Review

The 'correlates' in neural correlates of consciousness

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A R T I C L E   I N F O

Article history:
Received 29 November 2010
Received in revised form 16 May 2011
Accepted 23 May 2011

Keywords:
Consciousness
Awareness
Correlates
Attention
Substrates
Prerequisites
Consequences
Sufficient
Necessary

A B S T R A C T

In the search for neural correlates of consciousness (NCC), the concept of 'consciousness' remains problematic. We suggest that not only the 'consciousness' in neural correlates of consciousness is a confused term, but 'correlates' is as well. When brain events are found to covary with conscious experience, these brain events can be the neural substrates of the experience, as is often (implicitly) suggested, but they can also be neural prerequisites or neural consequences of the experience. We here disentangle these different sorts of brain processes conceptually. But we also propose a concrete multi-pronged research program that may, in near-future consciousness research, distinguish these brain processes empirically.

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1. Introduction

The cognitive neuroscience of consciousness is blossoming. Age-old questions about where our experiences come from, centuries-old questions about what distinguishes conscious from unconscious processing, or recent questions about which exact
brain regions are involved in these conscious or unconscious processes, today we can address all these questions. The search for ‘Neural Correlates of Consciousness’ (NCC: Koch, 2004) has given rise to many theoretical proposals and debate (e.g. Cleeremans, 2006; Noé and Thompson, 2004) and has taken flight especially since science has been able to look directly into brains to both see and manipulate what happens there. Using a variety of experimental paradigms, conscious experience can be manipulated independently of stimulus parameters. This is important, because changes in our conscious experience are generally confounded by changes in external input. To isolate changes in conscious experience for study, these changes must be separated from changes in stimulation conditions.

One example is the multistable paradigm, in which a constant stimulus gives rise to alternating conscious experiences over time (e.g. Blake, 2001; Fox, 1991; Howard and Rogers, 1995; Kim and Blake, 2005; Kleinschmidt et al., 1998; Levelt, 1965; Wheatstone, 1838). While a participant engages in multistable perception, brain imaging methods such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) can be used to look at activity throughout the brain, to evaluate in which areas the activity covaries with conscious experience. Whereas the sequence of conditions in an fMRI experiment (the protocol) is usually defined by experimenters beforehand, in these kinds of studies the protocol is defined by the subject. He or she generally uses button presses to indicate which conscious percept is currently experienced. This subjective report then defines the timing and duration of conditions that are later contrasted in statistical analyses. In a set of binocular rivalry experiments, one form of multistable paradigm, one eye was continually presented with one image (e.g. a grating, or house), and the other eye with a second image (e.g. a face). The conscious experience alternated between the two images despite constant visual input, and the subjects indicated with button presses when, for example, a face or house was perceived. Activity related to these switches (Lumer et al., 1998; Lumer and Rees, 1999) or activity in house- and face-specific regions (Tong et al., 1998) were then evaluated to see which regions modulated their activation in response to subjective experience changes, rather than objective visual input. We will discuss the results of these experiments below, but it should be clear that brain areas thus revealed were related to consciousness. Since their activity correlated to conscious experience, such areas are commonly referred to as NCCs.

1.1. Multiple possible roles of NCCs

These studies were as important as they were interesting, since they offered early insights into brain mechanisms to do with consciousness-related processes. But in this writing, we would like to draw attention to a largely neglected conceptual problem within the cognitive neuroscience of consciousness. To look ahead, the problem is that several sorts of brain processes can correlate to consciousness and are therefore often lumped together. However, these processes can have rather different roles or meanings. In other words, there is not one consciousness-related process, there are probably several. And these consciousness-related processes are generally all grouped together under the banner of ‘NCC’. We suggest that this is no longer appropriate, or necessary. But before we can outline this issue in more detail, we will first need to make clear what we mean exactly by ‘consciousness’—so that it is unambiguous what we are discussing the correlates of. This is the ‘consciousness’ in neural correlates of consciousness. Then, we will outline the various types of brain processes that will correlate to consciousness. These are the ‘correlates’ in neural correlates of consciousness. It may come as a surprise that there is not one brain ‘correlate’ of a conscious experience, but we suggest there are actually three. We will distinguish them conceptually, but also proceed to suggest a program that may in future studies distinguish them empirically.

2. The ‘consciousness’ in neural correlates of consciousness

There are many classifications that can be made when it comes to ‘types’, ‘kinds’, or ‘definitions’ of consciousness. Consciousness remains, after all, one of the most ill-defined concepts in science and philosophy. In our view, one can distinguish between self-awareness, higher-order awareness, medical awareness, and consciousness as experience. Self-awareness, or self-consciousness, refers to all the aspects of our mind that create our perception of being some ‘one’ in a world consisting of ‘others’ and ‘things’. We perceive continuity in our being, personality, body, and perhaps even possessions and so on. Higher-order awareness is likely a form of consciousness that separates us from most animals. It involves those aspects of our minds that allow us to reflect on things, such as past, present, and future that form the foundation of (or perhaps are founded by) language. Medical awareness, or state-consciousness (e.g. Hohwy, 2009), is the state of being conscious, as compared to not being conscious. Medical awareness is the type of consciousness studied by researchers comparing sleeping versus awake (Massimini et al., 2005), healthy versus comatose (Owen et al., 2006), drugged versus sober subjects (Ferrarelli et al., 2010). But being in a conscious state is really more of a precondition for the kind of consciousness we are interested in here. Consciousness as experience, or sometimes called content-consciousness (e.g. Hohwy, 2009), is the actual phenomenal quality that is, at any given point in time, in the mind of a conscious person. Over time these contents of consciousness change, such as in a multistable paradigm, which means that a subject experiences different things (but is all the time conscious in the sense of ‘medically aware’). The experiences we collectively refer to have previously been dubbed ‘phenomenal awareness’ (Chalmers, 1996), or ‘qualia’. The information ‘presented’ in experiences is probably, in most cases, globally available to the information processing system that is the brain (Dehaene and Naccache, 2001; Tononi, 2004); meaning it has reached ‘access consciousness’ (Block, 2005). Such experiences, ‘qualia’, items in ‘content-consciousness’, phenomenal pieces of information, are the kind of consciousness we focus on in this article.

A short way of saying this is that the NCC research we are considering here is the type of research that evaluates what happens in the brain when we consciously experience one thing, rather than another thing. Often, as in our example above, this comes down to contrasting the conscious experience of one visual image with the conscious experience of a second visual image (such as a house versus a face).

3. The ‘correlates’ in neural correlates of consciousness

We have now distinguished different ‘types’, or ‘kinds’, or ‘definitions’ of ‘consciousness’. We also constrained our discussion to the type of consciousness that is ‘experience’, or ‘qualia’, also referred to as the ‘contents of consciousness’. To make such clear distinctions and demarcations constitutes one step forward. However, even within the NCC program as restricted to experiences, a conceptual entanglement remains. This is illustrated by the schematic in Fig. 1. Say, a human subject is tested in an fMRI experiment. A stimulus near perception-threshold is presented several times, sometimes perceived (conscious), sometimes not perceived (non-conscious). The activations in the brain are compared for the conscious versus the non-conscious trials. The differences in activation correlate to the differences in consciousness: we have
found an NCC! (Note that while we provide the example of an fMRI experiment with a resulting BOLD activation that is an NCC, nearly everything we say below applies also to NCCs of other kinds: fMRI BOLD activations, EEG frequency-band modulations or grand averages, single-cell spiking rates, and so on.)

We suggest that the NCC thus identified can reflect not one, but three things. The activation differences may be (part of) the neural prerequisites for the conscious experience, may be (part of) the neural consequences of the conscious experience, or may indeed be (part of) the neural substrate of the conscious experience itself.

3.1. Neural prerequisites

By neural prerequisites we mean that this activation (this neural event, or process) was necessary for the conscious experience to arise. If this activation or process had not occurred, we would not have been conscious of the stimulus. But, and this is our point, such activation or process is not itself the neural ‘instantiation’ of the conscious experience. Being an NCC does not automatically mean that the brain process identified ‘codes for’ the conscious experience. It merely correlates with it by being a necessary accompaniment.

In this context, one particularly difficult confounder in many consciousness experiments is attention. Attention plays a crucial role in the establishment of consciousness as indicated by classic psychological phenomena, such as the attentional blink (Luck et al., 1996) and inattentional blindness (Mack and Rock, 1998), both examples where a lapse or (mis)allocation of attention prevents a particular stimulus from reaching consciousness. The relation between attention and consciousness is so strong, that a rather severe debate rages on whether consciousness is really nothing more than attention, or stimuli reaching attention (Beck and Eccles, 1992; Koch and Tsuchiya, 2007; Mack and Rock, 1998; Merikle and Joordens, 1997; O’Regan and Noe, 2001; Posner, 1994; Velmans, 1996). Coming back to multistable perception, frontoparietal regions have been associated with perceptual switches and thus consciousness (Inui et al., 2000; Kleinschmidt et al., 1998; Lumer et al., 1998; Schoth et al., 2007; Sterzer et al., 2002). But frontoparietal regions have also been associated with attention (e.g. Corbetta, 1998; Coull et al., 1996; Naghavi and Nyberg, 2005; Nobre et al., 1999; Pessoa et al., 2003). Perhaps appropriate activity in frontoparietal regions is a prerequisite for conscious experience, because attention may be a prerequisite of conscious experience. We are not suggesting it here, but would attention and consciousness always go together (for example because nothing can reach consciousness without first being attended to, in a fashion), then any brain process responsible for conscious experience would always co-appear with the brain processes responsible for attention (al selection).

This scenario exemplifies the fundamental entanglement of neural prerequisites and substrates of conscious experience: they always co-occur. However, based on our view of prerequisites and substrates of conscious experience, this would not mean that attention and consciousness are the same, but rather the opposite! Some of the brain processes correlating to a particular conscious experience would be the actual substrates of that experience (of its phenomenal constituents, or qualia), while the ‘attentional brain processes’ would merely be prerequisites. This eternal co-appearance may seem impossible to tackle empirically, and thus prompt one to simply treat attentional and conscious processes as one and the same. We suggest that this step would constitute a premature forfeit. Neural substrates and prerequisites can still be disentangled, not only conceptually but also experimentally (see below). From each other, and from a third co-existing neural correlate of consciousness: neural consequences of consciousness.

3.2. Neural consequences

By neural consequences, we mean that an activation (neural event, process) was a result of the conscious experience. In other words, because the conscious experience was there, this activation arose. There can be two forms of this. To exemplify the first, a multistable paradigm might employ two images, namely a rose and a house. When we consciously experience an image of a rose, it reminds us strongly of the kind of roses our grandmother, recently passed away, grew in her garden. Thus, this image gives rise to a plethora of emotional and associative responses, all co-varying with the conscious rose-experience. But these resulting activations or processes are in themselves, again, not the neural instantiation of the experience.

However, this is a content-specific (or stimulus-specific), and probably subject-specific form of neural consequences, and it might be countered by using different kinds of stimuli, for example. There is a more general form of neural consequences of consciousness, which is potentially more problematic. The conscious experience itself may, as a consequence, trigger specific neural events: neural events that are always triggered. Thus, there is one real NCC that gives rise to the experience, but having an experience (i.e. any conscious experience) then triggers or alerts other areas, for instance to prepare responses, change alertness level, or just to say “oh wow, I just had an experience”. These content-invariant neural consequences may not be vital at all to the experience itself, but always follow any kind of conscious experience. In these cases, it would be
much harder to disentangle them than in the content-specific rose example, but we suggest possible courses of action below.

3.3. Neural substrates

The third option for the brain activation or process identified is that it is actually the neural instantiation, or substrate, of the conscious experience. In other words, this brain activation is directly underlying the experience, not a result and not a precondition and is the minimal neural activity that is sufficient for a specific conscious percept (Chalmers, 2000; Koch, 2004). In identity theory terms: this brain activation IS the conscious experience, or at least part of the brain activation that IS the conscious experience (note that the conceptual distinctions made apply in varying degrees whether identity theory, epiphenomenalism, or even dualism is adopted as the metaphysical starting point). Many studies of the NCC find brain activation differences as described in our examples and make (implicit or explicit) claims that the activation is the substrate, without considering the other two possibilities of prerequisite or consequence.

Hohwy (2009) recently argued that context- (experience-) NCC research, contrasting conscious versus non-conscious percepts, or one conscious percept versus another conscious percept, is methodologically problematic: the resulting brain activations or processes would not necessarily reflect the phenomenality of our conscious experience, but rather the selection of one conscious experience over another. Sympathetic to his distinction, which seems to touch on ours, we think both the phenomenality (corresponding to our ‘substrate’) and the selection (corresponding to our ‘prerequisites’) must occur in the brain and can (and do) appear in the brain activations (events, processes) identified in NCC studies. In fact, it is inherent to our schema that whenever a conscious experience X occurs, the prerequisites P and consequences Q, always co-occur.

Indeed, that is the root of the problem: X, P, and Q are all neural correlates of consciousness. But really, would not we like to know which brain processes, of all the NCCs that we are seeing in a particular experiment, are X, which are P and which are Q? To provide a concrete example, recent fMRI evidence has shown that activity in early retinotopic cortex follows consciously experienced size (Murray et al., 2006), color (Hsieh and Tse, 2010), and object identity (Hsieh et al., 2010), but not the physical stimulus itself. These neural ‘correlates’ of consciousness may reflect neural consequences of consciousness, neural substrates of consciousness, or even neural prerequisites of consciousness. How could we go about disentangling these options?

4. How to untangle the entanglement: empirically distinguishing the correlates

The question is: if neural prerequisites (preconditions) and consequences always co-occur with the neural substrate of a ‘quale’ (experience, content of consciousness), how can we ever separate the substrates from the non-substrates? We here propose five general approaches for a near-future cognitive neuroscience of consciousness, which we will apply to the frontoparietal cortex as a candidate for NCC.

4.1. Cross-literature integration

First, one could examine in the literature which brain activations or processes (almost) always correlate to awareness. In other words, which NCCs are invariant to the stimulation paradigm? We and others before us (e.g. Dehaene and Naccache, 2001; Rees, 2007) have noted that frontoparietal cortex activations seem correlated to conscious awareness in very different research paradigms using very different stimuli, for instance, in multistable paradigms (Lumer et al., 1998; Lumer and Rees, 1999; Schoth et al., 2007; Sterzer et al., 2002) and masking paradigms (Dehaene et al., 1998, 2001). We would argue that, if frontoparietal cortex is active in conscious trials (or perceptual switches), no matter what the experience is like (be it a visual rose, a blaring trumpet, a soft touch on the cheek), these frontoparietal areas are unlikely to be the substrate of neural experience. Rather they would likely be neural prerequisites or (content-invariant) consequences. Substrates of conscious experience are likely to be content-specific (but see below). After all, the visual experience of a rose is different from the visual experience of a grandmother’s face. Therefore, the brain processes underlying these two experiences must be different (and the exact same brain process cannot randomly yield one experience sometimes and the second experience at other times). Thus, a good starting point for separating neural substrates from neural prerequisites/consequences would seem to look for neural correlates of consciousness that are content-specific versus content-invariant.

A practical recommendation for resolving this issue might be to use newly emerging brain activation databases. For instance, Brain-Map holds a large number of published PET and fMRI studies and makes meta-analyses and cross-study overviews possible (Fox and Lancaster, 2002).

4.2. Brain interference methods

If the option of neural substrate is thus rendered less plausible for a given NCC, because it is content-invariant, the question is how to distinguish between neural prerequisites and neural consequences of consciousness. In the case of frontoparietal cortex, either both of frontal and parietal cortices could be prerequisite: for example causing the perceptual switches directly in a multistable situation (e.g. by starting a re-evaluation of the input; Sterzer et al., 2009; see also Carmel et al., 2010; Kanai et al., 2010; Zaretskaya et al., 2010). Similarly, either or both frontal and parietal cortices could be activated by consequence: for example if the breaking through to awareness of the current stimulus causes an automatic, salient, attention-grabbing response in frontoparietal cortex (e.g. de Graaf et al., 2011a). The second general approach that we advocate therefore is the use of brain interference methods to distinguish between these options.

Transcranial magnetic stimulation (TMS) is one method that allows us to change brain activity in relatively restricted brain regions non-invasively in conscious human volunteers. If a region is causally relevant for a particular task, TMS disruption of that region should result in changes on that task. Applied to consciousness in one example; if frontal cortex is a neural prerequisite for consciousness, TMS over frontal regions should be able to interfere with conscious perception. If frontal cortex activations frequently found in consciousness studies are ‘only’ neural consequences of conscious experience, then TMS should have no effects. Thus, TMS might be fruitfully applied to consciousness studies in regions beyond early visual cortex, where it already has documented effects on conscious and unconscious vision (Amassian et al., 1989; de Graaf et al., 2011b; Ro et al., 2004; Silvanto, 2008; Silvanto et al., 2005; Thielscher et al., 2010). The usefulness of TMS has been extended beyond merely introducing ‘noise’ to a particular region, since TMS can induce ‘virtual lesions’ (Pascual-Leone et al., 2000), raise excitability of a region (Hallett, 2007), and now has been shown able to induce frequency-specific oscillations in brain regions (e.g. Romei et al., 2010). This latter method we find particularly exciting, because we might thus use TMS to test whether NCCs found in EEG/MEG research are functionally relevant for conscious perception. Of course, the same logic applies also to other brain interference methods (such as tDCS, e.g. Rosenkranz et al., 2000), which may have varying advantages and applications.
4.3. Temporal information, effective connectivity, and pre-stimulus brain states

Third, timing information might be used. EEG is well-known for its high temporal resolution, and we would by default classify all the pre-stimulus ‘NCCs’ that have recently been found as part of the neural prerequisites of consciousness. For instance, pre-stimulus alpha power determines whether a liminal stimulus will be perceived (van Dijk et al., 2008), and even the phase of alpha-waves has a strong influence (Busch et al., 2009; Mathewson et al., 2009). Whether brain processes occurring after stimulus presentation (e.g. the 200 ms ERP negativity increase; Koivisto et al., 2008; Koivisto and Revonsuo, 2009) could automatically be defined as neural consequences of consciousness is a more difficult question. We do not believe they could, since it is not straightforward at which point in time our phenomenal awareness of a stimulus is ‘built’ (Breitmeyer and Ogmen, 2006; Koch, 2004; Wilenius and Revonsuo, 2007). But other methods are increasingly applied that operate in the temporal domain even if temporal resolution is notoriously low.

For fMRI, some form of temporal order can be inferred, either directly using BOLD chronometry (Formisano and Goebel, 2003) or with newer analysis tools including connectivity methods (dynamic causal modelling: Friston et al., 2003; Granger causality mapping: Goebel et al., 2003; Roebroeck et al., 2005; see de Graaf et al., 2010; for an fMRI application and de Graaf et al., 2009; for a comparison with TMS chronometry). If a regional activation is a neural consequence of awareness, this region should receive information, and arguably be active later, than modular regions that are hypothesized to be part of the NCC. Another temporal approach is to examine whether and how neural activity occurring before stimulus onset can predict the initial percept in multistable paradigms, thereby inferring the causal role of neural activity in determining conscious perception. It has previously been shown that pre-trial activity in higher cortical areas can be analyzed as a neural predictor of subsequent memory (Turk-Browne et al., 2006), perceptual decisions (Andrews et al., 2002; Hesselmann et al., 2008), motor decisions (Soon et al., 2008), and moment-to-moment fluctuations in cognitive flexibility (Leber et al., 2008). One can adopt this temporal approach and ask whether the initial dominant percept during an episode of perceptual rivalry (in multistable paradigms) can be determined or biased by pre-trial neural activity. In general, the interplay between pre-stimulus brain states and incoming stimulus inputs is likely to be a relevant part of neural prerequisites of consciousness.

4.4. Unconscious perception paradigms

However, although we have now detailed several approaches to separate neural prerequisites from neural consequences (using brain interference or temporal inference procedures), we have not yet delineated a true approach to separate neural substrates from the two non-substrates. This seems to us indeed the most severe challenge, but several advances could be made. First, by a process of elimination, brain processes that turn out to be consequences or prerequisites are not substrates. Second, neural substrates are likely to be content-specific, as mentioned above. However, even if a brain process is found to be content-specific, does this mean the identified brain process/activation is a substrate? One possible approach to specifically distinguish neural prerequisites and neural substrates of consciousness, in this regard, is to look for special cases in which the neural prerequisites of consciousness might be present without consciousness.

For example, with unconscious perception paradigms, one can present subliminal stimuli and ask what neural processes can still occur even without conscious perceptions. There are many recent studies showing that several brain regions can be activated even when stimuli are not consciously perceived (Dehaene et al., 2001; Fang and He, 2005; Haynes et al., 2005; Luck et al., 1996; Marois et al., 2004; Morris et al., 1999; Moutoussis and Zeki, 2002, 2006; Naccache et al., 2005; Pasley et al., 2004; Rees et al., 2000, 2002; Vuilleumier and Driver, 2007). These regions might contain neural processes that are not necessary for, but still always co-occur with, conscious perceptions in normal situations. Studies that thus show that FFA still shows face-specific activity in the absence of conscious face-perceives (e.g. Moutoussis and Zeki, 2002) demonstrate that activity in FFA alone is not sufficient for ‘face-qualia’, or the conscious experience of a face. Other studies show that even with ‘normal’ levels of activity in modular regions, such as motion area V5/hMT, conscious perception of motion need not occur (Goebel et al., 2001).

Applying this strategy the other way around; drawing conclusions based on a lack of activity in a region with or without conscious perception, is more difficult (de Graaf and Nack, 2011). But the strategy of finding regions that do activate during ‘unconscious perception’ should eliminate content-specific candidates (such as a certain level of BOLD activity in V5/hMT) as substrates of conscious experience. Subsequent studies should thus investigate, for example, whether various combinations of content-specific and content-invariant activations/processes are required for conscious experience.

4.5. Orthogonal attention, performance, and consciousness modulations

A special mention here for the problem of confounders. Among others, Koch and Tsuchiya (2007) are proponents of a conceptual separation of attention and consciousness, citing empirical support. However, even if attention and consciousness are not one, in most consciousness studies, attention seems to confound the NCC results. For instance, in multistable paradigms, a change in conscious experience surely affects the neural substrates in the NCCs. But it seems logical that a change in conscious experience also grabs attention, and it seems plausible that changes in attention might cause a change in conscious percept. So, whether these options are veridical or imaginary, they genuinely do confound NCCs in multistable paradigms. One way to investigate this issue is to start including (as much as possible) orthogonal attention manipulations in consciousness experiments. This can be done in multistable paradigms (for instance by allocation of attention to the perceived visual stimulus or to a different kind of stimulus or to a concurrent effortful task), but might also be done in other types of studies such as masking paradigms. We refer to a recent review for further considerations on separating attention and consciousness (van Boxtel et al., 2010).

A second confounder in many consciousness studies, particularly in masking paradigms, is task performance. Hakwan Lau points out that when consciousness differs, behavioural task performance often differs as well (Lau, 2008). Therefore, a purer look at correlates of conscious experience would require the delineation of conditions in which behavioural (visual) task performance is equal, while conscious experience differs. This can lead to new and interesting results (Lau and Passingham, 2006).

These two paradigmatic advances can certainly help future consciousness research to isolate the relevant neural processes behind conscious perception, even if they may not completely disentangle neural substrates, prerequisites, and consequences.

5. Conclusion

New methods and analysis tools, and a comprehensive search of the literature combined, should make it possible for future cog-
ractive neuroscience to begin a separation of neural prerequisites, neural consequences, and neural substrates of conscious experience. At the very least an awareness of these conceptual distinctions would be valuable for both fledgling and established consciousness researchers. At any rate, we suggest that it will not suffice to simply identify neural correlates of consciousness without any further consideration, if we truly want to understand what happens in the brain to establish conscious vision.

But we will end with an assumption and a warning. The assumption we make explicit is that all three brain processes correlated to conscious experience: neural prerequisites, neural consequences, and neural substrates can, in principle, be observed with brain imaging methods. Theoretically, the correlates of consciousness we see in the brain in many consciousness experiments performed today, could reflect only neural prerequisites and consequences (for example). The substrates themselves might be on a level of (organization, or of detail) that is beyond our current, and possibly future, imaging tools. This is a very pessimistic viewpoint, and there is no need to entertain it further, but the caveat should be kept in mind since this writing (along with most consciousness scientists) does assume that substrates of conscious experience are both in the brain and measurable.

The warning is the following: it may be tempting to conclude that any NCCs that are not content-invariant (thus content-specific) are by default neural substrates of experience, and that NCCs that are content-invariant are not substrates of experience. We would not go that far. For instance, there could be content-specific neural consequences, as in the grandmother’s roses-example, or even content-specific neural prerequisites. It could also be, and this would not be a good thing for consciousness purists, that content-specific brain processes interact with content-invariant processes and that this interaction itself is the neural substrate of conscious experiences. If that is the case, things may become a lot more difficult to disentangle empirically. But it is too early to tell, and we should at this juncture not be dissuaded by such prospects. Also, it could still be that in such a situation we could disentangle neural prerequisites, consequences, and substrates, with advanced methods and design.

For now, the distinction between the three aspects of NCCs should find its way into the consciousness community, particularly the empirical members, and we do believe that a lot can still be gained by starting on the practical research proposals we have here introduced.

Acknowledgements

T.A.G. and A.T.S. are supported by NWO, Dutch Organization for Scientific Research, grant numbers 021-002-087 and 452-06-003, respectively.

Funding: The research leading to these results has also received funding from the European Research Council under the European Union’s Seventh Framework Programme (FP7/2007–2013) / ERC Grant agreement n [263472].

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