Trends in Cognitive Sciences

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Letter

High Action Values Occur Near Our Body

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In a recent Opinion article Bufacchi and Iannetti (2018) [1] claim that peripersonal space (PPS) – the space immediately adjacent to one's body – is widely considered to be 'a single entity, with binary in-or-out boundary, and mostly dependent on stimulus proximity to the body'. In counterpoint, the authors argue that PPS should not be conceived as an area of space demarked by a strong boundary but instead as 'fields' computing 'contact-related behavioral relevance' [1]. They argue that this conceptualization (i) allows PPS measures to change gradually with distance, (ii) reflects the fact that there are many different PPS measures showing different response profiles, and (iii) explains the functional significance of the values composing PPS. Regarding this last point, they suggest that '[t]here is no reason to think that . . . stimulus proximity is more important to PPS measures than any of the other factors they are sensitive to'. We fully agree with (i) and (ii); PPS should be conceived as a gradient and as plurality of representations [2]. Contrarily, we argue that, although PPS can be conceived as a 'value field', and this definition indeed allows disparate neural networks (e.g., reward systems) to interact with the PPS network, 'value' for PPS neurons is nevertheless defined by proximity to the body and is encoded by a specific population of multisensory neurons.

Bufacchi and Iannetti (2018) [1] argue that, because a whole host of phenomena (e.g., tool-use, personality traits) modulate the size and shape of PPS, when indexing PPS we are in fact measuring the value of performing a particular action, given the structure of our environment and our action possibilities. This argument is appealing in that it places PPS within the perception-to-action continuum [3], in line with the location of PPS neurons within sensorimotor frontoparietal networks [4]. Further, because 'values' are the measure of interest, this theory reinforces the fact that PPS-related processing can occur in areas beyond frontoparietal networks, such as in prefrontal and limbic areas. This framework beyond classic sensorimotor loops helps to clarify how, for instance, the perceived moral quality of a conspecific [5] or idiosyncratic phobias [6,7] can modulate PPS. Lastly, the theory provides clear leverage on wide-open questions within the field, specifically from the perspective of developmental psychology and computational modeling. Namely, if one ascribes the PPS literature to 'value' computation, we would need to suppose that PPS is matured over development as a consequence of reinforcement learning.

Taking the reinforcement learning perspective further, however, leads to the conclusion that, in principle and given enough time, PPS values (most of them close to zero) will exist for all space and time coordinates. For example, there is a particular value in my taking action today for a potential consequence in 10 years. This possibility, however, refers back to the earlier neurophysiological literature (e.g., [8,9]) which is notorious because it holds that particular actions – those that are most relevant because of spatiotemporal proximity – are directly mapped onto specific neurons. Even though a larger neural network, including reward centers, may be involved in computing the value of executing any possible action at all possible positions in space and time, the matter of the fact is that there are specific multisensory neurons that encode potential contact and action possibilities in near space and time [10,11]. Thus, although Bufacchi and Iannetti [1] provide an appealing functional view, from a neurobiological standpoint it is simply the case that neurons with explicit proximity tuning – via spatially overlapping, body part-centered, multisensory receptive fields – have been described [8,9]. Likely, these neurons exist because the physical laws of our environment are such that objects move gradually across space/time and do not jump instantaneously across these dimensions. Further, tactile receptive fields are anchored on our body, we can only manipulate and physically interact with objects near us, and damage to our bodies implies direct physical contact. Thus, the value of performing a goal-directed action or avoiding a threat is by necessity higher in close spatiotemporal proximity. In turn, as Bufacchi and Iannetti [1] propose, it is possible that values associated with particular actions are computed in a distributed manner, but it seems equally true that high values are encoded explicitly in PPS neurons and that the defining characteristic of these neurons is the fact that they encode proximity. In other words, we propose that value functions across the entirety of space and time may be computed/approximated in a distributed manner – the only way this is feasible, given the computational burden. Importantly, these values only cross a certain threshold, leading to potential defensive or goal-directed behavior, when a stimulus is in close spatiotemporal proximity – because they are explicitly hard-coded in PPS neurons. This hard coding is ill suited for flexibility, but is fundamental for adaptive fast reactions.

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