Letters Response

Attentional pointers: response to Melcher

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Melcher appears to have misunderstood our opinion piece on attention pointers [1], or perhaps we did not state it clearly enough. We did not claim that when it comes to visual stability, the attention system does the work. The oculomotor system does the work and the attention system comes along for the ride. The performance benefits that comprise the central properties of spatial attention appear to be parasitic on the functions of the eye movement control system [2]. As reviewed by Awh *et al.* [3], stimulation of cells in the saccade control centers triggers attentional benefits at corresponding retinotopic locations. However, when the eyes move, the activity in saccade centers is shifted to the locations that targets of interest will have following the saccade. Attention does not do this shift work, but the consequence is that attentional benefits will then be at the appropriate locations following the saccade.

To summarize, the saccade control centers maintain a set of potential target locations as peaks of activity. If the activity at one location crosses a movement threshold (while subcortical neurons are controlling the fixation pause [4]), a saccade is triggered. At lower levels of activity, these location pointers confer attentional benefits at the corresponding retinotopic locations in early visual cortices [3]. That is why we called these peaks of activity in saccade centers attentional pointers. Shifting these pointers at the time of saccades is a service of the oculomotor system that keeps the attention pointers appropriately aligned with targets of interest.

By contrast, we were clear that there is nothing in these pointers that relates to features. They are not, in our proposal, feature-specific in any way, although experiments might show them to be so in the future. We did note that there must necessarily be a link between the location information of a target (its attention pointer) and some other set of identity information about the target. The combination of the identity with location would correspond to the putative structure of 'object files' [5]. The nature of this link is central to the understanding of visual processing in general, as well as spatiotopy in particular, as pointed out by Melcher [1].

We also suggested that these attention pointers, coupled with a link to their target identity, allow high-level spatiotopy: we know where the target is after the eye movement so we know what its properties are even before we start to re-encode them from its new location. This can easily lead to spatiotopic priming (e.g. [6]). By contrast, it is not clear that the information stored about an object includes the adaptation state of the cells that are encoding it. It is this information that would have to be transferred to generate the spatiotopic aftereffects (e.g. [7]) that have been difficult to replicate (e.g. [8]). Therefore our distinction between the presence of high-level spatiotopy (for identity, in the form of priming) and the absence of low-level spatiotopy (for aftereffects) is straightforward. The link between location and identity is a very general requirement of visual processing and the lack of evidence of where or how it works is a challenge for all visual science and is not a weakness of our proposal in particular.

Finally, these attention pointers and their shifts at the time of saccades are sufficient to explain that apparent motion seen between two successive stimuli is based on spatial coordinates and not retinal coordinates when a saccade intervenes between the first and second stimulus [9]. However, Melcher points out that some types of apparent motion cannot be explained by mere shifts between the centers of the two stimuli. In particular, if the stimuli have different shapes, a transformation is seen between the two [10] even across a saccade [1]. Clearly, a shift of a pointer is not sufficient to explain this phenomenon. Our interpretation is not that the pointers are linked to features such as shape, but that the activity pattern on the saccadic map is shaped like the target. We have evidence of this in a recent remapping study using fMRI [11]. In line with previous fMRI studies of remapping (e.g. [12]), saccades generated BOLD activity in early retinotopic cortices at an expected post-saccadic retinotopic location of a target even though the target was removed before the saccade landed and so was never present at that location. In our case, the target had a wedge shape that changed orientation on each saccade, and indeed the spatial pattern of the remapped activity was correspondingly wedge shaped, rotating in step with the stimulus.

Given that the activity pattern confers attentional benefits on the corresponding location in early cortex (which is where we were measuring the BOLD activity), this shaped pattern of activity, if it holds up in future studies, also makes sense of object-based attention [13] where attention to one part of an object spreads throughout the object. Admittedly, calling this target-shaped activity pattern a pointer goes beyond the usual meaning of 'pointer'. Nevertheless, it does 'point' in that it indexes all locations within the object. A better label could emerge but 'target-shaped attention pointers' is not it, so we still favor 'attention pointers'.

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Book Review

Interpreting brain images: reflections on an adolescent field

Foundational Issues in Human Brain Mapping
by Stephen José Hanson and Martin Bunzl, The MIT Press, 2010. $38.00/£28.95 (321 pp.) ISBN 978-0-262-51394-4

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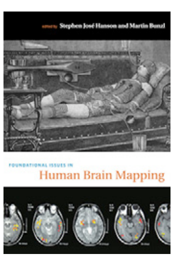

Functional brain imaging is maturing, but still adolescent. The field has developed a rich toolbox of experimental and data analytical techniques and is addressing an ever expanding range of questions about brain and mind – at various levels of methodological rigor. Some of these questions (e.g. romantic love) are difficult to pin down with science. Occasionally, results are naively overinterpreted in scientific papers and in the media. It is appropriate then to reflect on our basic assumptions.

This edited book is a useful collection of conceptual and methodological arguments on how to best use imaging to learn about cognition and brain function. The issues range from experimental design and analysis to theoretical interpretation of the results, spanning multiple disciplines, including statistics, computational modeling, cognitive and brain theory, and philosophy.

Imaging seems to explain the fluff of the psyche at the level of the hardware and it combines the prestige of serious science with the broad appeal of intuitive images. This combination is dangerously seductive. The brain blob has the power to make us believe, however tenuous its link to the proposition in question.

But brain images are not like photographs, direct and simple reflections of their content matter. We must not jump from a colored blobs to mental conclusions. Instead we need to consider the intervening inferential steps: the blob through the statistics reflects the imaging signal, which reflects the hemodynamic response to neuronal activity, which in turn might or might not underlie the mental phenomenon (Roskies; parenthetical names refer to chapter authors). These perils notwithstanding, our intuition is fundamentally correct: brain images really do afford discovery ('Will any region be found?' 'If so, which one?') and substantial theoretical insight into brain information processing.

Since the cognitive revolution, we have been constructing theories about information processing in the brain. Initially our models of cognition were based on behavioral data alone. Despite ingenious methods for inferring internal processes, cognitive theory is vastly underconstrained by behavioral data: there are many different theories consistent with the data. Brain imaging can help not only to localize functions anatomically, but also to better constrain theories at the cognitive and neural levels (Coltheart; alternative perspectives by Mole and Klein; Harman; Loosemore and Harley; and Bechtel and Richardson).

One challenge of engineering (or reverse engineering) an information-processing system is functional decomposition: how is the complex process to be divided into functional subcomponents implemented in separate physical parts of the system?

In building computers and algorithms, we divide the system into modules such that interactions across boundaries are limited. This enables us to reason about the system at a higher level of description, where we can safely

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