

Psyche, attention and consciousness

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It is a great pleasure to re-launch *Psyche*. As the journal of the Association for the Scientific Study of Consciousness (ASSC), the mission is to provide a prominent forum for the communication of scientific efforts to understand consciousness. With $\sim 10^{11}$ neurons and $\sim 10^4$ synapses per neuron, understanding how the human brain can achieve consciousness is arguably one of the biggest challenges that humans have ever attempted. Progress will depend on the rigorous interplay of numerous researchers coming from several different disciplines and the interaction of ideas from different fields. In this light, *Psyche* is not restricted to a particular approach or experimental technique but aims to encompass and integrate different scientific efforts.

For those of us interested in understanding consciousness, this is arguably one of the most exciting times in History. Although consciousness has been a matter of much debate over centuries, we did not have the right tools to even begin asking the appropriate questions. It is conceivable (although not certain by any stretch of imagination) that sometime in the future, some of the basic mysteries will be solved. We are part of that transition period, full of information, chaos, excitement, novel ideas, new techniques, new theories and new measurements. It is our hope and goal that *Psyche* will play a fundamental role in this transition.

Psyche now has a new web site (<http://journalpsyche.org/>), new editors (Robert VanGulick and Gabriel Kreiman) and a distinguished set of scientists and philosophers who have agreed to help and are part of the new editorial board (check the web site for the full list).

We start with a Special Symposium entitled "Attention and Consciousness" that addresses a central ongoing debate about the relationship between the mechanisms responsible for attentional processing and consciousness. These articles are written by prominent researchers coming from different fields and using different perspectives. We hope that these articles illustrate the power of integrating different approaches to understanding consciousness.

As reviewed by Posner in this volume, modern psychologists, philosophers and neuroscientists distinguish several components of attention: (1) a top-down, endogenous, goal-related, task-relevant, central-executive component; (2) a bottom-up, exogenous, task-irrelevant component and (3) arousal or alertness component. As to consciousness, most scientists distinguish between (1) consciousness as awake and aroused states (as opposed to coma, dreamless sleep, and anesthesia) (See Cavanna and Nani in this volume); (2) the contents of consciousness, such as visual color, tactile sensation,

emotion, etc. The contents of consciousness can in turn be divided into two types; (2a) phenomenal/experiential consciousness (i.e., qualia) and 2b) access/reflexive consciousness (Block, 1996; Zeman, 2001; Koch, 2004; Block, 2007). Most of the arguments in this Symposium discuss the relationship between top-down attention and the contents of consciousness, but other components are also considered.

The relationship between attention and consciousness has been debated since the beginning of psychology (James, 1890). Although few would argue against the idea that they are intimately related psychological processes, the exact nature of the relationship remains unclear. One school of thought claims that only attended objects give rise to conscious awareness and that only consciously perceived objects can be attended. In other words, attention and consciousness are considered to be very tightly interwoven, if not the same mental processes with attention being necessary and sufficient for consciousness (Posner, 1994; Jackendoff, 1996; Velmans, 1996; Merikle and Joordens, 1997; Chun and Wolfe, 2000; O'Regan and Noe, 2001; Prinz, 2004). An alternative school of thought claims that attention and consciousness are distinct processes with differentiated functions and neuronal mechanisms (Iwasaki, 1993; Baars, 1997; Hardcastle, 1997; Kentridge et al., 1999; Naccache et al., 2002; Lamme, 2003; Koch, 2004; Dehaene et al., 2006; Koch and Tsuchiya, 2007; Tsuchiya and Koch, 2008).

Recent psychophysical and neurophysiological studies have provided experimental support for 'attention without consciousness' (for review see Koch & Tsuchiya 2007). On the other hand, 'consciousness without attention' has been controversial. To some, consciousness without attention is an obvious fact because we can always perceive stimuli in the periphery, outside the focus of attention. Dual-task paradigms experimentally support this idea: non-trivial tasks, such as scene categorization (Li et al., 2002), gender discrimination (Reddy et al., 2004), and face identification (Reddy et al., 2006) can be performed in the "near absence" of attention. Yet, dramatic demonstrations of change blindness (Simons and Rensink, 2005) and inattention blindness (Mack and Rock, 1998) show that we are not aware of very large changes in the display unless top-down attention is employed. These results suggest that our awareness at the periphery is merely 'illusory'; unless we deploy attention to the periphery, we actually cannot perceive any peripheral information (O'Regan and Noe, 2001). Likewise, the dual-task results have been criticized because some attention may be spilling over into a peripheral target when subjects attempt to report on it (See Taylor, this volume).

Although it might be difficult to show 'consciousness in the complete absence attention' experimentally, one could show the opposing effects of consciousness and attention (Koch and Tsuchiya, 2007). Afterimages, low spatial frequency target detection and implicit learning are potential examples where attention impairs performance while conscious awareness of the stimuli improves the performance. Similar examples in attentional blink (Olivers and Nieuwenhuis, 2005) and decision making (Dijksterhuis et al., 2006) are discussed by Posner and Shelton et al. in this volume, respectively.

Posner gives a succinct update of his previous position (Posner, 1994). He first distinguishes three definitions of consciousness, each of which is associated with a

different attentional network. As to some evidences that show dissociation between attention and consciousness (Olivers and Nieuwenhuis, 2005), Posner suggests that it is crucial to dissect attention and consciousness into even finer components, such as “ambient awareness” and “focal awareness” (Iwasaki, 1993). Finally, Posner considers what the most important “Hilbert” questions are in the field as well as what kind of methods would be necessary to solve these questions.

Ghorashi et al combine two distinct psychological illusions in order to dissociate consciousness from attention. First, to manipulate the contents of consciousness, they use attentional blink to render the target invisible in about half of the trials. Further, to infer the locus of spatial-attention during attentional blink, they use the shooting line illusion (Hikosaka et al., 1993). With those two illusions at hand, they distinguish conscious awareness of the location and the identity of the object. When the identity of the target is correctly perceived (i.e., attentional blink is not effective), attention is attracted to the target location. Next, when the target is rendered invisible due to attentional blink, attention is not drawn to the invisible target. Interestingly, when the location, but not the identity, of the target is consciously perceived, it is not sufficient to attract attention. The authors suggest there are several levels of attention and consciousness, requiring further behavioral studies.

Shelton et al review models of working memory and emphasize that the contents of consciousness usually overlap with the current focus in working memory, whose information is selected by an attentional process, suggesting the tight relationship among working memory, attention and consciousness. They point out that all the models contain a working memory component, whose information is not accessible to conscious awareness. The function of such a component is discussed in relation to the recent findings by Dijksterhuis that show that unconscious processing can produce a more desired outcome in certain situations. Shelton and colleagues suggest maintaining information about items within the conscious working memory system can interfere with some cognitive operations.

Bartolomeo reviews evidence from neuropsychology, anatomy, and fMRI and considers the relationship between exogenous/endogenous attention, contents of consciousness, and access consciousness. Based on the experiments in visual neglect patients, Bartolomeo claims that exogenous attention supported by front-parietal networks produces primary perceptual consciousness.

Cavanna and Nani argue that attention and consciousness can be orthogonally defined functionally, however, they realize those two functions are often mapped into overlapping brain regions in neuroimaging experiments. They suggest the recurrent processing within fronto-parietal association areas may represent the intersection among attention, contents of consciousness, and consciousness as wakefulness.

Taylor reconsiders the experimental evidence for dissociation between attention and consciousness from a viewpoint of his CODAM model, suggesting it is yet not necessary to consider the independence of attention and consciousness even in those

cases. Taylor concludes that attention is a necessary but not sufficient condition for consciousness. He also lists up five “Hilbert” questions.

The articles in this Symposium discuss the “Hilbert” questions in the field. Progress in science is achieved not only by new technologies, new methods and new answers but also by the ability to pose the right questions at the right time. We hope that some these Hilbert questions will inspire researchers in the field to take new challenges and to think about ways to open new doors and push the frontiers of consciousness research.

- Baars BJ (1997) Some essential differences between consciousness and attention, perception, and working memory. *Conscious Cogn* 6:363-371.
- Block N (1996) How can we find the neural correlate of consciousness? *Trends Neurosci* 19:456-459.
- Block N (2007) Consciousness, accessibility, and the mesh between psychology and neuroscience. *Behav Brain Sci* 30:481-499; discussion 499-548.
- Chun MM, Wolfe JM (2000) Visual attention. In: *Blackwell's Handbook of Perception* (Goldstein EB, ed), pp 272-310. Bla.
- Dehaene S, Changeux JP, Naccache L, Sackur J, Sergent C (2006) Conscious, preconscious, and subliminal processing: a testable taxonomy. *Trends Cogn Sci* 10:204-211.
- Dijksterhuis A, Bos MW, Nordgren LF, van Baaren RB (2006) On making the right choice: the deliberation-without-attention effect. *Science* 311:1005-1007.
- Hardcastle VG (1997) Attention versus consciousness: A distinction with a difference. *Cognitive Studies: Bulletin of the Japanese Cognitive Science Society* 4:56-66.
- Hikosaka O, Miyauchi S, Shimojo S (1993) Voluntary and stimulus-induced attention detected as motion sensation. *Perception* 22:517-526.
- Iwasaki S (1993) Spatial attention and two modes of visual consciousness. *Cognition* 49:211-233.
- Jackendoff R (1996) How Language Helps Us Think. *Pragmatics and Cognition* 4:1-34.
- James W (1890) *Principles of psychology*. London: Mac Millan.
- Kentridge RW, Heywood CA, Weiskrantz L (1999) Attention without awareness in blindsight. *Proc R Soc Lond B Biol Sci* 266:1805-1811.
- Koch C (2004) *The Quest for Consciousness: A neurobiological Approach*. CO: Roberts and Publishers.
- Koch C, Tsuchiya N (2007) Attention and consciousness: two distinct brain processes. *Trends Cogn Sci* 11:16-22.
- Lamme VA (2003) Why visual attention and awareness are different. *Trends Cogn Sci* 7:12-18.
- Li FF, VanRullen R, Koch C, Perona P (2002) Rapid natural scene categorization in the near absence of attention. *Proc Natl Acad Sci U S A* 99:9596-9601.
- Mack A, Rock I (1998) *Inattention blindness*. Cambridge, Mass.: MIT Press.
- Merikle PM, Joordens S (1997) Parallels between perception without attention and perception without awareness. *Conscious Cogn* 6:219-236.

- Naccache L, Blandin E, Dehaene S (2002) Unconscious masked priming depends on temporal attention. *Psychol Sci* 13:416-424.
- O'Regan JK, Noe A (2001) A sensorimotor account of vision and visual consciousness. *Behav Brain Sci* 24:939-973; discussion 973-1031.
- Olivers CN, Nieuwenhuis S (2005) The beneficial effect of concurrent task-irrelevant mental activity on temporal attention. *Psychol Sci* 16:265-269.
- Posner MI (1994) Attention: the mechanisms of consciousness. *Proc Natl Acad Sci U S A* 91:7398-7403.
- Prinz J (2004) *Gut Reactions*. New York: Oxford University Press.
- Reddy L, Wilken P, Koch C (2004) Face-gender discrimination is possible in the near-absence of attention. *J Vis* 4:106-117.
- Reddy L, Reddy L, Koch C (2006) Face identification in the near-absence of focal attention. *Vision Res* 46:2336-2343.
- Simons DJ, Rensink RA (2005) Change blindness: past, present, and future. *Trends Cogn Sci* 9:16-20.
- Tsuchiya N, Koch C (2008) The relationship between consciousness and attention. In: *The neurology of consciousness* (Laureys S, Tononi G, eds).
- Velmans M (1996) *The science of consciousness*. London: Routledge.
- Zeman A (2001) Consciousness. *Brain* 124:1263-1289.