

Two Neural Correlates of Consciousness¹

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Abstract

Neuroscientists continue to search for 'the' neural correlate of consciousness (NCC). In this article, I argue that a framework in which there are at least two distinct NCCs is increasingly making more sense of empirical results than one in which there is a single NCC. I outline the distinction between phenomenal NCC and access NCC, and show how they can be distinguished by experimental approaches, in particular signal-detection theory approaches. Recent findings in cognitive neuroscience provide an empirical case for two different NCCs.

I have previously proposed a conceptual distinction between phenomenal consciousness and access consciousness. [1,2,3] Phenomenally conscious content is what differs between experiences as of red and green, whereas access conscious content is content, information about which is "broadcast" in the "global workspace". Some have accepted the distinction but held that phenomenal consciousness and access consciousness coincide in the real world. [4, 5, but see 6] Others have accepted something in the vicinity of the conceptual distinction but argued that only access consciousness can be studied experimentally. [7] Others [8] have disparaged the conceptual distinction itself. This article argues that the framework of phenomenal consciousness and access consciousness helps to make sense of recent results in cognitive neuroscience; we see a glimmer of an empirical case for thinking that they correspond to different NCCs.

Phenomenal NCC

Christof Koch defines "the" NCC as "the minimal set of neuronal events and mechanisms jointly sufficient for a specific conscious percept" [9, p. 16] . However, since there is more than one concept of consciousness, this definition allows that a given percept may have more than one NCC. In my proposed framework, the Phenomenal NCC is the minimal neural basis of the phenomenal *content* of an experience, that which differs between the experience as of red and the experience as of green. I will start with an example: the neural basis of visual experiences as of motion is likely to be activation of a certain sort in area MT/V5². (Philosophers often use the terminology 'as of motion' instead of 'of

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² The first classical "visual" cortical area is V1; later classic "visual" areas include V2, V3, V4, V5. V5 has two names because it was identified and named by two groups. I put "visual" in scare quotes because there is some debate as to whether some of the classic "visual" areas are best thought of as multimodal and spatial.

motion' since the experience can and does occur without motion.) The evidence includes:

- Activation of MT/V5 occurs during motion perception. [10]
- Microstimulation to monkey MT/V5 while the monkey viewed moving dots influenced the monkey's motion judgments, depending on the directionality of the cortical column stimulated [11]
- Bilateral (both sides of the brain) damage to a region that is likely to include MT/V5 in humans causes akinetopsia, the inability to perceive—and to have visual experiences as of motion. (Akinetopsic subjects see motion as a series of stills.) [12, 13]
- The motion after-effect—a moving afterimage—occurs when subjects adapt to a moving pattern and then look at a stationary pattern. These moving afterimages also activate MT/V5. [14]
- Transcranial magnetic stimulation (TMS³) applied to MT/V5 disrupts these moving afterimages. [15]
- MT/V5 is activated even when subjects view “implied motion” in still photographs, for example, of a discus thrower in mid-throw. [16].
- TMS applied to visual cortex in the right circumstances causes phosphenes⁴—brief flashes of light and color. [17] When TMS is applied to MT/V5, it causes subjects to experience moving phosphenes.[18]

Mere activation over a certain threshold in MT/V5 might not be enough for the experience as of motion: the activation probably has to be part of a feedback loop, what Lamme [19,20] calls recurrent processing. Pascual-Leone and Walsh [21] applied TMS to both MT/V5 and V1 in human subjects with the pulses placed so that the stationary phosphenes determined by the pulses to V1 and the moving phosphenes from pulses to MT/V5 overlapped in visual space. When the pulse to V1 was applied 5 to 45ms later than to MT/V5, all subjects said that their phosphenes were mostly stationary instead of moving. (See [21] for references to single cell recording in monkeys which comport with these results.) The delays are consonant with the time for feedback between MT/V5 and V1, which suggests that experiencing moving phosphenes depends not only on activation

³ TMS delivers an electromagnetic jolt to brain areas when placed appropriately on the scalp. The effect is to disrupt organized signals but also to create a signal in a quiescent area. Thus TMS can both disrupt moving afterimages and create phosphenes. A comparison is to hitting a radio: the static caused might interrupt good reception going on but also cause a noise when there is no reception. (I am indebted here to Nancy Kanwisher and Vincent Walsh.)

⁴ To experience phosphenes for yourself, close your eyes and exert pressure on your eye from the side with your finger. Or if you prefer not to put your eyeball at risk, look at the following website for an artist's rendition: <http://www.reflectingskin.net/phosphenes.html>

of MT/V5 but also on a recurrent feedback loop in which signals go back to V1 and then forward to MT/V5. [21]

So recurrent activity in and around MT/V5, in the context of other brain areas functioning normally—exactly which brain areas are required is unknown at present—is a good bet for being the physical basis of visual experience as of motion. (But see Box 2 and [22,23] for some data that complicate the conclusion.) Corresponding conclusions can be drawn for other types of contents of experience. For example, recurrent activation of the fusiform face area on the ventral (bottom) surface of the temporal lobe (again in context) may determine experience as of a face.[24] The overall conclusion is that there are different Phenomenal NCCs for different phenomenal contents. (Cf. Zeki on micro-consciousness [25, 26])

Of course no one would take activation of MT/V5 + recurrent loops to V1 all by itself in a bottle as sufficient for experience of motion. (See Box 1.) A useful distinction here is that between a *core* and a *total* NCC. [27,28] The *total* NCC of a conscious state is—all by itself—sufficient for the state. The *core* NCC is the *part* of the total NCC that distinguishes one conscious content from another—the rest of the total NCC being considered as the background conditions, which supply the rest of the sufficient condition. (One interesting issue is whether there might be somewhat different background conditions for different experiential contents, or whether the background conditions—at least in a single sensory modality—are always the same.⁵) In these terms, then, the core Phenomenal NCC for the neural basis of the experience as of motion as opposed to the experience as of red or as of a face, is likely to be recurrent activation of MT/V5. See Figure 1.

⁵ The distinction between core and total NCC as I defined it depends on the assumption that at least some core NCCs share background conditions. Suppose the background condition for the experience as of red and the experience as of green are the same and are the same as other visual experiences, but not the same as the background condition for the taste experiences, e.g. the experience as of saltiness. Then the core NCC for visual experiences will have to be defined as the part of the total visual NCC that distinguish one visual content from another.

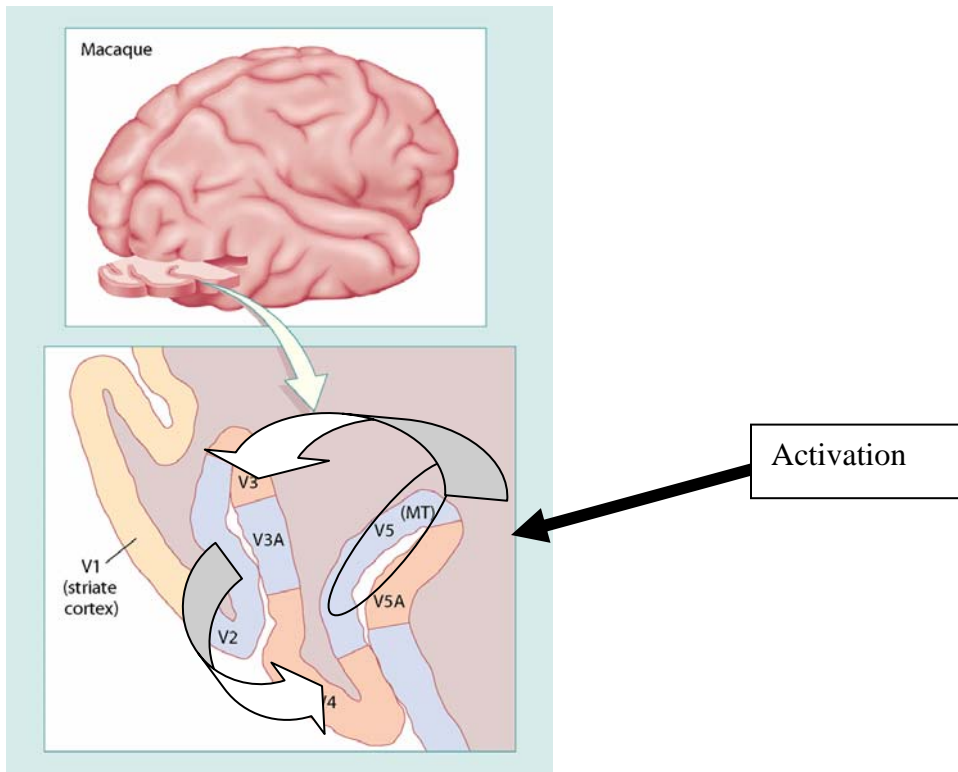


Figure 1. The core Phenomenal NCC for the visual experiential content as of motion: MT/V5 activation with recurrent loops to and from lower areas. The arrows are supposed to indicate recurrent loops. Adapted from Zeki, S., *A Vision of the Brain*, Blackwell (1993), p 97, as modified by Gazzaniga, M., Ivry, R. and Mangun, G., *Cognitive Neuroscience*, second edition, Norton, 2002. Arrows indicating recurrent loops added

Box 1 Area MT/V5 in a bottle?

The *total* Phenomenal NCC for the experience as of motion is a sufficient condition all by itself for the experience. What might that turn out to be? I suggest approaching it by asking what we could *remove* from a normal brain and still have that experience. My suggestion is that we might be able to remove—at least—areas responsible for access to experiential contents and still have the heart of the same experiential contents. (On my picture, areas responsible for access to experiential contents probably also are responsible for conceptualization of those contents. So experiential contents without access might be non-conceptual, or may only involve purely sensory concepts.) Nakamura and Mishkin [29, 30] removed frontal, parietal and superior temporal areas in one hemisphere of monkeys, leaving what is usually considered the visual system intact. They also disconnected visual inputs to the undamaged hemisphere. This preparation is sometimes said to cause blindness [13], but Nakamura and Mishkin are careful to say that this is shorthand for behavioral unresponsiveness to visual stimuli (at least temporarily), and should not be taken to show complete lack of visual sensation. One intriguing result is that when the

limbic (emotional) system in the damaged hemisphere is intact, the monkeys showed eye and head movements as if engaged in visual exploration. This contrasts with monkeys in which V1 is ablated who stare fixedly.

Box 2: Blindsight and MT/V5

The picture presented in the text is complicated by attention to studies involving blindsight patient GY, who has experiences of motion that may be visual but does not have the corresponding part of V1. GY does well in forced choice guesses about stationary stimuli to his blind field that he says he does not see. But he says he is aware of some moving stimuli. [31] Functional magnetic resonance (fMRI) shows that GY's area MT/V5 is activated when he is aware of moving stimuli presented to his blind field.[31] However, he does not experience moving phosphenes when TMS is applied to MT/V5 in the left hemisphere of his brain, where he is missing the corresponding V1.[22] Recent neuroanatomy has shown that there is a pathway between the eyes and MT/V5 that bypasses V1 (directly from the LGN—the neural way-station between the eyes and the cortex) [23] GY has spoken to investigators about his experience. In 1994, GY said that his experience of motion in the blind field was “a ‘feeling’ of something happening in his blind field”. [22] In 1996, he said his experience was that of “a black shadow moving on a black background”. [22] The shadow description comports with Riddoch's 1917 paper which included studies of 5 patients who had gunshot wounds affecting V1 in World War I. (Zeki and ffytche, [22] commendably and rarely in neuroscience, quote some of these patients.) The conclusion I would draw from reading what these subjects and GY say is that their experiences are very abstract, involving pure motion without any other experiential features such as color, light, shape or contour. (Some philosophers I have mentioned this to wrongly think this description is incoherent!) It is not certain that these motion experiences should be described as visual. One suggestion is that activation of MT/V5 requires feedback loops to lower areas for experiences as of color, light, shape and contour and for moving color, light, etc, but not for *pure* motion. However, it may be that recurrent processes are necessary for all conscious experience, since there may be recurrent processes feeding back to MT/V5 from higher areas.

ACCESS NCC

We can distinguish between phenomenal contents of experience and access conscious contents, contents information about which is made available to the brain's “consumer” systems: systems of memory, perceptual categorization, reasoning, planning, evaluation of alternatives, decision-making, voluntary direction of attention, and more generally, rational control of action. Wide availability motivates the idea that there is some mechanism via which producing systems can communicate with all the consuming systems at once, a

“global workspace”[32], and that information concerning conscious representations is “broadcast” in this global workspace. According to the global workspace metaphor, the sensory systems are the “producers” of representations, and the aforementioned systems are the “consumers”. The neural basis of information being sent to this global workspace is the “Access NCC”.⁶

Rees, et.al. [13] note that in studies of the neural correlates of bistable perception, in which there are spontaneous fluctuations in conscious contents, reports of conscious contents correlate with activation in frontal and parietal areas. Dehaene and Changeux [33] suggest that a significant piece of the neural machinery of what they call “access to consciousness” (roughly equivalent to my access-consciousness) is to be found in “workspace neurons” which have long range excitatory axons that allow, for example, visual areas in the back of the head to communicate with frontal and parietal areas further towards the front of the head. Thus it is a good guess that the Access NCC, the neural basis of access, is activation of these frontal and parietal areas by occipital (classic “visual”) areas in the back of the head. (See Figure 2.)

Figure 2

⁶ The “made available” terminology is supposed to capture both the occurrent nature of the experience (when something is *made* available, something happens) and the dispositional aspect (availability). There are many somewhat different ways of precisifying access consciousness on this picture. One might think of the crucial feature as representations being *sent*, or else, *received*, or else *translated* from the system of representation of the producing systems to the system of representation of the consuming systems.

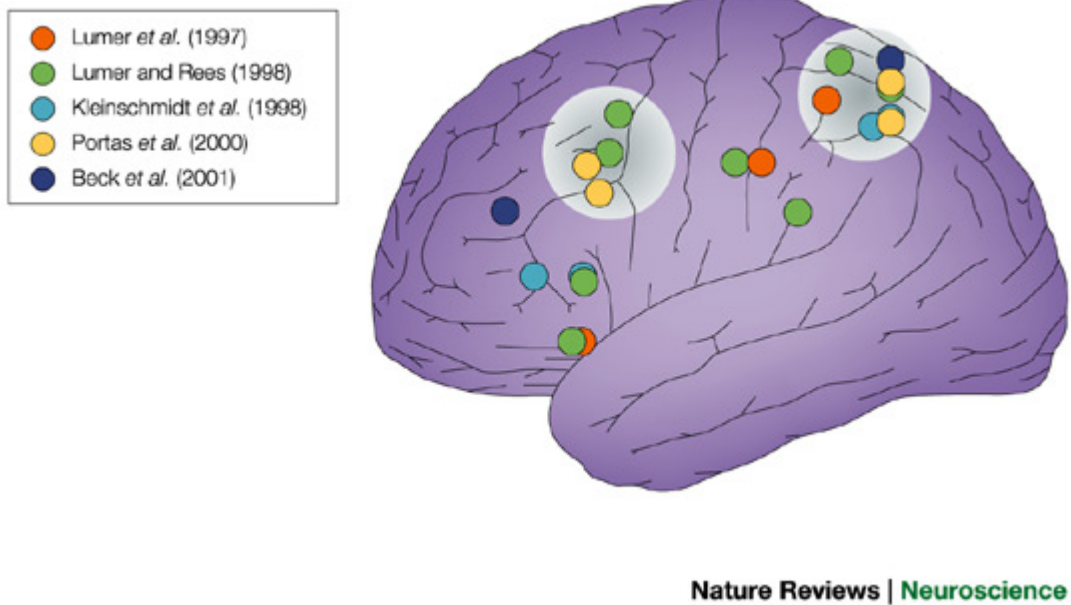


Figure 2. Suggestion for the core Access NCC for visual experiences, from [13]. Different colors indicate different studies. Activations cluster in superior parietal and dorsolateral prefrontal cortex as indicated by large light circles. These are frontal and parietal areas that fluctuate spontaneously in binocular rivalry and other bistable perception in a way that is time-locked to fluctuation in reported experience. The core Access NCC may be activation of these areas by neural firing in the occipital cortex in the back of the head. Do we count the Phenomenal NCC as part of the Access NCC—in which case this figure pictures the Access NCC minus the Phenomenal NCC? Or do we regard the Access NCC as not including the Phenomenal NCC, in which case this figure pictures the Access NCC. This is a terminological issue--assuming that phenomenal consciousness is the gateway to full-blooded access consciousness.

As Dehaene and his colleagues [33] have emphasized, there is a winner-take-all competition among representations to be broadcast in the global workspace.⁷ This point is crucial to the nature of the Access NCC and the difference between it and the Phenomenal NCC. One item of evidence for winner-take all processes derives from the attentional blink paradigm, in which the subject is given a string of very brief visual stimuli, most of which are distractors. The subject is asked to report on one or two “targets” after the sequence of rapid visual stimuli. If there are two targets separated by an appropriate delay, the subject does not report seeing the second one, even though the second one would have been likely to be reported if the subject had

⁷ The idea is not that the auditory signals from a voice compete with the visual signals from the person’s mouth moving, but rather that a “coalition” which involves neural processing of both of those signals competes with other coalitions.

not been given the first target. Dehaene, et.al. [34] used a modified attentional blink paradigm, in which subjects were asked to indicate on a continuous scale the visibility of the second target. The second target was at its peak of invisibility when the targets were separated by 260 ms. The result of interest here is that the subjects almost never used the *intermediate* cursor positions (at the 260 ms delay); that is they rated the “blinked” stimulus as either totally unseen or as maximally seen almost all the time. Thus Phenomenal NCC activations compete for *dominating* the Access NCC. Importantly, it is not the case that the Phenomenal NCC representation that is highest in initial activation will dominate, because domination can be the result of “biasing” factors such as expectations or preferences [35, 20].

Although the winning Phenomenal NCC will in general be amplified by the recurrent loop, a losing Phenomenal NCC may itself involve recurrent loops *to lower areas* that will be sufficient for an experiential or phenomenal content. For example, an activation of area MT/V5 might have recurrent interactions with V1, making it the neural basis of an experiential content, but nonetheless lose in the winner-take-all competition and so not be accessed [20]. The general point is that the simplest and most explanatory theory may be one in which recurrent MT/V1 loops are sufficient for an experiential content despite not being accessible when they lose the winner-take-all competition. Thus the winner-take-all process that is part of the nature of global broadcasting also strongly suggests that the Phenomenal NCC can be instantiated without the Access NCC, so global broadcasting does not encompass all of consciousness. This idea is further bolstered by evidence that there is brief parallel processing of many objects in the ventral visual stream⁸ (up to infero-temporal cortex) before zooming in on one or two of them. [36]

Box 3 NCC or NDC?

I started out talking about one “neural correlate of consciousness”. But the evidence of the sort just described argues for something *both stronger* and *weaker* than correlation.

Weaker, because none of the evidence cited has anything to say about whether there is some *other* sort of physical constitution—an alternative biology, or even silicon chips—that is sufficient for the same experiences. The evidence supports a **one**-way connection, neural→experiential, not a **two** way connection, neural ↔ experiential.

⁸ Milner and Goodale distinguish between a conscious visual pathway from the classic visual areas in the back of the head feeding into the temporal lobe on the side of the head (ventral stream) and an unconscious “dorsal” action-oriented stream starting in the back of the head and feeding to the top of the head. (Milner, A. D. & Goodale, M. A., 1995. *The Visual Brain in Action*. Oxford University Press: Oxford

Stronger because it is evidence for *determination*, not just correlation. There is a correlation between the temperature in Brooklyn and Manhattan, but there is no necessity to it. The relation between recurrent MT activation and experience as of motion appears to be a necessary one: you can't have (recurrent) activation of MT/V5 (together with certain unknown supporting areas) without visual experience as of motion.

Thus we should really be thinking about the “NDC” for “Neural Determiner of Consciousness” instead of the NCC. (I will continue to use the term ‘NCC’ since it is established terminology.)

But is the Phenomenal NCC Really the Neural Basis of a Kind of Consciousness?

You may ask, “If the Phenomenal NCC can perhaps occur without the Access NCC, how do we know that the Phenomenal NCC is really the neural basis of anything conscious?” A quick answer is that, since the Phenomenal NCC determines the *contents of experience*, what it determines is *ipso facto* a kind of consciousness. The Phenomenal NCC for visual motion determines the experiential content of visual motion—as distinct from the experiential content of seeing something as a face. That content itself is a kind of phenomenology, a kind of consciousness. If there could be a phenomenal content without anything that could be called awareness of it, some might not want to apply the word ‘consciousness’ to it. For this reason, Burge [37] distinguishes between phenomenality—which he is uncomfortable about calling a kind of ‘consciousness’-- and phenomenal consciousness which is phenomenality that is the subject of some kind of access.⁹ If one accepts Burge’s terminology, though, it is important to realize that it is phenomenality that is the important and puzzling phenomenon that is the heart of the mind-body problem and what we do not understand how to explain in neurological terms. If we could solve the “Hard Problem of consciousness” [4] for phenomenality in Burge’s sense, there would be no “Hard Problem” left for phenomenal consciousness in Burge’s sense.

But this answer is too quick, since the doubt that motivates the question is a doubt that the Phenomenal NCC really does determine the contents of experience, and since the Phenomenal NCC was defined in terms of the contents of experience, the doubt challenges the evidence presented earlier for a

⁹ More specifically, Burge argues that there is a kind of primitive of-ness of a phenomenally conscious state that is not reducible to higher order thought (and not reducible to any other cognitive notion). In [3], I argue that “phenomenal consciousness” in my sense of the term can be either transitive (take an object of which the subject is conscious) or intransitive. My intransitive phenomenal consciousness corresponds to Burge’s phenomenality, and my transitive phenomenal consciousness corresponds to Burge’s phenomenal consciousness.

Phenomenal NCC. The doubter may say that without access, there can be no true phenomenal contents but only *proto-contents* that *become* contents when globally broadcast. But how does the doubter claim to know that? Some are motivated by a terminological point—that we shouldn't call something 'phenomenal' or 'conscious' if it isn't broadcast for access. [24] However, the *substantive* empirical question is: if our evidence always concerns phenomenal contents that are actually accessed, how can the Phenomenal and Access NCC ever be empirically distinguished?

The answer is that it is not true that our evidence always concerns experiential contents that are accessed. There are a variety of paradigms in which we can use convergent evidence involving varying degrees of access to try to separate out the Phenomenal from Access NCC. One such paradigm is signal detection theory.

Signal Detection Theory (SDT) Approaches

Suppose a subject is shown a series of stimuli at around threshold level and asked to press one button if a target is visible and another if not. SDT models the subject's behavior in terms of two factors: the extent to which the subject has an experience of seeing it and the criterion the subject implicitly sets for reporting seeing it. The criterion is famously influenceable by features of the experimental setup that affect the subject's expectations or motivation—such as the proportion of “catch trials” (where no stimulus is presented) and by rewards for hits and penalties for false alarms. We know from standard SDT analyses that the subject's reports of whether there was a target or whether he saw it *do not just reflect the extent to which the subject did see it* (i.e. did have a visual phenomenal state), but also the subject's threshold for reporting and even for believing that he did see it. Two experimental setups in which there are the *same* experiential contents may issue in *different* beliefs and different reports.

A dramatic recent example is a recent series of experiments concerning the “exclusion” paradigm [38], in which subjects are instructed to complete a word stem with something other than the end of a masked word that has just been presented to them. If the word 'reason' is presented “unconsciously” at 50 ms, the subject is more likely than baseline to *disobey* the exclusion instructions, completing 'rea ___' with 'son', whereas if 'reason' is presented “consciously” at 250 ms, the subject is more likely than baseline to choose some other ending (e.g. as in 'reader'). This paradigm has impressed many because it appears to yield opposite results for unconscious and conscious stimuli. However, Visser and Merikle [39] showed that changing the motivation of the subject by using a reward structure can change the degree of exclusion. They started subjects with a \$15 credit and docked them \$1 for each error. Visser and Merikle interpret the result in terms of the effect of reward/punishment on increased attention, accepting the idea that the 50 ms/250 ms difference engenders an unconscious/conscious difference. But there is an alternative SDT interpretation

suggested by Snodgrass [40] in which the results in part *reflect a criterion shift rather than a difference in consciousness*. The idea is that punishment for errors of failing to exclude pushes the criterion level (the degree of phenomenal experience that the subject implicitly sets as a condition for action) for inhibiting the immediate response so low that weak conscious perception of ‘reason’ blocks use of ‘son’ even though the subjects are so unconfident that they say and think they don’t see the word. That is, their criterion level for inhibiting the immediate response is lower than their criterion level for believing that they saw a word, and the phenomenal level is in between the two criteria. The subject’s state of mind when successfully excluding one of the 50 ms stimuli could be articulated—over-articulated, no doubt-- as “I probably didn’t see a word but if I did, it was ‘reason’, so I’d better complete the stem with ‘reader’.” [41] And the SDT interpretation is confirmed by the effect on “inclusion” instructions. With “inclusion” instructions, the subject sees ‘reason’ and then is given ‘rea___’ but is told to complete the stem with *the word he saw* if possible. In this paradigm, SDT predicts no shift with change in reward or punishment, because there is no issue of a criterion level. There is no degree of experience that the subject implicitly sets as a condition of acting: rather, the subject just uses the first word that comes to mind regardless of level of confidence that it is the word he saw. And the result [39] is just that: the difference in reward/punishment structure makes no difference in the result under “inclusion” instructions.

There is, therefore, evidence in the “exclusion” case of experiential contents (e.g. as of seeing ‘reason’) without the kind of access required for report, planning, decision-making, evaluation of alternatives, memory and voluntary direction of attention. Some of the 50 ms stimuli are weakly conscious although not broadcast in the global workspace. Thus SDT gives us reason to think that experiential content—based on the Phenomenal NCC—can be instantiated without the kind of access that is based in the Access NCC.

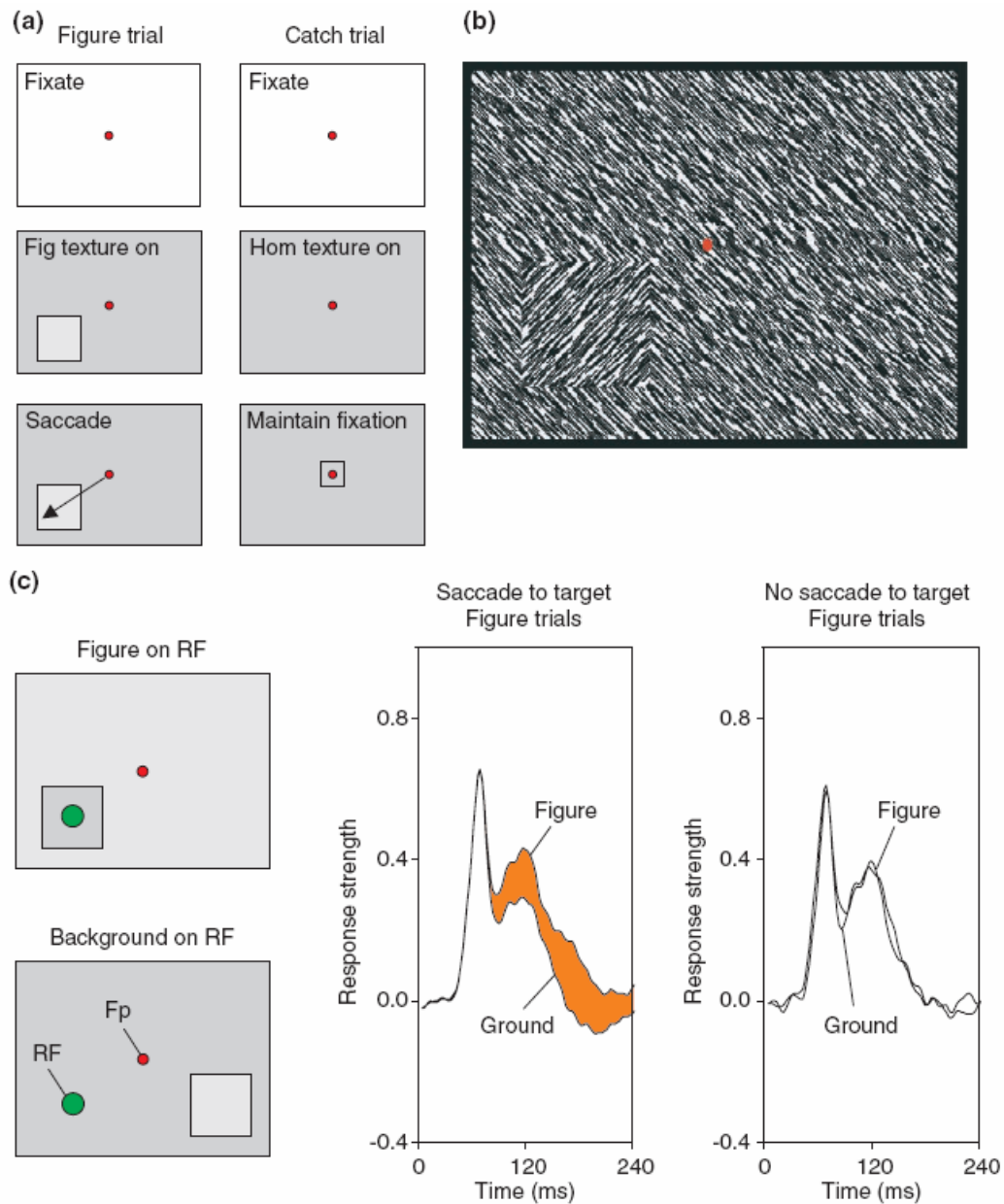
Neural SDT

In a landmark series of experiments, Super, et. al. [42] recorded from V1 (which, you will recall is the first classic “visual” area in the cortex) during a task in which monkeys were rewarded for saccading to a target if there was one or continuing to look at the fixation point if not. (A saccade is an eye movement whose function is to make a region of interest project to the densest part of the retina; in natural visual exploration, there are roughly two per second although the movement itself takes only 30 ms.) Super, et. al, manipulated whether the locations in V1 corresponded to figure or ground. When the monkey detected (saccaded to) the target, there was an increased V1 response for figure as compared with ground. See Figure 3, in which this increased figure response is referred to as “modulation”.

Super, et.al. were able to manipulate the modulation by varying the saliency of the stimulus (i.e. the number of pixels in line segments in the target— Figure 3b) and the proportion of “catch trials” in which there was no target. For high saliency stimuli and small numbers of catch trials, there was a near perfect correlation between modulation and saccades to the target, and in that sense modulation and access to the target corresponded well. But moving the saliency down or the percentage of catch trials up boosted the modulation when the animal did not saccade to the target to the 50% range. That is, with low saliency or a high number of catch trials, the monkey’s criterion level for saccading was close enough to the visual “signal” that the modulation averaged the same whether the animal saccaded to the target or not. For example, this happened when the pixel count was reduced from 16 to 4, maintaining catch trials at 20%, and also when the pixel count was 16 and the catch trials were raised to 50%. If the pixel count was reduced to 4 but the catch trial percentage was also reduced to zero, then the correlation between modulation and access was restored. These results show that the modulation does not reflect access to the target (since it was the same whether the target was or was not accessed). Nor does the modulation reflect the saccade, so it is on the sensory rather than motor side of the decision process. Nor does it reflect attention, since the detected targets can be assumed to draw more attention. The modulation seems to reflect something intermediate between the stimulus and access. In a classic signal detection analysis, Super, et. al., indeed showed that the modulation is an intermediate level representation that can be disconnected from access either by raising the perceptual decision criterion or by decreasing saliency of the stimulus, lowering the visual “signal” to the range of the decision criterion.

The modulation shown by Super, et.al. disappears under anesthesia [43] and is probably produced by recurrent processes [44], unlike other V1 representations like direction and orientation tuning. So there is some plausibility to taking it as an indication of if not directly part of a Phenomenal NCC for the experiential content of seeing the target. (See also [45])

Figure 3



TRENDS in Cognitive Sciences

Caption to Figure 3:

(a) Super, et. al. [42] trained monkeys to saccade from a fixation point to a target (bottom left of (a)). Initially, a fixation point was presented (top). Then a target texture was presented ('Fig texture on', left) or there was a homogenous pattern with no target ('Hom

texture on', right). If there was no target, the monkey was rewarded for maintaining fixation for 500 ms (right panels). The target could be in one of three locations. **(b)** The targets were areas of an overall pattern in which the lines were orthogonal to the rest of the pattern. **(c)** Super *et al.* recorded from sites in V1 whose receptive fields (RF) included those three locations in which targets could occur. When the monkey saccaded from the fixation point (Fp) to the target, the neural response from the target counted as 'figure' and the other two sites were counted as 'ground'. Figure responses were greater than ground responses after ~90 ms, as indicated in the orange shaded area (central panel). The shaded area indicates the degree of 'modulation'. When the targets were highly salient and the number of catch trials were few, modulation disappeared when the monkey did not detect the target (right panel). That is, when the monkey did not saccade to the target and the saliency was high and catch trials low, there was little difference between the activity in the part of V1 corresponding to the target and the two other locations, as indicated in the right-most panel of (c). (However, when the saliency of the target was low or catch trials high, there was a substantial difference.) Modulation also disappeared under anesthesia. Super *et al.* manipulated the saliency of the target by decreasing the size of the line segments used. The target shown in (b) is 16 pixels on a side, but they also used 8 and 4 pixel targets. For 16 pixel targets, modulation is present as shown in (c) when the target is detected and absent when the target is absent. But as the number of pixels is decreased, the difference between the case when the target is detected and not detected decreases, so long as the number of catch trials is held constant. When the pixel count is 4, there is no significant difference in modulation between detection and non-detection. Figures (courtesy of Victor Lamme) redrawn with permission from [42].

Can the Phenomenal NCC be Studied Empirically?

Doubts about whether phenomenal consciousness (and hence its neural basis, the Phenomenal NCC) can be studied empirically are common (See Box 4), and often based on the idea that ultimately, introspective reports, that is, reports about one's conscious experience, are the fundamental epistemological basis of theories of consciousness, the gold standard. [7, 31, 46]. Reports are not supposed to be infallible, but any discounting of reports as reporting too much or too little, will supposedly have to be based solely on *other* reports. Reports inevitably reflect the Access NCC, not just the Phenomenal NCC. When people tell you about their conscious states, you only hear about the ones that have won the winner-take-all competition. Hence we can only study "access to consciousness" [7], that is, access to experiential content, not experiential content itself. I do not agree with this methodological view for a number of reasons.

First, observed electrons can provide evidence about electrons that cannot in principle be observed, for example electrons that are too distant in space and time (i.e. outside our light cone) to be observed. Why should we suppose matters are any different for consciousness?

Second, there is no gold standard of evidence, here or in any area of science. We should go for the simplest theory compatible with *all* the evidence. *No evidence is privileged.* In particular, it is not true that our theory of consciousness should be completely determined by the introspective reports of subjects. An analogy: it is trivial to program two computers to yield the same input-output function via different algorithms. No theory of what goes on in computers based wholly on the computers' "reports", i.e. input-output relations, stands a chance of success. Why should we suppose consciousness is any different? Just as two computationally different computers can have the same input-output function, two brains that are different in conscious structure might at least in principle have the same input-output function.

Third, any neuroscientific approach that bases everything on reports about a subject's own experience is in danger of focusing on the *neural basis of higher order thought*—thought to the effect that I myself have an experience—rather than the neural basis of experiential content or even access to experiential content. In order to give an introspective report, the subject has to have a higher order thought—so to insist on introspective reportability as the gold standard is to encourage leaving out cases in which subjects have experiences that are not adequately reflected in higher order thoughts.¹⁰

Finally, even those who assimilate experiential content to its accessibility should not accept introspective reports as a gold standard. Animals have plenty of access to their experiences, but probably little in the way of higher order thought about them of the sort that could be the basis of an introspective report. Cowey and Stoerig [47] showed that monkeys that had been made blindsighted on one side and trained to make a visual discrimination in their sighted field, could make the discrimination in their blind field. However, when given the option, they preferred a third "nothing" response. This is evidence about the monkey's perceptual state that does not depend on any introspective reports.

¹⁰ Armstrong, Carruthers, Lycan and Rosenthal have argued for seeing consciousness in terms of higher order thought. One some versions of this view—for example Rosenthal's—experiential content can exist without higher order thought. Anyone who takes such a view should agree with me that a methodology focused exclusively on introspective report alone will be in danger of finding the neural basis of higher order thought rather than the neural basis of experiential content. The difference between the Rosenthal type view and mine is in part a view about whether the term 'consciousness' refers to a higher order state or to a first order state. (My view is that the term 'consciousness' is ambiguous and in one sense refers to a higher order state and in another sense a first order state.) But that difference about how the term is used is itself dependent (I believe) on a difference of opinion on whether the "Hard Problem" applies to experiential content. For someone who does not believe in the Hard Problem for experiential content, a higher order thought about such contentful states may seem a more worthy bearer of the term 'consciousness'.

But is the monkeys' button-pushing just a *non-verbal introspective report*? Non-human primates which have learned symbolic systems for communication may not even make spontaneous reports about the world [48, 49], so there is little ground for supposing that they are prone to reports about their own experience.¹¹ If a human were to push the "nothing" button, we might guess whether there is a thought underlying the response. We might consider two hypotheses: first, the *introspective report*, "I am having no visual experience" and second, the *environmental report*, "There is nothing on the screen". If the subject were a child of 3-4, the introspective report would be unlikely since children have a great deal of difficulty with states of mind about their own mental states [50, 51]. Given that the environmental report would be preferable even for a child, we can hardly suppose the introspective report would be preferable in the case of a macaque! The take home message is that you don't need reports *about the subject's experiences* to get good evidence about what the subject is experiencing: indications of what the subject takes to be in front of him will do just fine.

Where are we? I have proposed a distinction between a Phenomenal NCC and an Access NCC. The "single NCC" framework does not do as well in making sense of the empirical data, in particular Signal Detection Theory data as an account in which there are two NCCs, a Phenomenal NCC and an Access NCC. Of course both NCCs are to be firmly distinguished from perceptual representations that are not conscious in any sense (as in the right-most panel of Figure 3c). More generally, rather than asking "What is the direct evidence about the Phenomenal NCC independently of the Access NCC?" we should instead ask "What framework makes the most sense of the data?"

Box 4: Questions for Future Research

1. In visual extinction due to right parietal damage, the subject reports not seeing a stimulus on the left when there is a competing stimulus on the right. Rees, et.al. [52] showed that the fusiform face area (in the relevant hemisphere) of an extinction patient can be activated robustly when the patient says he does not see the face (because of a competing stimulus) though not quite as strongly as when the subject says he does see the face. One question is: is there *recurrent* activation of the relevant part of V1 in such a patient? A related question is: does the fusiform face area activation in such a patient show the enhanced figure modulation response described by Super, et. al.? If the answer to both turns out to be yes, that is evidence that recurrent fusiform face activation is a genuine

¹¹ There have been many claims of reports by non-human primates, for example, by Savage-Rumbaugh, but it is controversial whether those claims are based on trained-up responses given in the expectation of reward.

core Phenomenal NCC for face-experience, even though the subject says he doesn't see a face.

2. If indeed recurrent activation of sensory areas are the core Phenomenal NCCs, why? For example, why is recurrent activation of area MT/V5 (together with the unknown background activation) sufficient for visual experience of motion instead of some other experiential content or no content? That is a form of the infamous Hard Problem of consciousness.

[4]

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