

Brains blog on ‘Minority reports: Consciousness and the prefrontal cortex’ by Matthias Michel and Jorge Morales

‘Minority reports’ is, I think, an excellent paper. Michel and Morales’ paper is a response to a movement in consciousness science that argues that consciousness is located at the back of the head, rather than in the front. This debate, or something like it, has been going on for a while: Melloni, Singer and colleagues have been pushing claims that the NCC is early rather than late, and at the back of the head (Melloni et al. 2007; Melloni et al. 2011), rather than at the front, as claimed by proponents of Global Neuronal Workspace Theory and higher-order theories of consciousness (e.g. Brown et al. 2019; Dehanene et al. 2006). Recent arguments focus more on the results from no-report paradigms (e.g. Pitts et al. 2014; Tsuchiya et al. 2015), rather than the specific, and rather more sophisticated, methods that Melloni and colleagues seek to promote (e.g. Aru et al., 2012).

Ideally, to find the/a neural correlate of consciousness (NCC), the only difference between seen and unseen trials would be between whether the NCC was active or not – comparing seen and unseen trials would then easily allow one to identify it. However, if there are further contrasts between seen and unseen trials, then the neural differences between them might pick up on things other than the NCC. For example, if there are contrasts across whether pre-conscious processing is present or not, then differences in neural activity across seen and unseen trials may indicate pre-requisites for consciousness (NCC-pr), rather than consciousness itself. Similarly, if there are contrasts in the presence of post-conscious processing, then differences in neural activity across seen and unseen trials may pick out consequences of consciousness (NCC-co), rather than consciousness itself.

Critics of report-based paradigms (e.g. Boly et al. 2017; Pitts et al. 2014; Tsuchiya et al. 2015) claim that participants in seen trials, but not unseen trials, are maintaining stimulus-specific perceptual representations as a *consequence* of conscious perception. The claim is that it is this contrast, related to the consequences of conscious perception, rather than the intended contrast between conscious perception and non-conscious processing, that drives the identification of the neural correlates of consciousness. That is, researchers are identifying NCC-cos rather than NCCs (Table 1).

Table 1: Critical reading of neural contrasts in report-based paradigms from e.g. Pitts et al., Tsuchiya, etc. Contrastive analysis may well be identifying NCC-cos rather than/as well as NCCs, and perhaps NCC-pr.

	Pre-conscious processing (of stimulus) present? (NCC-pr)	Conscious processing of stimulus present? (NCC)	Post-conscious processing of stimulus present? (NCC-co)
Unseen trials (consciousness of stimulus absent)	Probably?	No	No
Seen trials (consciousness of stimulus present)	Yes	Yes	Yes

One of the key moves in ‘Minority Reports’ is to clearly identify what the difference really is between what participants have to do report-based paradigms in seen vs. unseen trials. Michel and Morales argue that in both seen and unseen trials, participants are likely using working memory to remember perceptual decisions (which they have to make in either case) rather than perceptual representations, so that there is in fact very little difference in the post-conscious cognitive activity found in both seen and unseen trials. In this case, the primary contrast is in fact between conscious perception and non-conscious processing (Table 2). In this case, many existing experimental results using report-based paradigms remain valid.

Table 2: Michel and Morales’ reading of contrasts in report-based paradigms. Main contrast is between NCCs, and perhaps NCC-pr.

	Pre-conscious processing (of stimulus) present? (NCC-pr)	Conscious processing of stimulus present? (NCC)	Exercise of cognitive faculties present?
Unseen trials (consciousness of stimulus absent)	Probably?	No	Yes (same format as for seen trials, but different content)
Seen trials (consciousness of stimulus present)	Yes	Yes	Yes (same format as for unseen trials, but different content)

As reviewed by the authors, there is also empirical evidence showing that PFC *is* active in relevant conditions, and more sensitive methods of analysis may pick up more evidence still that it is an essential NCC. For now then, I will just grant all of this. The comments below either bolster existing arguments in the paper, or suggest further problems for relying primarily on contrastive analysis in the search for NCCs.

1: What is being contrasted in no-report paradigms?

The aim of no-report paradigms is to get around at least some of the worries raised about using contrastive analysis to identify the NCC. As noted above, when using report-based trials, there is a worry that one may be identifying the correlates of the consequences of consciousness (NCC-co) as well as the ‘true’ neural correlate(s) (NCC) (see Table 1). In removing the need for participants to make explicit reports about e.g. whether or not they consciously perceive a stimulus, one removes a potential experimental confound by taking consequences of consciousness out of the picture (Table 3). Barring worries about participants still introspecting about seen stimuli during experimental trials (Overgaard & Fazekas 2016), grant this.

Table 3: Standard presentation of contrasts in no-report paradigms. Main contrast is between NCCs, and perhaps NCC-pr.

	Pre-conscious processing (of stimulus) present? (NCC-pr)	Conscious processing of stimulus present? (NCC)	Consequences of conscious processing present? (NCC-co)
Unseen trials (consciousness of stimulus absent)	Probably?	No	No
Seen trials (consciousness of stimulus present)	Yes	Yes	No

However, there is the curious status of the marker that is used instead of reports. One still needs a behavioural marker of some kind to distinguish between seen and unseen trials. The marker chosen usually highly correlates with reports, and so is intended to reliably distinguish seen from unseen trials. There are two options here.

First, the new marker could be a consequence of consciousness. In this case, while no-report paradigms could (depending on the marker chosen) eliminate activity related to post-conscious *high-level* cognitive functions, they do not necessarily eliminate all activity that is a consequence of consciousness. So, the activity found in seen vs unseen trials could still include instances of NCC-co (Table 4).

Table 4: Marker for a no-report paradigm is a consequence of consciousness. Contrasts present across all NCC-pr, NCC and NCC-co.

	Pre-conscious processing (of stimulus) present? (NCC-pr)	Conscious processing of stimulus present? (NCC)	Consequences of conscious processing present? (NCC-co)
Unseen trials (consciousness of stimulus absent)	Probably?	No	No
Seen trials (consciousness of stimulus present)	Yes	Yes	Yes

The other option is that the marker is a consequence of a reliable pre-requisite of consciousness. That is, it might be some regular physiological effect of pre-conscious (but not yet conscious) processing. The issue here is that depending on how tightly the marker correlates with the reports that are usually used for differentiating between seen and unseen trials, it might not very reliably differentiate between seen and unseen trials in no-report paradigms. It would instead differentiate between trials where *pre-requisites* of

consciousness are present, and where they are not, but this may not always translate into trials where consciousness was present and where it was not (Table 5). In this case one does not even have a clear contrast anymore across the main conditions (i.e. in presence/absence of NCC).

Table 5: Marker for no-report paradigm is a consequence of pre-requisite of consciousness. Contrasts present across NCC-pr and NCC.

	Pre-conscious processing (of stimulus) present? (NCC-pr)	Conscious processing of stimulus present? (NCC)	Consequences of conscious processing present? (NCC-co)
Unseen trials (consciousness of stimulus absent)	Probably?	Mostly no?	No
Seen trials (consciousness of stimulus present)	Yes	Mostly yes?	No

In this case, even if Michel and Morales' argument does not go through (I think it does), no-report paradigms are not a perfect methodological answer to the issue of how to identify the 'true' NCC using contrastive methods: they may either also track NCC-co, or not reliably track NCCs at all.

2: Different types of consequences

Somewhat related to this in the context of contrastive analysis, there is, I think, also a puzzle about conceptualizing what the NCC is, and how to locate it. Here is how Aru et al. discuss it:

"The existence of [post-conscious] processes is a logical consequence of assigning any function to conscious perception – if conscious perception enables certain processes that unconscious perception does not, these processes would inevitably appear in the contrast between trials with and without conscious perception, even if they are solely the consequences and not the direct correlates of consciousness. Importantly, most theories of consciousness do confer a function to consciousness in the chain of information processing...for instance sustained maintenance of information, access to long-term memory, novel combinations of operations, and intentional behavior." (p. 739, Aru et al.)

One question then is whether one can have conscious perception without any consequences of it (and how that impacts methodology). Normally, and as in the quotation here, the consequences of conscious perception are identified with high-level cognitive functions. But there can of course be lots of other types of consequences of conscious perception, including physiological effects, changes in learning profiles and long- and short-term local connectivity patterns, and other things that cannot be identified with the performance of high-level cognitive functions, and/or are not consciously accessible. Some of these things might happen automatically as a result of conscious perception.

Given this, one might think of the 'enabling' function of conscious perception in two different ways: conscious perception may 'enable' certain consequences in terms of causing them to occur in a strongly determined way, and in addition conscious perception may 'enable' certain consequences in terms of making it possible to perform certain cognitive functions on the contents of consciousness, where these are not strongly determined, and/or may vary according to task demands.

The issue for contrastive analysis is that even if one removes the demand for participants to engage with high-level cognitive processing, there may still be rather a lot of consequences of consciousness about. If these consequences rarely occur on unseen trials, but regularly/mostly/always occur on seen trials, then pulling NCC and NCC-co apart may be harder than imagined. (I think one can run the same story for NCC-pr too).

There are two other ways of thinking about this enabling function, linked with two different theoretical stances within the literature. One is treating the NCC as a state that is causally very close to the exercise of cognitive functions often associated with NCC-co. This mostly fits with GNWT: the NCC is a global state of 'ignition', with a lot of activity in pre-frontal areas that allows for various cognitive functions to occur. While consciousness might be (normally) operationalized using reports, it is not identical with the ability to report per se: it is identified with the global state that enables a wide range of cognitive functions. These cognitive functions may also be exercised through activity in pre-frontal areas (NCC-co), but they can be teased apart. A different way of thinking about this enabling function, coming from opponents to GNWT, is to reject the idea that there is this separate 'enabling' state of ignition, and to treat pre-frontal activity as just being identical with the *actual* exercise of cognitive functions. In this case, anything pre-frontal is by default treated as being an NCC-co.

These stances are of course informed by empirical work, but they are not purely empirical claims. If, for example, it turns out that there is a fair amount of activity found in pre-frontal areas in seen vs. unseen trials, GNWT proponents can claim this as evidence that pre-frontal activity is an NCC. GNWT opponents could though use the argument above to suggest that pre-frontal activity is merely a reliable and strongly determined consequence of conscious perception, and so still just an NCC-co. In sum, as ever, experimental data cannot by itself lead us to the NCC: a lot of theorizing has to happen along the way.

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