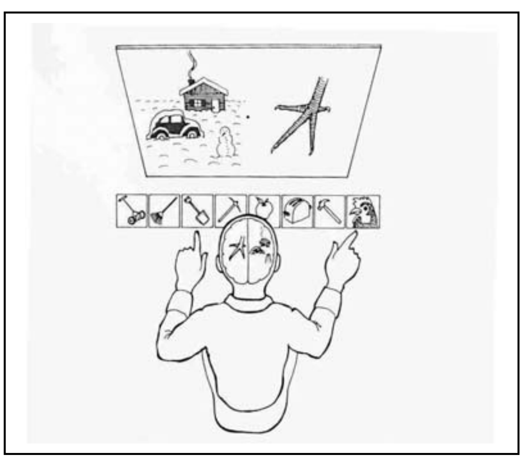

Figure1. The split-brain patient's left hemisphere was required to process the answer to the chicken claw, while the right dealt with the implications of being presented with a wintry scene. See text for implications. From Gazzaniga and LeDoux [8].

In Figure 1, a split-brain patient fixes his gaze on the center of the screen. Images appearing on his right visual field will be projected to his left hemisphere, while images appearing on his left visual field will be projected to his right hemisphere. An image of a chicken claw is projected to his left hemisphere. He is then asked to choose one image from a set of four images with his right hand (controlled by his left hemisphere). He chooses the image of the chicken head. And of course we know why.

An image of a wintry scene is then projected to his right hemisphere. He is then asked to choose one from the same set of images with his left hand (controlled by his right hemisphere). He chooses the snow shovel. Again we know why, for we know what was projected to his right hemisphere.

The surprise comes when he is asked why he chose as he did. He explains that he has chickens and needs the shovel to clean the chicken shed!

It seems obvious that the patient is not conscious of what his right hemisphere has processed. It is not merely that the patient is not able to verbalize his experience, or that he is confused. For the patient is quite confident, indeed adamant, that he has seen nothing, and even resorts to confabulation to explain his choice of the snow shovel. Whatever mental process takes place in the right hemisphere clearly meets the McGovern-Baars criteria to qualify as an unconscious process, for:

(1) It can certainly be verified, since the patient makes the relevant choice.

(2) It is clearly not claimed to be conscious.

(3) It cannot be *voluntarily* reported, operated upon, or avoided.

And
(4) The reporting conditions can be considered optimal.

It seems then that we have a workable operational definition of consciousness and unconsciousness in this case.

Nevertheless, for clarity's sake it is important to respond to those who insist that in the split brain both hemispheres may be conscious. Koch [2] seems to think that since the brain mechanisms in the two hemispheres are similar, and since they are able to produce successful behavior (e.g., making the right associations: chicken head – snow shovel), then we are entitled to conclude that the right hemisphere is conscious too, just as we are entitled to conclude that the cat is conscious because of the way it jumps and screams when we step on its tail. So structure plus behavior justify the conclusion of consciousness.

This analogy fails, however, because, when it comes to consciousness, first-person reports are crucially relevant behavior (not beyond doubt, but surely no less significant than the cat's screaming). And the subject is adamant that he does not experience the wintry scene. It thus seems reasonable to accept his testimony that he has *seen nothing*, just as in the case of blindsight we accept the subject's testimony that she does not see the wooden blocks she successfully places into the slanted slots.

It may seem that stronger evidence in favor of consciousness is provided by patients under general anesthesia. Such patients, according to Alkire, Hudetz, and Tononi, "sometimes carry on a conversation using hand signals, but postoperatively deny ever being awake" (p. 877). Retrospective oblivion, the authors conclude, "is not proof of unconsciousness" [10]. In this case, however, the reporting conditions demanded by McGovern-Baars are far from optimal, as the disruption by anesthesia of thalamic and cortical areas is substantial and may well interfere with the formation of memories. Moreover, in the case of the Gazzaniga-LeDoux experiment, the subject's "retrospective oblivion", if any, is immediate.

The MacGovern-Baar's proposal thus seems to provide reasonable operational criteria to distinguish consciousness from unconsciousness in split-brain experiments such as the one by Gazzaniga and LeDoux. It is not intended, however, as an "in principle" demonstration that the right hemisphere could not be conscious, particularly in light of the plausibility given to dual consciousness by the Alien Hand Syndrome exhibited by some split brain patients. Additional considerations from neuroscience, though, will show that such syndrome may occur as the result of purely unconscious processes, thus strengthening the psychological argument presented in this section.

III. Unconscious Occurrences of Alien hand Syndrome

A plausible explanation of why consciousness seems to be correlated with hemispheric dominance is: (1) as Gazzaniga, Ivry and Mangun point out [11], the evidence suggests that because brain resources are limited, there seems to be only one integrated spatial attention system in split-brain patients (their attentional system is unifocal) (p. 462); and (2) it is possible that "consciousness follows the task of materials and that different hemispheres are consciously aware at different times" [12]. In the Gazzaniga-LeDoux experiment, however, it is clear that the task of materials centers on the left hemisphere, at least in their patient.

In any event, we do recognize that some split-brain patients may have some conscious function in the right hemisphere, although as Gazzaniga and LeDoux already pointed out in 1978, only a few in whom the left hemisphere is not dominant for language exhibit consciousness in the right hemisphere [8]. But in such cases there are some behavioral differences.

Others might be tempted by Block's distinction between "access" and "phenomenal" consciousness [13], or some other way to separate consciousness from awareness. These highly controversial views will not be discussed here, but one must wonder about their possible motivation. The most likely explanation is the knowledge that, for a few months after the callosotomy, some split-brain patients, a la Dr. Strangelove, suffered from Alien Hand Syndrome. This would certainly make it appear, at first sight, as if there were two independent conscious minds fighting for control of the one body they shared [3].

Neuroscientific considerations about the control of action, however, make clear why the perplexing phenomenom of dual consciousness in conflict should yield to the more nuanced approach taken by Gazzaniga, i.e. the view that the different hemispheres are conscious at different times, depending on the task.

When planning an action, the premotor cortex (PMC) and the supplementary motor area (SMA) entertain a variety of potential movements that might fulfill the intended goal, e.g. picking up a cup of tea, which could be done with the right or left hand, in a quick or slow motion, etc. The various motor plans can be said to compete against each other, with the selected candidate being passed on to the motor cortex (MC), which will issue the efferent signal to the relevant muscles [14]. This cortical selection hypothesis agrees with the distributive nature of motor planning. As Gazzaniga, Ivry and Mangun point out, "The supplementary motor area reflects the contribution of internal sources of activation – goals and motivational states – whereas the lateral premotor area is driven more strongly by external sources, such as the positions of the effectors and objects that might be manipulated" (p. 293) [11]. Both types of sources are likely to combine in any one task, and in responding to external influences, in particular, many candidate motions will be entertained. It is obvious, however, that though many are called, few are chosen.

As we will see, this account of the organizational nature of the control of action can be deployed to explain why some split-brain patients exhibited Alien Hand Syndrome, although Gazzaniga and his colleagues did not draw such inference themselves.

We can now appreciate the first crucial insight from neuroscience. The selection mechanism for movement can be damaged, e.g. by strokes or other lesions, particularly to the SMA, where internal sources of activation are paramount. This means that the SMA will not be able to exercise proper supervision over the PMC, and this situation will then permit actions to be performed that ignore or override goals or specific instructions. Motor patterns that would have otherwise been inhibited may now be put into effect. Thus the right hand may reach for the pencil, in accordance with the individual's intended action, but the left hand may do something not in accordance with the goal, and even when the subject has been instructed not to do so, simply because a cup of coffee nearby (which may belong to someone else) may prompt the pattern for a potential movement to grasp it. Once again, normally, such pattern of movement would be inhibited and, thus, it would not reach the MC: It would not become action. When it is not inhibited, when it does become action, then we have a case of Alien Hand Syndrome.

The second crucial insight from neuroscience is that the PMC activation is *bilateral*, as shown by brain imaging studies, even when the subjects are required to perform the actions with the same hand, as reported by Gazzaniga et al, who point out, in addition, that "The transition of bilateral activation over premotor areas to unilateral activation over the motor cortext also is seen in measurements of evoked potentials" (p. 293) [11]. This means that in the performance of ordinary actions the two hemispheres will compete regularly. As we have seen, this competition will be regulated. But when the regulating mechanisms are thrown off kilter, one hand may operate in accordance with the intended action while the other will operate as a result of being recruited by external influences (e.g. there being something graspable nearby). It will then seem that the right and left hands are operating *as if* they had minds of their own: The individual will suffer from Alien Hand Syndrome. It should be clear, however, that there are no two conscious minds at work inside one individual, fighting for pride of place. What we have instead is a number of unconscious processes, motor patterns entertained in the PMC, some of which are no longer inhibited.

Now, the reason this insight is relevant to the split-brain case is, of course, that, when the corpus callosum is severed, bilateral inhibition may no longer be in effect. In many actions the supplementary motor area actually coordinates the two hands for more efficacious action, e.g. when climbing a ladder or hammering a nail. But when a choice is made for a single hand to move, e.g. to shake the hand of someone to whom we are being introduced, then the motion of the other hand is inhibited. Indeed, recent work by Palmer *et al* supports the view that interhemispheric inhibition mediates cortical rivalry between the two hemispheres through callosal input (as Palmer points out, "The corpus callosum consists almost entirely of excitatory fibers, which implies that interhemispheric inhibition arises from the activation of local interneurons") (p. 990) [15].

Therefore, when the corpus callosum is absent, as it is the case with split-brain patients, then the standard interhemispheric inhibition may fail. Moreover, the coordination and supervision of the PMC by the SMA may also be compromised. A reason for this is that the supplementary motor area projects not only to its ipsilateral motor cortex, as we would expect, but also to the contralateral SMA and MC through the corpus callosum. Many of these projections are inhibitory. When this circuitry is disrupted, as in a callosotomy, the normal functioning of motor control (selecting a movement on the contralateral side of the body while inhibiting an analogous movement on the ipsilateral side) is also disrupted. This results in so-called "mirror movements" in patients with damage to the SMA. As Gazzaniga, Ivry and Mangun tell us: "When a subject is asked to reach for an object with the hand contralateral to the lesion, the ipsilateral hand makes a similar gesture" (p.294) [11].

IV. CONCLUSION

It is thus not surprising that we should see some cases of Alien Hand Syndrome amongst new split-brain patients. Eventually, of course, new sub-cortical connections or other mechanisms may alleviate the problem. We have seen, however, that the syndrome can be caused, in lesions to the SMA, even though the relevant brain processes are unconscious, presumably even by the standards of the proponents of consciousness without awareness. None of the steps essential to the account presented in this paper is novel or particularly controversial, although they have been brought together in a novel way to explain otherwise puzzling phenomena. The explanation proposed in this paper thus presents strong evidence contrary to the perplexing, almost shocking, claims made by some. Nevertheless, although it provides a more sensible account of the phenomena, it is in many respects no less fascinating.

ACKNOWLEDGMENT

I am grateful to Yi Zheng for her able editorial assistance and to Shelton Hendricks and David Paulsen for their helpful comments.

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