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Commentary

Why the P3b is still a plausible correlate of conscious access? A commentary on Silverstein et al., 2015

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We read with interest the article by Silverstein and colleagues (Silverstein, Snodgrass, Shevrin, & Kushwaha, 2015) who questioned the putative specificity of the P3b event-related potentials (ERP) component as a neural signature of conscious access to a visual representation. Prior to this new study, numerous empirical reports revealed that a brain response peaking ~300 msec after stimulus onset and maximally distributed over parietal electrodes – the so called P3b – is closely related to subjective visibility (Sergent, Baillet, & Dehaene, 2005; Vogel, Luck, & Shapiro, 1998). These experimental findings provided the bases to develop neuronal and computational theories of consciousness such as the global workspace model (Dehaene & Changeux, 2011; Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Dehaene & Naccache, 2001). Silverstein and colleagues used a 'passive attentive' version of a masked visual odd-ball paradigm while recording scalp ERPs. In each trial, subjects were presented with either the masked word 'LEFT' (in 80% or 20% of trials) or the masked word 'RIGHT' (in 20% or 80% of trials). Word frequency was balanced across subjects, who were asked to carefully attend to the masked sequence. Not only were they instructed that this sequence contained a masked word, but also that: "however implausible it might seem, our prior data suggested that the stimuli would nonetheless be unconsciously perceived and produce brain wave effects – but only if they maintained their attention". When contrasting ERPs elicited by rare and frequent masked words, Silverstein and colleagues identified a P3b ERP component followed by a late, and sustained, slow wave (LSW). Given that participants subjectively reported the absence of conscious perception of words, and that they performed at chance-level in a stimulus detection task performed after the main experiment, Silverstein and colleagues concluded that a P3b can be observed during unconscious perception. If valid, their interpretation would then simply invalidate the P3b as a possible candidate neural signature of conscious access.

This original and provocative study, however, raises both methodological and conceptual concerns which need to be addressed before one can adopt Silverstein and colleagues' interpretation.

1. A set of methodological problems

The P3b is part of a larger complex of positive deflections – the so-called P300. Of particular importance here, the P3a can be

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functionally distinguished from the P3b: it is known to occur in the absence of conscious perception (Muller-Gass, Macdonald, Schroger, Sculthorpe, & Campbell, 2007) and even in non-conscious patients (Faugeras et al., 2012). Both the P3a and P3b are positive deflections and occur in similar time windows, but they can nevertheless be separated based on their topographies. The P3b is maximally distributed over parietal electrodes, while the P3a is more frontally distributed. The spatial sampling of the EEG signal is therefore critical to separate these ERPs. Surprisingly, the authors only used 3 midline (Fz, Cz, Pz) electrodes referenced to linked ears, as well as 2 electrodes at the right eye to detect eye movement artifacts. As expected for a P3b component, the effect reported by Silverstein and colleagues was maximal over Pz, but we simply do not have access to the scalp topographies of the ERP effects reported in this work. We agree that there is no intrinsic relationship between the number of electrodes and the quality of a result, but in the context of distinguishing P3b from P3a ERP components this limitation turns into a genuine problem.

In the same vein, one of the most reliable findings in the vast odd-ball literature, is the existence of a N2 and mismatch negativity (MMN) ERP effect occurring before the P3 complex (Tiitinen, May, Reinikainen, & Naatanen, 1994). The apparent absence of such an effect (a small inverse difference is seen in Figure 2) confirms the necessity of sampling brain activity with a richer spatial resolution in order to reliably describe the observed effects.

Moreover, shortcomings in the statistical analyses of the ERPs deserve further discussion. Visual inspection of the 'effects' suggests that the effect size reported by Silverstein et al. are not substantially different from fluctuations within the baseline and from other periods of the ERPs (see e.g., Figure 2C). Actually, the authors did not assess significant differences on the entire time course of the ERP but only on predefined time windows. Thus it is impossible to determine whether the reported effects are temporally and spatially precise and specific to the P3b. A better approach would consist in performing non selective sample-by-sample tests, and then identifying temporal clusters during which ERPs significantly differ.

More importantly, although the article by Silverstein et al. opens by asking the fundamental question "How can perceptual awareness be indexed in humans?", their experimental design is lacking the crucial comparison of the unconscious 'P3b' with its conscious equivalent. Rather than using exclusively masked trials, the authors could have added unmasked trials, in order to compare the properties (latency, amplitude and effect size, duration, topography) of conscious and unconscious ERP effects. By doing so previous studies could identify specific components of conscious access (Dehaene et al., 2006). From a theoretical perspective, we previously mentioned and modeled the possibility for a masked stimulus to "evoke transient workspace activity of variable intensity and duration" (see also Figure 1 in Dehaene & Naccache, 2001). Such transient and partial activation of the workspace could appear as brief and small patterns of activity distinct from a large and sustained P3b component. Therefore, without this crucial conscious contrast, it becomes almost impossible to precisely qualify the observed ERP effect.

It is noteworthy that according to our theory, conscious access associated with the P3b is also associated with other signatures (Gaillard et al., 2009) such as: long-range synchrony in theta–alpha–beta band, decrease of alpha power, and late increase of gamma power. None of these neural signatures, complementary to the P3b, are tested here and the nature of the observed ERP effects therefore remains unclear.

Additionally, the interesting use by Silverstein et al. of 'LEFT' and 'RIGHT' as target words opened the possibility of complementing the results by lateralized readiness potentials (LRPs) analyses. Such analyses proved to be very useful to explore both unconscious and conscious processing of masked primes (Dehaene et al., 1998; Eimer & Schlaghecken, 1998). Unfortunately, the use of only 3 midline electrodes, and the absence of C3/C4 electrodes precluded this interesting complementary approach.

Furthermore, from a Bayesian perspective, we think the authors should have mentioned and discussed more extensively the large set of empirical evidence that their finding seems to contradict: numerous studies conducted in normal controls as well as in many clinical settings (e.g.,: blindsight, visual neglect) support the P3b theory by reporting rich unconscious processing of visual stimuli without any late P3b signature (for a review see Dehaene & Changeux, 2011). This literature, acting here as a strong prior against Silverstein and colleagues interpretation, needs to be addressed.

2. Conscious metacognition of unconscious perceptual processes?

Beyond these notable methodological issues, this article also raises a more profound question. The major difference between this study and previous studies rests in the fact that subjects were told from the very beginning of the presence of masked stimuli, and were instructed to pay attention to them very carefully. Therefore, even if we discard the methodological issues we just raised, and consider that these results are correct, it may be the case that the P3b signature observed here between deviant and standard stimuli corresponds to a metacognitive effect, that is to say to conscious access to the consequence of unconscious processing of masked primes. For instance, a motor effect induced by the processing of the rare 'LEFT' prime (or 'RIGHT' for other subjects) in motor areas may well lead to conscious access to a subjective confidence information that the prime was deviant or standard. By amplifying subjects' attention to monitor prime processing, this metacognitive interpretation may well explain the striking pattern of results reported here. Interestingly, a growing empirical evidence demonstrates that a large class of unconscious cognitive processes are strongly influenced by the conscious posture and endogenous attentional allocation (Naccache, Blandin, & Dehaene, 2002). In addition to such an amplification, it might be the case that subject informed of the presence of subliminal stimuli could more easily introspect a form of surprise originating either from perceptual or from motor-related areas ('LEFT', 'RIGHT'). In other words, this study may illustrate conscious access to the downstream effects of an unconsciously perceived stimulus. Interestingly, a recent study using a visual masked priming paradigm

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reported that the conflict between masked prime and visible target stimuli modulated two ERP components (Desender, Van Opstal, Hughes & Van den Bussche, 2016): an early N2 component, as well as a late P3 complex. During this experiment, subjects had to perform two tasks on each trial: they first had to respond to the target, and then to introspect the difficulty of the trial. Nicely, introspection of the prime-target conflict elicited by the unconscious processing of the prime was possible, and correlated only with the P3 component. Similarly, in the study by Silverstein and colleagues, one may suppose that the P3b component and the LSW they observed correspond to the conscious introspection of processes elicited by the unconsciously perceived prime.

As a conclusion, if the results reported in Silverstein et al. do correspond to a genuine P3b ERP component (but see our methodological concerns above), they may elegantly illustrate the complex relations prevailing between conscious and unconscious processes, and still not refute the relationship prevailing between conscious access and the P3b ERP component.

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