Trends in
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Spotlight

Action observation network: domain-specific or domain-general?

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The action observation network (AON) has traditionally been thought to be dedicated to recognizing animate actions. A recent study by Karakose-Akbiyik *et al.* invites rethinking this assumption by demonstrating that the AON contains a shared neural code for general events, regardless of whether those events involve animate or inanimate entities.

Imagine you are watching a football match. During the game the star player kicks the ball toward the goal, but it hits the goalpost and bounces back toward him. This scene encompasses both actions and object events in which the player performs actions such as kicking and jumping, while the ball is also bouncing and rolling. Both actions and object events involve physical principles such as force, momentum, and gravity that govern their dynamics and outcomes. As you witness this scene, your brain activity changes. However, does your brain process the actions of the player and the movements of the ball in the same way?

Karakose-Akbiyik and colleagues conducted an innovative study to explore how the human brain encodes information about actions and object events [1]. They utilized multivariate pattern analysis and cross-decoding in an fMRI study. Observers were shown videos or sentences of human actions (e.g., walk, jump, kick) and object events (e.g., roll, bounce, hit) while their brain activity was measured. A multivariate decoding approach, known as multi-voxel pattern analysis (MVPA), was used to identify the neural organization of actions and object events. This method extracts information from the patterns of activation across a set of voxels, and has been shown to be a more sensitive and quantitative tool for characterizing the neural representation of a specific cognitive process [2]. In addition to within-category MVPA, researchers also performed cross-category MVPA to investigate common neural codes for actions and object events. For within-category MVPA, classifiers were trained and tested to distinguish actions or object events based on their respective neural activity patterns. For cross-category MVPA, a classifier was trained to distinguish neural activity patterns associated with observed actions, and its accuracy was tested on observed object events, and vice versa.

Karakose-Akbiyik *et al.* found that the frontoparietal and posterior temporal brain regions, known as the AON, encode information for both actions and object events in a similar manner. Moreover, they discovered a shared neural code for observed actions and object events, as evidenced by successful cross-animacy decoding. A shared neural representation of event information that is invariant to stimulus animacy and modality is present in the lateral occipitotemporal cortex (LOTC). This implies that the LOTC can encode events at a general level, whether they are presented visually or linguistically [3]. These findings have thought-provoking implications for our understanding of how the brain encodes information about actions and object events, and suggest exciting avenues for future research.

Human action observation is often studied in the context of the AON, a proposed homolog of the 'mirror neuron system' found in macaques [4]. It has been well documented that the AON is involved in the perception and understanding of human actions and animate-specific events [5]. However, the finding that this network can also represent inanimate object events invites a reassessment of traditional beliefs and implies that its function may pertain to more general properties. This prompts the question of what drives the common encoding of actions and object events in the AON. Karakose-Akbiyik *et al.* speculate that the shared aspects of actions and object events encoded by the AON might be related to their physics and kinematics. Alternatively, the authors discuss whether our tendency to anthropomorphize inanimate entities could also account for the shared neural representations of actions and object events. Investigating the sources of the shared neural representations of actions and object events will be a significant undertaking for future research.

This work calls for a reconsideration of the widely held assumption that the AON is mainly linked to human actions and animate-specific events. It also raises the question of whether other brain regions are specifically involved in human action perception, given that actions convey unique goals and intentions which are fundamental for social interactions and adaptive functioning [6]. We argue that the goals and intentions of an observed human action might be encoded in a network different from the AON. Indeed, Karakose-Akbiyik *et al.* discovered that the posterior superior temporal sulcus, temporoparietal junction, and superior parietal lobes exhibit superior decoding of actions compared to object events. Earlier research has also associated these regions with animate event information such as intentionality, social interactions, and biological motion [7]. However, whether this 'social perception network', as we term the aforementioned brain regions, displays specialization for actions but not for object events remains unclear.

A promising avenue for future research will be to employ other types of action and

object stimuli, such as point-light displays, to validate action-specific representations that generalize across different types of animate signals in the social perception network [8]. Moreover, future studies could investigate this question by using transcranial magnetic stimulation or by studying patients with brain damage. If the social perception network specifically encodes the goal and intention of an observed action, then one would predict that patients with damage to this network would show a deficit in their ability to infer the goal and intention of the action.

We further propose that actions can be understood at different levels, ranging from low-level features (e.g., kinematics) to high-level properties (e.g., intentions) [9,10]. It is plausible that the AON and the social perception network serve distinct roles, where the former codes for actions at a low level, invariant to animacy, and the latter supports action representations at a high level that are dependent on animacy. The AON may operate as a domain-general system in tandem with a domain-specific system (the social perception network) to elucidate the meanings of actions and object events. Although further work will be necessary to precisely characterize the action representations in these two different networks, the initial data reported by Karakose-Akbiyik *et al.* suggest that this is likely to prove fruitful. In summary, this study has the potential to enhance our understanding of how we perceive and interact with the physical world, including in sports scenarios such as that mentioned at the beginning of our text.

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Declaration of interests

The authors declare no conflicts of interest.

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